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From the Editor

Literature Lost: The Case for Electronic Publishing in the Profession

The lack of a comprehensive research base underlying the new paradigm known as technology education is a common refrain in the profession. At the same time, much of the scholarship of our field is lost each year, simply because it has not systematically been archived in print. There are a host of reasons—some good, others not so good—why this is the case. Regardless, we now have an opportunity and an obligation to rescue this scholarship on behalf of the profession. To do so, we should take proactive measures *right now* to archive the important ideas of the field electronically. The technology and expertise are available, and this is a task worthy of our pursuit.

The quantity of the scholarship that we let fall through the cracks each year is substantial. While we manage to preserve some literature in the few journals published by and for technology education, these articles represent only a small portion of the breadth of scholarship in the field. The actual number of articles published in our research journals is exceedingly small. What becomes of other ideas and "new knowledge" that are not published in these few journals? By and large, the ideas are lost forever.

This loss includes not only the formal research of our profession, but also the creative work of our practitioners. While I remain convinced that some of the best instruction in all of education takes place in technology education laboratories, I am hard-pressed to locate documentation of this claim. Each year, more than fifty technology teachers and fifty programs are recognized by name for their outstanding work at the annual conference of the International Technology Education Association. Yet there is little published about these and other exemplary work in the field. Thus, the ideas are slow to disseminate, particularly beyond our profession. A handful of teachers and programs are illuminated each year in *The Technology Teacher*, but the rest are invisible beyond the walls of their laboratories.

Educational decision-makers are simply unaware of the work, aspirations, and potential of our field. It seems to me that the most effective way to disseminate our ideas to significant numbers outside our profession is through publication efforts. More specifically, I think we can and should be "reaching out" via electronic publication avenues.

What Are We Losing?

I am not suggesting that *everything* written be published. On the contrary, I think much of the work requires the careful attention of an editor, as is the case with existing professional publications in our field. Following are some examples of scholarship that I think we are losing from the public record each year. The list is representative, rather than inclusive.

Masters theses. How many masters theses are written each year in our profession? Does anyone really know? What happens to them upon completion? While *Dissertation Abstracts International* provides a lasting record of doctoral work, the same cannot be said for the masters theses written by professionals in our field. They are not systematically catalogued, and are thus lost to the profession over time. Foster (1995) included masters theses in a bibliography of recent research in technology education. This was published as an electronic supplement to the JTE, and is an example of the sort of archiving we should be pursuing aggressively. Accessing the full text of master theses is still another problem, only partially solved by the relatively cumbersome interlibrary loan. Thus, we should go one step further. We should publish each masters thesis and doctoral dissertation electronically. Beginning January 1, 1997, *every* masters thesis and doctoral dissertation written at Virginia Tech will *only* be published electronically. The hard copy version will no longer exist on our campus or in our library. As a result, every thesis and dissertation completed at Virginia Tech will be immediately accessible electronically, worldwide. Our profession should implement a similar scheme.

Conference proceedings. Most conferences in our field do not publish a proceedings of any sort. This is unfortunate, as very few of the papers presented at our conferences ever make it into print. Moreover, the logistics of conferences are such that very few have the opportunity to attend any given presentation, regardless of the substance of the presentation. The annual conference of the International Technology Education Association used to publish a proceedings, but no longer does so. Regional conferences in our field such as the Mississippi Valley Conference and the Southeast Technology Education Association collect and disseminate papers among the participants, but those papers are not published in any traditional manner, and are therefore not accessible beyond the small number of participants who attend these meetings. The Jerusalem International Science and Technology Education Conference, convened in January 1996, decided not to publish a proceedings of the conference. These papers may have been as comprehensive a source of information about technology education worldwide as has ever been assembled. But, in the absence of a conference proceedings, much of the data is lost. Likewise, no proceedings were published for the Technology Education Issues Symposium which took place in Hawaii this past June. In a similar vein, many state technology education associations host annual conferences; to my knowledge, none publish a proceedings from the conference. Perhaps there *are* papers presented at these conferences that warrant electronic publication. Or, to offer a different twist, perhaps if proceedings from conferences *were* published, the quality of the presentations themselves would improve. This too would be a good trend for our profession.

Curriculum materials. It is currently fashionable in our profession to blame vendors for the poor curriculum materials that accompany the hardware they sell. Indeed, many believe that curriculum development is now primarily in the hands of vendors. Is it really the case that no one else is developing curriculum?

Or, is the problem really that of limited access to those curriculum materials that are being developed? Perhaps it is easier for schools to justify the expense of vendor-developed curricula—incorporated into the cost of the new modular technology systems—than to purchase curriculum materials outright from other sources, such as the Technology Education Bank, CITE, or commercial publishers. If every state technology education curriculum guide were available at no cost on the World Wide Web, along with activities teachers developed to augment the curriculum they purchased from vendors, would we still think of curriculum as vendor driven? Why not put all these guides on the Web? After all, these curriculum materials are generally provided as a service to teachers by the state department of education; they aren't developed for commercial purposes. The "Science, Technology & Society Curriculum Newsletter," edited and published by the Lehigh University STS Program is another example of the sort of curriculum documentation we might produce for technology education in electronic format.

Research findings/reports. Most faculty in higher education are involved in research of one type or another, yet relatively little of this work is published traditionally. Perhaps this is because much of the work doesn't "fit" the scope of the traditional publications in our field. Oftentimes, the work is developmental in nature (e.g. curriculum material) and therefore not specifically suited to our research journals. Much of it is too lengthy to appear in outlets such as *The Technology Teacher*. Given the general lack of funding and corresponding shortfall of research in the profession, it seems a shame that so much of it never sees the light of day. Let's put it on-line.

Why Haven't We Published More as a Profession?

There are any number of factors which contribute to the shortfall of literature in our field. One is the relatively small number of individuals who are interested and willing to take the time to prepare their ideas for formal publication. Another reason is the lack of commercial opportunity for publishers in our field. Our field simply isn't large enough to allow publishers to generate sufficient profits from professional papers. While academic publishers in other disciplines survive on upscale subscription fees charged to academic libraries (some journal subscriptions cost libraries *thousands* of dollars each year), that subscription structure really won't work in our field.

Another aspect of the problem is a lack of suitable publication outlets for the work being done in technology education. Researchers may find opportunity in two or three research journals in the field, and *The Technology Teacher* provides an opportunity for articles aimed at classroom teachers. But the type of work noted in the examples above may require different publication outlets.

The expense of printing is a primary impediment to publication of the literature in any field. I suspect most conferences in our field have not published a proceedings because the market is unable to support the expense. This doesn't necessarily mean there isn't worthwhile content to publish. It may simply mean we are not willing or able to subsidize traditional modes of publication for this body of work.

Another real expense is the time required to prepare materials for professional publication. Manuscripts must be solicited, reviewed, revised in accordance with the review, and formatted for publication. In other academic disciplines, this work is regularly attended to by professionals within the discipline. If publishing of any sort—traditional or electronic—is to be worthwhile in our field, we will need to have well-qualified professionals step forward to take on the associated editorial tasks.

What Steps Might We Take?

We continue to think conservatively about our literature. Despite the phenomenal success of electronic publishing avenues such as Gopher and more recently the World Wide Web, we continue to think first of “print” as the primary dissemination mode. The publish-it-on-paper mind-set needs to change. The advantages of economy and global access associated with electronic publication should cause us to think *first* about electronic dissemination for much our literature. While traditional publishing formats remain appropriate for a portion of our literature, a growing body—perhaps even the majority of our literature—might best be published electronically.

Scholars have turned to electronic sources as their *primary* means of accessing information, largely because the search capabilities of these electronic databases are far superior to those associated with hard-copy. Through a tool known as “First Search,” for example, I am able to access 57 vast databases without cost from my office, including ERIC and *Dissertation Abstracts International*. Regardless of the database selected, I may perform author, subject, and title searches electronically through a consistent user interface. Many of these databases provide full-text documents on CD-ROM, and a growing number provide network access to these full-text documents. We too must take advantage of the opportunities that electronic publishing provides our field.

I believe the next step is for the profession to promote and support new electronic publishing initiatives. In some cases, this means providing electronic access to publications which are already in print, as is done, for example, with the JTE. In other cases, we should experiment with electronic means as the sole source of delivery. This would promote far wider dissemination of our literature, particularly *beyond* the ITEA membership. After all, it is the audience *outside* our profession we must convince if we are to remain a viable school subject in the future!

It is now a fairly simple and inexpensive task to convert electronic files on floppy disk to pages on the World Wide Web. Moreover, it is relatively easy to establish World Wide Web servers to provide access to the types of literature noted above. Any number of universities, state associations, and individuals in our profession have set up WWW servers that might become repositories for our electronic publications. Just recently, University Microforms International has begun to accept electronic submissions of both masters and doctoral theses. So the logistics of electronic publishing are not a problem.

The argument that people prefer hard copy to reading materials on-screen is moot. If the profession will support print, put the document in print. If not, make the document accessible electronically. The fact is, electronic documents offer *both* options. If publications are put on-line in Adobe's portable document format (PDF files), the reader may print a version that is nearly identical to the original. Admittedly, the cover and binding won't be the same. Where cosmetics are critical, traditional print may in fact be a more appropriate medium, assuming the market will bear the cost.

While there are still a number of substantive issues to be addressed—for example, provision must be made to assure long-term access to the data—we should begin as soon as we can to pursue electronic publication as a means of archiving and disseminating the literature of our field. In the meantime, a great deal of good work continues to be lost forever.

MES

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Guest Article

Technology Education: Beyond the "Technology is Applied Science" Paradigm

Marc J. de Vries

How Important is Science for Technological Innovation?

In the early days of the development of philosophy of technology as a discipline that reflects on technology, one finds the opinion that technology is applied science. (Bunge, 1966 speaks about "technology" and "applied science" as "synonyms"). Gardner (1994) shows how Francis Bacon already defended the thesis that technology should be applied science and that we find this opinion time and again in later literature. It is then suggested that there is a more or less straightforward path from that scientific knowledge to the technological product. This opinion for some time functioned as a paradigm for the philosophy of technology.

Nowadays we find much opposition against this paradigm and it is clear that we are going through a revolution in the Kuhnian sense (Kuhn, 1970) from one paradigm to the next. But what will be the next paradigm? That is not always so clear. Some recent literature tends to swing towards the opposite and suggests that technology precedes science. The example of the steam engine is mentioned to illustrate that. Elsewhere, I described the development of a successful corkscrew by a Dutch company named Brabantia (de Vries, 1994a). In that study it became evident that scientific knowledge had only a very limited influence on the development of the product and the explanation for the great success of the corkscrew is only to a small extent based on clever use of knowledge of natural phenomena. Rather the success is the result of a clever use of the combination of scientific-technological know-how and know-how of social (market, juridical) phenomena. The case studies in aeronautics by Vincenti in his well known *What Engineers Know and How They Know It* confirm that. When he surveyed the various types of know-how that helped engineers to design their aircraft, he found that scientific knowledge is only one of several types (Vincenti, 1990).

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Technology in Science Education

The “technology is applied science” paradigm in the philosophy of technology is reflected in education. Apart from traditional subjects like industrial arts or craft, we find elements of technology in science education. Science education for many years used to be a rather abstract subject where it was difficult for pupils to recognize the relationship between the knowledge that was taught in science lessons with their daily life. This relationship is found mainly through the technological products they find all around them and therefore a trend emerged in science education to show how scientific knowledge was applied in technological products (de Vries, 1994b). When one considers the course material that resulted, one can easily recognize the “technology is applied science” paradigm.

In almost all cases there seems to be no process in between the scientific knowledge and the technological product. The success of the product this way seems to be in the scientific knowledge. This paradigm could be used to support the “science for all” ideal that was preached as a result of for example, the Sputnik shock. Teach pupils scientific knowledge and later they will be the engineers that will be able to apply this knowledge for developing technological products. In the latest Workprogramme of the Targeted Socio-Economic Research (TSER) of the European Commission's Fourth Framework Programme, one of the research tasks is “Science and technology teaching as components of general education.” But this is explained as: “approaches, concepts and methods in science teaching (including history and philosophy of science as a way of improving science understanding). Comparative research on the role of scientific education in the building knowledge and general education” and no reference is made to technology education at all!

As we saw before, the “technology is applied science” paradigm is challenged now. Does that mean that we also can move away from “science for all” and replace it by “Technology for all, science for some” or “Technology for all Americans” as is the title of a nationwide project in the USA (Martin, 1995)? Can we reduce the role of science education to that of “gate keeper” (Gardner, 1995), which it already seems to fulfill in many cases? To answer that question wisely we have to consider the relationship between science and technology somewhat more carefully.

Science Does Play a Role, but Not the Only Role

The example of the steam engine that is often quoted to attack the “technology is applied science” paradigm is suggestive of course, but not sufficient to do away with this paradigm. Examples of other technological developments do seem to support that paradigm. Elsewhere I have described the case of the development of Active Matrix Liquid Crystal Displays (AMLCD's) in a small Dutch firm (de Vries, 1996b). Here the most important breakthrough in the development was the new knowledge that the Philips Research Laboratories produced on demand by the AMLCD firm. A study of the development of the transistor in the Bell Laboratories by Sarlemijn shows the same phenomenon. Here too, it was only thanks to sophisticated scientific knowledge of microstructures that the product could be developed. In both cases, however, we also see that social factors play a role, but in a quite different way than for example, in the case of the Brabantia corkscrew. In the case of the Brabantia corkscrew, market requirements had a practical impact on the product development from the very beginning of that process. In the case of the AMLCD and the transistor, the influence of market factors could only become practical late in the process when the functional problems of the product had been solved in principle through the application of the scientific knowledge.

The Need to Differentiate Between Types of Technologies

None of the previous cases show us that the "technology is applied science" paradigm gives an adequate description of the technological innovation. In all cases, factors other than natural phenomena and the use of knowledge about those phenomena also played a role. And the role that scientific knowledge played differs substantially between the various cases; sometimes it is dominant in the early and crucial stages of the development, sometimes it is almost absent. This makes it difficult to make any general statement about "the relationship between science and technology." In fact there appear to be several possible relationships between science and technology. Many discussions in literature were fruitless because authors wanted to defend one overall theory on the relationship between science and technology without realizing that one needs to differentiate between different types of technology if one wants to give an adequate description of the role of science of technological innovations.

Based on the case studies that have been mentioned above and other cases (e.g., the Philips Stirling engine) one can identify at least three different types: experience-based technologies, macrotechnologies and microtechnologies. The Brabantia corkscrew is an example of an experience-based technology. Here the role of science is limited to knowledge of natural phenomena that was gained by experimentation and not by deriving it from fundamental theories. Such deductions are made in macrotechnologies, where the fundamental theories are the classical ones (mechanics, thermodynamics and electromagnetic) that are all concerned with macroscopic structures. Deductions from theories on microstructures play a vital role in microtechnologies, of which the transistor and the AMLCD's are examples. At first sight, this differentiation may seem similar to Bame and Cumming's differentiation into caft and machine, machine and power, and power, atomic and cybernetic levels of complexity (Bame and Cummings, 1988). But it is different in nature

As we have seen, the relative influence of scientific-technological and social factors is different for the different types of technologies and also varies as the development process goes on. Three caveats should be mentioned here. In the first place most products are combinations of elements some of which have been developed in an experience-based way, others in a macrotechnological way and others in a microtechnological way, as Sarlemijn and I described in the case of the Philips Plumbicon, a television pickup tube, that was developed in the Sixties (Sarlemijn and de Vries, 1992). In the second place, sometimes there is a transition in the way products are developed. Bridges, for example, for a long time were developed purely on the basis of practical rules of thumb that were the result of many years of experience in designing bridges. Strauss (1964) gives examples from L. B. Alberti and C. Fontana in the 17th century. But later, due to a new type of engineers' training program in the French Ecole des Ponts et des Chaussees, civil engineers designed bridges by deriving and applying equations from Newton's laws of classical mechanics. And still experience-based knowledge plays a role in the design of sophisticated bridges, which makes designing them often a risky enterprise (Petroski, 1994). The length of the cables in a suspension bridge can still not be predicted exactly, but is adapted even during the construction of the bridge. This is not unlike practice in the time of Dufour, who designed many of those bridges in the previous century.

New Paradigms and Their Weaknesses

The abolition of the "technology is applied science" paradigm has caused a variety of new paradigms. Some of them have gained field very rapidly, such as the social constructivist approach (Bijker), the actor-network approach (Callon) and the systems approach (Hughes). Each of these approaches focus entirely on the role of social actors in technological innovations. When Pinch and Bijker (1994) for example, describe the development of the bicycle, they state that a bicycle primarily is what relevant social actors define it to be. In the early days of bicycles, boys found it to be a suitable device for showing their courage and safety requirements were absolutely not desirable. Later on, this changed when one started to see it primarily as a transportation means for all people. Likewise, Callon showed how the development of the electrical car in France can largely be described as the result of a struggle between various social actors (business industries, scientific laboratories, and government).

It is useful to remark that it is a misunderstanding to think that science is less sensible to social influences and more objective and neutral. Pickering (1984) for example, has shown how scientific knowledge too can be described as a social construct. One can question if any of these approaches does justice to the role of scientific and technological factors. All of them seem to belong to what Mitcham (1994) called the humanities approach as opposed to the engineering approach. Based on case studies Sarlemijn and I proposed a different approach, which we called the "STeMPJE" (Sarlemijn and de Vries, 1992; Sarlemijn, 1993). It has more the character to look at technology "from inside." STeMPJE is the acronym that represents all factors that we found to be relevant for describing technological innovations: scientific, technological, market, political, juridical and aesthetic factors. Several studies by mechanical engineering students in our Science, Technology and Society program showed the usability of this approach to help business companies determine their products strategy and not only for analyzing historical cases.

Consequences for Technology Education

What does all this mean for technology education? Is our present practice in line with this or do we need to make changes? In the first place we can state that pupils seem to have great difficulties in recognizing the role of science in technology. Their opinion varies from "science and technology are the same" to "science and technology have nothing to do with each other." International PATT (Pupils' Attitudes Towards Technology) studies initiated in the Netherlands and later extended to other countries and the U.S. (Bame, Dugger and de Vries, 1993), showed that pupils mainly see technology as a collection of products. This is a one-sided image of technology, because it lacks a process awareness. The way science education now tends to integrate elements of technology by focusing on the application of his knowledge in existing products will stimulate this product oriented thinking about technology.

We also see that pupils hardly realize the variety of types of technology; they mainly see technology as "high tech" (or microtechnology). Sometimes they explicitly reject examples of experience based technologies as being technology (e.g., a wooden spoon or a plastic cup). This is at least partially caused by the way technology is presented in popular magazines, television programs, and so forth. Technology education has the task to make this concept of technology broader and more varied. The differentiation between types of technology as sketched above can be helpful to identify how to do this. We can only give pupils a proper understanding of the role of science in technological developments when we make them aware of the differences between different types of technology.

A Separate Subject: Technology?

As we have seen, the danger of integrating technology into science education is that it does not do justice to the real relationship between science and technology. But how about the other option: making technology education a separate subject? This option is challenged by the question whether or not it is possible to define a body of knowledge and skills called "technology" that we can treat as a separate subject (Herschbach, 1995). What could be characteristic of such a body of knowledge and skills? At least one can think of the "system" concept that seems to be integrated in all engineering fields (Hubka and Eder, 1984) and is already used in technology education as well (see e.g. Wright, 1992). International trends show that the answer to this question more and more is found in the design process as the heart of technology. And even though the academic background for the school subject technology is far less than science education, there is a growing discipline "design methodology" as part of the philosophy of technology that can serve as a resource for determining how we should give pupils a realistic image and experience of design.

The short history of this discipline has shown that the naive idea that there can be one ideal prescription for any design process is not realistic. The need to distinguish between different design processes for different products is well established now, even though design handbooks with general flowchart diagrams for design processes are still published that seem to deny this (e.g., Pahl and Beitz, 1988). In technology education, we often have not discovered this yet, given the fact that several textbooks for technology education still seem to try to teach one overall scheme for designing to pupils. Maybe this can be useful to help pupils getting started with designing, but soon we should make them aware that different products may require different strategies for designing. Thereby, we should realize that in elementary and junior high school we probably have to limit ourselves to experience-based and macrotechnologies, because microtechnologies are often too abstract and advanced to deal with in those classes. The further we move on toward senior high school, the more differentiated the concept of technology pupils hold becomes. In the training of future technology teachers, all types of technologies may be dealt with and student teachers should learn to understand the differences between them.

Quality as a Key Concept in Technology

As we saw, design is a key activity in technology that illustrates that it is possible to define a body of knowledge and skills called "technology." A concept that also illustrates this as typical for technology is "quality." This concept originally had a limited meaning in terms of reliability and non-failing behavior. Recently it went through a paradigm shift and came to mean "anything that adds to the attractiveness of the product for the customer." Quality is no longer limited to quality control at the end of the production process, but is now required in the design process. Dramatic changes in product creation processes have been initiated to realize this. In "integrated product design," one takes into account all later phases of the product (manufacturing, assembly, packing, distribution, sales, use, repair, maintenance, recycling). Tools have been developed to do that: quality function deployment, value analysis, design for assembly, failure mode and effect analysis, and so forth. One can go even further and start up the development of the later phases of the life cycle during the design process, and this advanced strategy is called "concurrent engineering." In technology education, we do not yet seem to have discovered this new trend towards quality thinking. Elsewhere, I have proposed to implement simplified versions of quality methods in technology education to make pupils aware of the importance of the quality concept for contemporary technological innovations in business corporations (de Vries, 1996a). Certainly at the level of technology teacher training projects, can be done in which student teachers learn to apply such tools themselves. Thus, they are enabled to help their pupils gain some understanding of those tools in their lessons.

Dealing with Design Properly in Technology Education

In summary, the most important lessons that we can learn from design methodology for teaching technology are the following (see also de Vries, 1992). First, we should avoid a naive use of generalistic design prescriptions. As in the reality of the industrial practice, we will find out that methods need to be adapted to the needs of the specific product that is being designed and do not have the general character that popular literature suggests they have.

Second, we should help pupils to integrate knowledge (scientific, but also other forms of knowledge) into their design processes. This is the only way design processes can be successful, as recent educational research has shown. It is evident that there is a role for science education here and that science education remains a crucial part of general education even where technology education has gone beyond the "technology is applied science" paradigm. Layton (1993) has indicated the various roles science can play for technology: 1) as a cathedral of fundamental research, from which experimental and quantitative methods for investigation and mathematical modeling can be drawn 2) as a quarry, from which scientists can pick out items they think they can use, and 3) as a company store, in which more dedicated "products" are provided for technologists. The last mentioned function is quite necessary. As studies by Vincenti, for example, have shown, scientific concepts often need to be transformed to become usable for technology. Third, we should realize that design processes should differ also because different people (pupils too) use different strategies for designing that fit their different personalities. Pupils can have quite different thinking preferences (in pictures or in words, more convergent or more divergent). We should not try to force them to use generalistic strategies that may not fit their personality. Finally, we should not only teach students to use scientific knowledge, but also knowledge about social phenomena (market requirements, laws, patents, political decisions, etc.). Thus they learn to recognize the complexity of real design processes, even though they do not yet need to cope with this full complexity themselves. Prospective technology teachers should learn how to guide that process and how to deal with the dilemma between a directive versus a more laissez-faire approach.

Final Remarks

It is evident that we face the challenge to move technology education beyond the "technology is applied science" paradigm. At the same time, we should not do so as if science hardly plays a role in technology. The current situation with a majority of technology teachers not having a sound science background can make this difficult to avoid. And science teachers often are hampered by the fact that they hold the "technology is applied science" idea, (Rennie, 1986). Projects that develop examples of integrating science, math and technology like the one that was initiated at Virginia Tech (LaPorte and Sanders, 1993), should be used to see how a balanced view of the relationship between science and technology may be created through practical classroom activities.

To make use of the new knowledge about the relationship between science and technology in the context of Science, Technology and Society (STS) programs, a structural co-operation between technology education programs and academic STS programs is important. The organization of the Technology Education Distinguished Lecture of Spring 1996 at Virginia Tech (co-sponsored by the STS program) is a good example of such a cooperation that can help technology educators to build a more sound academic basis for their school subject. Another need for technology education in terms of the science-technology relationship is educational research with respect to how pupils see this relationship and how their ideas may be changed in technology education. In general, the educational research basis for technology still needs to be strengthened and extended. Here a lot can be gained from experiences in science education, where many studies into the conceptions that pupils have of scientific concepts and principles have been reported (de Vries, 1994). In the building up of a sound educational research base for technology education and the translation of the outcomes to teachnology education and technology teacher training, there is certainly a challenge for all those who feel committed to technology education as a valuable contribution to the general education of all future citizens.

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Articles

Does Integrating Technology, Science, and Mathematics Improve Technological Problem Solving? A Quasi-Experiment

Vincent W. Childress

Introduction

Most educational reform reports since the mid 1980's call for higher standards for curricula, higher standards for student achievement, and new approaches to teaching and learning. Many of these reports call for reform in technology, science, and mathematics education and integration of the three curricula. These calls for educational reform and curriculum integration have led many technology educators to understand the urgent need for research like the study reported herein.

The Need for Research

In 1958, Mayhew, writing on reform in higher education, emphasized the need for research in curriculum integration. "Attempts at integration have considered...the means to the desired end. They have not given attention to how to determine whether or not the end has been achieved" (p. 148). Little has changed since 1958. Loepp (1992) and Foster (1995), recognized the lack of research studies on curriculum integration and the limitations encountered by researchers. LaPorte and Sanders (1995a) cited research concerning hands-on science and the effects of various integrated curricula related to technology, science, and mathematics. They concluded primarily that much more research is needed, especially in the field of technology education.

Related Research

Findings are inconclusive among the few integration research studies related to this study. It is difficult to identify patterns among them. Some of the studies that used samples larger than 100 subjects and treatments longer than eight months found significant differences between the curriculum integration treatments and the control groups. However, other studies of comparable size and duration found no significant differences. Studies using smaller samples and shorter treatment periods also had conflicting results. (Among other studies, see

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Anderson, 1992; Brusic, 1991; Clayton, 1989; Dugger and Johnson, 1992; Dugger and Meier, 1994; Graves and Allen, 1989; Scarborough and White, 1994.)

The Technology, Science, Mathematics Integration Project

The Technology, Science, Mathematics (TSM) Integration Project, with support from the National Science Foundation, developed a set of technology activities called the *Technology, Science, Mathematics Connection Activities* (LaPorte and Sanders, 1995b). They are designed to help middle school teachers correlate planning and classroom instruction among the three disciplines. The activities do not constitute a curriculum *per se*, but are units that set up technological problems for students to solve. In the process, students learn concepts from each of the three disciplines and apply what they learn to the design, construction, evaluation and redesign of the technological solution.

Each activity is divided into several sections. The students are provided with a design brief that introduces the problem, specifies any design constraints or limitations to the problem solution, and explains how the students' solutions will be evaluated. The Teacher Overview provides the teachers with an overall explanation of how the activity is organized, and it includes an instructional sequence chart and some details of how the technology, science, and mathematics concepts are interrelated. Finally, the Technology, Science, and the Mathematics Components provide detailed suggestions for instruction and certain content for each subject area (LaPorte and Sanders, 1993).

Purpose

The purpose of this study was to determine if TSM curriculum integration improves the ability of technology education students to solve technological problems. The research question was:

> Do technology education students achieve in technology better when their technology education teacher correlates planning and instruction with their science and mathematics teachers?

The study examined student solutions to technological problems and whether the solutions were better in the experimental group or in the control group. The study also examined whether or not students were attempting to apply the science and mathematics they learned.

Methodology

The researcher used a quasi-experimental, non-equivalent control group design to measure the effects of TSM curriculum correlation. While there were limitations within the methodology of the study, it can provide valuable guidance for future quasi-experiments in curriculum integration. This study's primary value is that it provides a pilot for quasi-experiments in technology education curriculum research and identifies the various limitations to such research. Feedback from field tests of the *Technology, Science, Mathematics Connection Activities* suggested that implementing curriculum integration is both difficult and requires commitment among the teachers involved to overcome the structural constraints to implementation (Sanders, 1993). The paramount consideration is common planning time for the teaching team during the regular school day. Common planning means teachers must commit to regular meetings and work together. Teachers also must be committed enough to work around student scheduling problems. In the context of TSM implementation, the teacher team may not share many students in common. The technology teacher and students may need to visit the science and mathematics classes to explain how the technology relates to the science and mathematics content. Science and mathematics teachers also use the technological solutions developed in technology class as teaching aids.

Based on this feedback, the sampling frame was composed of middle schools that had demonstrated interest in curriculum integration through participation in workshops and seminars prior to the study. While these schools may not have attempted to implement TSM integration, they would at least be more likely to have a group of faculty who have worked together in considering curriculum integration. These schools may also have more likely identified teachers who can work together and who have a common planning time.

In an attempt to control confounding variables, the researcher delimited the sampling frame to those schools that had two technology education teachers who both taught the same grade level and had access to general technology education laboratories. Theoretically, using one teacher would control for teacher differences. Realistically, it seems unlikely that a teacher would be able to isolate his or her behaviors as they relate to the treatment and control conditions. In an attempt to control for differences between the two technology teachers, an adapted set of treatment and control materials was employed to guide the teachers. Most of the few schools that met the criteria were not able to schedule the quasi-experiment. After identifying three schools that met the criteria and could schedule it, one school declined to participate because the academic teachers were too busy. A second school was used in the pilot study, and the third school was selected as the study cite. The selection of the school for the study was fundamentally a convenience sample.

Due to scheduling, the science and mathematics teachers were required to deliver the treatment instruction during their common planning period in the technology education lab, but they were committed to the assignment. TSM Integration Project field test results identified the lack of common planning as a major constraint to curriculum correlation. One of the strategies schools used to overcome this was to invite teachers into selected classes during their planning periods (Sanders, 1993). For this study, the only class of eighth grade technology education students available during this planning period was designated as the experimental group. The researcher selected one particular class of students for the control group because their schedule most closely matched that of the experimental group students. Any unforeseen interruptions experienced by one group would likely be experienced by the other. There were 17 students in the experimental group and 16 students in the control group. The convenience sample and the small sample size may have had fundamental effects on the findings of this study.

One of the *TSM Connection Activities*, "Capture the Wind," was selected and adapted to provide the instructional materials for the study. This activity was used as the basis for presenting the problem that both groups of students were to solve: "Design and build a device that efficiently transforms wind energy into electrical energy." Students designed and constructed wind collectors.

There were two iterations of problem solving throughout the course of the study. The first was prior to the pretest, and the second was after the pretest. No treatment was administered during the first iteration of problem solving. Students in both the experimental and control groups received the same instruction on designing wind collectors, and both groups had the same amount of time for instruction and lab work. The topics covered by the technology education teachers were as follows:

- Review of material processes
- History of wind power
- Wiring of the generator
- Demonstrate the generator without the use of a collector
- How to mount collectors on the generator
- Materials that can be used
- Collector design considerations
  - should the collector rotate on a horizontal or vertical plane
  - within the volume constraint, should students maximize the diameter or the depth
  - how to measure volume to see if collectors are too large
  - what to do to the restricted flow of air around the hub area
  - should collector mass be minimized or maximized
  - does the collector need to be rigid in the wind

The effectiveness in solving the problem was determined by measuring the actual performance of the student-made wind collectors. Each wind collector was connected to a small direct current generator and turned by a fan to hold wind speed constant. A voltmeter was connected across a fixed load resistor. An ammeter was connected in series with the circuit, and the voltage and amperage were measured simultaneously. The electrical output of each solution was measured using the same generator and under the same conditions. The voltage and amperage readings were multiplied to calculate the power output in milliwatts from the generator for each wind collector. The exact same procedure was used for both the pretest and the posttest.

The pretest data were collected the day after the first iteration of instruction and problem solving (15 class periods). The researcher performed an analysis of variance and found no significant difference between the experimental group and the control group in performance on the pretest. Thus, he did not consider the two groups to have significantly different problem solving ability as it relates to the wind collector problem prior to the administration of treatment. The pretest findings are tabulated in Table 1.

Table 1
Pretest Analysis of Variance for Milliwatts Generated

Source	*df*	*MS*	*F*	*p*

Group	1	33.5	0.18	0.7409
Error	31	301.1		
Total	32			

Group	*n*	*M*	*SE*
1. Control	16	25.06	4.33
2. Treatment	17	27.08	4.20

Treatment began for the experimental group the day after the pretest. The objective for students in both groups was to improve the performance of the wind collectors (a second iteration of problem solving). The experimental group received one and one-half class periods of science instruction and activity and one class period of mathematics instruction. This instruction was in addition to the time the treatment group had to physically improve their solutions. The amount of time that the treatment and control groups physically labored to implement collector improvements was equal.

The materials that the experimental group received included the technology, science, and mathematics content that was considered essential to the design, construction, and evaluation of the wind collector. The material received by the control group was identical except that the science and mathematics sections were deleted.

The concepts taught by the science and mathematics teachers were directly related to the technological problem that the students were attempting to solve. The science teacher taught students how the force of the wind can be redirected by the wind collector solutions. This included a qualitative demonstration. The science instruction also included experiments designed to identify the optimal pitch angle of wind collector blades using Tinker Toy-like wind collectors. During the mathematics instruction, students learned how to calculate the maximum volume within which the wind collector size was constrained, and how to maximize the collector dimensions within the volume constraint. The mathematics instruction also taught students how to tabulate data and graph relationships between (1) the pitch angle and wind collector power output, and (2) between the number of blades and the wind collector power output.

The control group received no science or mathematics instruction during the second iteration of problem solving. These students proceeded with the improvement of their solutions over five class periods after which the solutions were collected and stored until the posttest.

During the second iteration of problem solving, the researcher randomly selected six students from each group to interview individually. The questions asked were designed to see if experimental group students were attempting to apply science and mathematics principles as they solved the problem. For control group students, the exact same questions were used to identify what factors influenced their designs. The questions, listed below, were phrased to avoid response bias. The questions were phrased in such a way that it was impossible to give one-word responses such as “yes” or “no.” If the student gave a short response, the researcher would prompt him or her for more information without being suggestive. For example, if the student answered question one below, "Because I changed its blades," then the researcher would respond, "Changed its blades?"

1. *Why do you think that your wind collector will generate more power this time compared to what it generated last time?*
   If the student was rather elaborative about generally using science and mathematics in the improvement process but did not mention much about the actual concepts, then the researcher asked question 2.
2. *How did you learn of this new strategy/concept/approach?*
   If the student was rather elaborative about generally using science and mathematics in the improvement process but did not mention much about the actual concepts, then the researcher asked question 3.
3. *What did you learn that gave you this idea?*
   After seeking some response from the student that referenced the science and mathematics instruction and content, the researcher asked the remaining questions if the student did not answer them during responses to the preceding questions.
4. *Why are the blades on your wind collector bent at an angle?*
5. *Why did you use X number of blades on your wind collector?*
6. *How do you know that your wind collector is not larger than 122 cubic inches/2000 cubic centimeters?*
7. *If you made more than one change to your wind collector, how can you tell which change made it improve or get worse?*

The posttest data were collected from both groups on the same day after the experimental group completed their improvements. The experimental group received the same amount of lab work time to make their improvements.

Findings

The researcher was attempting to measure the effects of TSM integration on the technological problem solving ability of eighth grade technology education students. Analysis of variance was used to test the research hypothesis. Table 2 shows that there was no significant difference between the groups on the posttest, and the researcher failed to reject the null hypothesis. It is important to note that both groups improved. The mean electrical power produced by the solutions slightly favored the experimental group in the pretest and the control group slightly in the posttest. Upon inspection of the data for the experimental group, the researcher found that the solutions of ten students increased between the pretest and the posttest; the solutions of six students produced less power. All but two solutions improved for the control group on the posttest. This could partially explain why the mean of the control group went from being lower in the pretest to higher in the posttest.

Table 2
Posttest Analysis of Variance for Milliwatts

Source	*df*	*MS*	*F*	*p*

Group	1	350.1	1.45	0.2374
Error	31	241.1		
Total	32			

Group	*n*	*M*	*SE*
1. Control	16	36.71	3.88
2. Treatment	17	30.19	3.76

Why did more experimental group students perform lower on the second iteration than on the first? Post hoc t-test analyses were used in an attempt to partially explain these results. The adapted *TSM Connection Activity* stipulated that the wind collectors could not exceed a specified volume. The mathematics instruction was correlated with the *Connection Activity* in order that experimental group students could maximize the size of their wind collectors within the volume constraint. The experimental group did not maximize their solutions to the limits of the volume constraint. Nevertheless, there was, in fact, a significant difference in collector size favoring the experimental group as shown in Table 3. There was no mechanism within the design of the study to explain why experimental group students failed to maximize the sizes of their collectors to within the limits specified.

Table 3
T-Test for Size Constraint

Dependent Variable: Collector Size in Cubic Inches

Group	*n*	*M*	*SE*	*CI*		*p*
Control	16	62.75	6.64	48.59	76.91	0.0155*
Treatment	17	83.46	6.31	69.99	96.92	

During the second iteration of problem solving, the experimental group received science instruction related to the pitch angle of the collector blades. This science instruction included an experiment in which the students varied the pitch angle of Tinker Toy-like wind collectors. According to the science teacher, students concluded that 15 degrees was the best pitch angle to try on their wind collectors. Table 4 shows the large frequency of students using 15 degrees of pitch angle after science instruction. Control group students used a wide variety of pitch angles.

Table 5 categorizes the responses of the students that were interviewed as to why they thought that their second solution would perform better than their first solution.

Table 4
Distribution of Experimental Group by Pitch Angle

15 degree pitch angle:	10 students

Other pitch angle:	7 students

Table 5
Categorized Responses of Interviewed Students Concerning Why They Felt Their Second Solution Would Perform Better Than the First (n=6)

Responses	Reason (Treatment)
4	Based on what I learned through math and science instruction (general)
4	Pitch angle experiments in science
3	Control a variable in an experiment
1	Based on what I learned from observing other students
2	Intuition based on what I learned from building the first wind collector

Responses	Reason (Control)
3	Based on what I learned through technology instruction (general design considerations)
2	Pitch angle
2	Control a design variable
2	Based on what I learned from observing other students
3	Intuition based on what I learned from building the first wind collector

Conclusions

It is possible that the results of the science experiment on pitch angle were not transferable to the actual wind collectors that the students designed and built in the technology lab. If this is true, then it might explain why the control group improved more in the posttest; or more specifically, why some treatment group collectors produced less power in the second iteration.

Although the study revealed no significant difference between those who received correlated science and mathematics instruction and those who did not, in terms of wind collector performance there was evidence that the students did, in fact, attempt to apply what they learned in the correlated instruction. The 15 degree pitch angle frequency is one example of this evidence. In addition, the sizes of the collectors produced by the experimental group were closer to the specifications indicated in the adapted *TSM Connection Activity*. Since the wind collector size constraint required students to know how to calculate the volume of a cylinder, it is quite plausible that the students applied what they learned in the mathematics class about volume to the development of their solutions.

Further evidence of science application was provided by interviews with the students. The interviews provided the most positive findings in the study. They showed that experimental group students tended to consciously apply science to the wind collector problem. On the other hand, the control group students seemed to depend on a combination of what the technology teacher taught them and what they observed about the performance of their collectors and those of other students. It appears plausible that treatment group students applied science and mathematics in their solutions to the wind collector problem. However, whether or not the students actually understood the underlying science and mathematics concepts was beyond the scope of this study. The teachers involved with the experiment agreed with these findings.

Discussion

The results of this study have implications for the development of TSM curriculum integration efforts and future research related to TSM integration. Development of TSM curriculum integration materials that facilitate technological problem solving and the application of science and mathematics should continue based on evidence in this study that suggested students will, in fact, try to apply science and mathematics in solving technological problems. In future studies, post-experiment student interviews may be helpful in explaining results. Such an interview may have provided answers as to why some experimental group students in this study scored lower on the posttest and why the collector sizes were larger but not optimized.

In this study the technology teacher in the experimental group was not part of an interdisciplinary team at the school. It would be useful to conduct a parallel study to this one in which the technology teacher is an integral member of the interdisciplinary team that shares all students among team members.

Although it was beyond the scope of this study, it was difficult to determine whether or not experimental group students understood the science and mathematics concepts taught. The researcher recommends that a test be developed to evaluate students on the extent to which they understand the science and mathematics concepts in the *TSM Connection Activities* and similar activities.

In this study, students had to actually solve a problem for the pretest to assure that the experimental and control groups were not significantly different in ability to solve the particular technological problem. It is recommended that demographic, socioeconomic, intellectual ability, and academic achievement data be collected in a similar study. Such a study would attempt to develop an index of problem solving ability from the data and might allow future researchers to avoid the need to actually have students solve a problem in order to pretest. Such data could also be collected *a priori* for an ANCOVA in a better attempt to explain the results.

In this study, it was possible for students to observe the solutions of other students and integrate what the teacher taught them with their own ideas and their observations. It would be interesting, albeit difficult, to conduct a similar study in which the students work independently so that the effects of observing other solutions could be assessed. This might be accomplished in a "lab school" or clinical setting.

Because it is conceivable that the results of the pitch angle experiment were not transferable to the types of solutions that the students were working on, similar studies should use the actual student-made solutions as teaching aids and demonstration props. This is supported by recommendations made in the *TSM Connection Activities* (LaPorte and Sanders, 1995b).

In spite of the foregoing attempt to explain the results of this experiment, the most fundamental constraint to this study was the lack of probability sampling and the small sample size. Researchers should develop working partnerships with the public schools in order to pursue research interests through long-term planning. Such a relationship would ensure that future studies are able to identify a number of viable sites and are able to use random assignment of groups in experiments with complicated treatments such as curriculum integration.

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Industrial Arts Revisited: An Examination of the Subject's Continued Strength, Relevance and Value

Kenneth S. Volk

There has been a considerable amount of work, position papers and professional pressure in recent years expressing the need for technology education. This effort has often rallied around justifications which diminished or ignored the contributions and continued existence of industrial arts programs. Considering the recent trends and mandates toward technology education, have those educators previously initiated into industrial arts been indoctrinated to teach subjects such as woodworking, only to find the subject matter has no contemporary relevance and can no longer exist? In essence, are the curriculum, activities and equipment of industrial arts temporal in nature and of minimal educational value, or was it simply politically incorrect to discuss or support the subject?

This paper will attempt to clarify some of the arguments for and against industrial arts, as presented by proponents of technology education. In the scope of this discussion, an alternative view of the strength, relevance, and value of traditional industrial arts is presented. Concurrently, assumptions about technology education as being the *only* program in this arena of instructional worth are challenged. Concluding remarks will suggest a need for middle ground encompassing professional inclusion and program appropriateness.

As a former industrial arts woodworking teacher in the late 1970s to mid-1980s, and now in a university setting preparing teachers, I have been wrestling with the changes that have been occurring. I have witnessed both public school and teacher preparation programs in industrial arts/technology education drastically fall in numbers (Volk, 1993), and programs that were full of tradition being attacked. This author is not against the tenets of technology education, for who would argue against the need for students to understand technology? Rather, as a former industrial arts practitioner, I am convinced there were, and still are, aspects of industrial arts having educational value for today's youth.

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Evolutionary or Revolutionary?

A central theme rationalizing the move toward technology education has been that technology education evolved from industrial arts. Claims to this effect have been promoted by publications such as *Technology Education: A Primer* (Colelli, 1989), *The 50th Anniversary Edition of The Technology Teacher/ International Technology Education Association* (International Technology Education Association, 1989) and *The Foundations of Technology Education, 44th CTTE Yearbook* (Israel, 1995).

By using the term "evolution," two insinuations are made. First, in the grand march toward educational development and sophistication, technology education is placed in a superior position above industrial arts. Second, in this hierarchical scheme, those that still teach industrial arts are, by default, considered "neanderthalic" in their approach, content and relevance.

Viewed through the theory of change often associated with social Darwinism, evolution represents progress and superiority. Despite this common perception, social Darwinism never concurred with the specialist's understanding of evolution as being a naturalistic and non-directional process of change. In fact, as Novikoff (1976) pointed out, evolution need not always be in the direction of progress. In this same manner, the assumed hegemony and superiority of technology education can be questioned.

If one were to further challenge this premise and assumption of progress through evolution and argue that technology education is revolutionary, as opposed to evolutionary, then *both* subjects can coexist-exist. For example, the development of social studies as a new subject using history, anthropology, geography, and so forth, as a foundation did not preclude or necessitate the elimination of the latter subjects. So too does the development of technology education not necessarily preclude industrial arts from still being taught.

As distinct subject matter, overlaps can occur. These overlaps reflect the tools, materials, processes, objectives, definitions, and activities common to both programs. Figure 1 illustrates how industrial arts and technology education share common features.

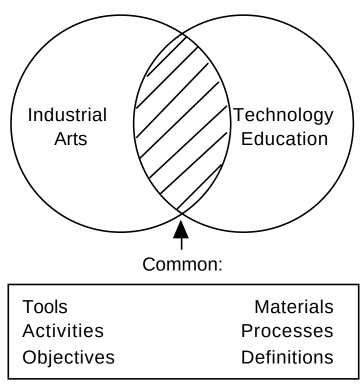

*Figure 1***.** Common features of technology education and industrial arts.

Although commonalities exist between the two subject areas, questions remain as to the degree of overlap. Should a great deal of overlap occur, then implications can be made about professional inclusion and direction. If there is little overlap, then perhaps discussion should be shifted to individuality, uniqueness and professional autonomy.

Academic Integration

Academic integration is a buzzword that seems to differentiate the way industrial arts and technology education are taught. Proponents now claim that technology education is the “place to put it all together.” However, teaching in this holistic manner is not a new concept, nor unique to technology education.

Edmondson’s (1987) examination of the nature-study movement in the early 1900’s described the integration and coordinating efforts industrial arts had with other subjects. Influenced by a growing awareness of conservation, the “Bird House Era” of industrial arts combined subjects of mathematics, geography and English in the holistic study of birds. Fryklund's (1941) status report on *Industrial Arts Teacher Education* specifically examined the amount of integration that existed with academic disciplines and commented on the benefits of such efforts. From those responding to his survey, 63 percent were using integrative techniques in their instructional process, with 41 percent participating with academic departments. According to Fryklund, “these co-operations were in varying degrees, from cutting stock with shop equipment to detailed efforts at combining subject matter into units” (p. 90).

Caution should be made when placing too much justification for a curricular area on its claims of being able to represent *all* disciplines. An argument can be made that if technology education can teach these other disciplines, then other disciplines can teach technology. Evidence of this trend can be seen with subjects such as “Principles of Technology” being taught in either science (especially physics) or technology classes. Furthermore, math and science disciplines are now using robotics, CAD and modular hardware typically found in technology education in order to provide concrete applications to their lessons. English classes, now often called communication, incorporate video production, desktop publishing, and other “tools” found in technology education's communication cluster. In this manner, technology education's hardware and activities have been easily incorporated into other disciplines, thus minimizing its unique contribution and necessity in a school setting.

What It Is, Is What It Is Not

Definitions of the subject have, in many ways, changed little from Bonser and Mossman's (1923) early descriptor of industrial arts being “a study of the changes made by man in the forms of materials to increase their value and of the problems of life related to these changes” (p. 5). Despite academic endeavors to massage and reinterpret the definition since that time, Foster (1994) noted “what the profession defines as ‘technology education’ - in an attempt to distance it philosophically from ‘industrial arts’ - is essentially the definition suggested many times in the past for industrial arts” (p. 16). For instance, the definition supplied by Wright and Lauda and accepted by the *Foundations of Technology Education Yearbook* (Bensen, 1995) stated that technology education is "an educational program that assists people [to] develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (Wright and Lauda, 1993, p. 4). From the 1923 and 1993 definitions, both industrial arts and technology education can be categorized in simple terms of process (i.e., changes in materials/design, produce, use) and outcomes-oriented (i.e., study problems of life/assessing appropriateness). Simply put, the definition has not changed much in 70 years.

However, noticeably absent from recent definitions of technology education is the general scope and intent of the subject. In a departure from the classic definitions articulated by Maley (1973) and Wilber and Pendered (1973), in which the non-vocational aspect of the subject was saliently described in terms of being "general education," recent descriptors conspicuously omit this aspect. Now phrased in terms of being just an "educational program," clarity of meaning has given way to obfuscation. One explanation for this omission may be the availability and infusion of Federal Perkins vocational funds and School-to-Work monies into technology education programs. For reasons of political posturing, strategic importance, and financial survival, vocational funding would be jeopardized if technology education was to be broadly characterized as part of general education.

Despite attempts to define and promote the term "technology education," confusion still exists; not only within the profession, but among the general public. For instance, the Technology-Edu listserv, the first electronic mailing list for the field of technology education, clearly states in its "welcome" statement that it is a forum for issues centering around "industrial arts" and "technology education." Even with this admonishment, the listserv regularly becomes clouded by discussions centered on educational technology and computer utilization. Similarly, the electronic posting of the *Journal of Technology Education* is located under an Internet directory which includes an eclectic variety of educational technology and technology trade magazines. Recognizing this continuing uncertainty of terminology, the Executive Director of the International Technology Education Association (ITEA) stated, "confusion is everywhere! ... it is safe to say that most educators don't know the difference" [between educational technology, technical education, and technology education] (Starkweather, 1993, p. 2).

To alleviate this confusion inside and outside the profession, technology educators are more likely to define their subject in terms of what it is *not*. This is to say: it is *not* woodworking. Much of this exclusion no doubt lies with the fixation, fascination, and fondness of "new technology" at the expense of anything that resembles "old technology."

Edutainment

Technology education has placed great emphasis on incorporating activities that purport to be state-of-the-art. Most identified with this learning environment are the modular systems being introduced into the technology education curriculum. This "high tech," computer-related, and often multimedia-centered instructional hardware may be in reaction to educators' fear of inadequacies to compete with the computer and video-driven environment with which students are most familiar. In a similar critique, Zuga and Bjorkquist (1989) suggested that "in many instances flashy equipment has been used to camouflage inferior teaching" (p. 70). What has often been the result is the reliance on high technology, that is, computers, and the inclusion of equipment with accelerated built-in obsolescence.

Contrast this approach with the relative stability of traditional industrial arts subjects such as woodworking, where many of the tools, materials, and techniques have stayed fairly constant. Granted, some technological advances have been made in calibration, composites and production, however the basic approaches remain timeless. This is not to condone teachers who thought their limited project selection was timeless, that is, your older sister or brother made the same knickknack shelf as you did. There was too much of this stagnation. Yet, offering students an experience that is unique to what they receive in other learning situations, plus introducing them to practical skills (Raspberry, 1989) is a powerful instructional setting and experience.

Questions about the educational value of modules have been raised by several authors. Petrina (1993) argued that modular approaches are organized and constrained by the equipment and devices contained in such programs. He also suggested modular programs were shaped by dated learning theory and reflected mechanistic assumptions about education. Harris (1994) also expressed concern that a number of decisions about using information technology and their associated measurement, control, simulators, data acquisition equipment may have been made by educators "without proper consideration of the longer-term implications" (p. 24).

Toomey and Ketterer (1995) further argued that the use of computers, including multimedia to enhance learning may be more promotional than investigative. An example of this promotional research can be found in the study conducted by Dobrauc, Harnisch and Jerich (1995) for Synergistic Systems labs. Synergistic Systems requested the study as "academic proof that their system was a better way to teach and a better way for students to learn" (p. 4). Despite not stating sample size, using a research methodology developed over 30 years prior to the research, and not having outside objective review, the researchers concluded that "it is a system students respond to and appear to like" (p. 13).

However, a more serious and immediate criticism is the role vendors have played in developing curriculum. With vendors introducing and updating modules each year, in a sense the curriculum is dictated by the supplier, not the user. The acceleration and influence of vendors in determining curriculum can be identified by examining recent ITEA conference programs. In the 1984 Columbus, Ohio conference, 18 percent of the presentations were conducted by the commercial (vendor) exhibitors. By 1994, the Kansas City, Missouri conference had 30 percent of the presentation topics conducted by vendors in the form of "Action Labs." Such presence at national conferences no doubt influences teacher purchasing and curriculum decisions. It also gives legitimacy to the vendors' efforts through these professionally-sanctioned meetings.

Build 'em, Race 'em, and Smash 'em

Competition is another buzzword that captivates recent technology education curriculum design. Many technology educators seem determined to have students compete in “design challenges” as an initiation into the real world of work and threat of global economic competition. What has been the result in many instances, is a reliance on too-few, non-relevant, and overly-used projects that tragically have no utilitarian or lasting value.

The Technology Education Advisory Council (1988), affiliated with ITEA, tried rallying educators to this competitive mode of education through their “Call to Action.” They stated: “The issue here is not whether technology education is good or bad; not whether it should or shouldn't be offered; or not how it is to be taught. The issue here is whether the United States will maintain its worldwide competitive lead in technology” (p. 21). A particular philosophy of the role of education is evident in this statement. Are schools and subject matter to be viewed as tools of capitalism, or should they be the foundation of democracy? Competition can more easily be associated with the former.

Contradictions in the simplistic justification and endorsement of competition are most evident when some of our chief “competitors” are examined. For instance, Japan and Hong Kong, whose people we admire for their technological sophistication and productivity, still encourage their youth to take courses in woodworking and other industrial crafts. These courses help foster skills in problem-solving, self-discipline, artisanship, and tool manipulation. Furthermore, through the creation of a competitive environment where “my success requires your failure,” research shows that competition can undermine self-esteem and disrupt relationships (Kohn, 1992).

In a sense, competitive events such as CO2 cars and model bridge building have become the pump lamps of the 90’s. Not only questioned on their potential gender bias, (racing cars) and educational relevance (how many bridges *really* need to be built), the homogenizing curriculum reduces program individuality, uniqueness and options. Such activities also tend to make programs vendor-dependent for prepackaged materials and supplies to continually justify and utilize their maglev, wind tunnel, race track, and bridge-testing apparatus (Petrina, 1993).

New Tricks and Old Dogs

The health of the profession has been failing in terms of the numbers graduating from teacher preparation programs and secondary school teachers implementing technology education. Several studies illustrate these trends.

University teacher preparation programs for technology education have seen a decline in student numbers (Scott and Buffer, 1995). Redesigned program emphases to non-teaching options have had their effects (Volk, 1993), yet other fundamental problems may exist. If one were to examine exactly what is being taught in secondary schools, surveys conducted as recently as 1992 still place woodworking and other industrial arts courses in the majority (Dugger et. al., 1992). This continued appreciation of the value of traditional industrial arts was supported by Jewell's (1995) state-wide survey of North Carolina principals. In this research, Jewell found principals disagreed with the statement that "programs that focus on woodworking and metal working is [*sic*] an out-of-date concept" (p. 22). What this suggests is that there is support for industrial arts teaching, but this support is not being met by teacher preparation programs. Reflecting on this dilemma Miller (1988) noted recruiting new teachers is difficult enough, but "the changing of the name into something else makes it even harder to recruit when you have to tell the prospective professional that the profession he/she is interested in has changed its name and direction" (p.4).

Teachers in the field may be proving resistant to technology education changes. For instance, Rogers' (1992) study on the transition to technology education by industrial arts teachers examined their acceptance using a Stages of Concern Model. This model, developed by Hall (1979) maintains that the feelings, attitudes, and perspectives a person has, must go through several stages or processes as they consider, approach and implement use of an innovation. Rogers found that the majority of industrial arts teachers had failed to accept technology education, and that older and more experienced teachers were more likely to refocus it before accepting it.

Perhaps a further explanation of why new teachers are not entering the profession or why experienced industrial arts teachers are not accepting the changes can be found in the work of Wicklein and Rojewski (1995). In their study of psychological type of industrial arts and technology education teachers they administered a Myers-Briggs Type Indicator personality profile and Keirsey-Bates temperament type instrument. The authors found industrial arts teachers prefer introversion, sensing and judging orientations, while technology educators prefer extroversion, intuition and feeling orientations. These profile types help understand the professional inclinations of industrial arts teachers toward teaching technical skill development in their subject matter, as opposed to the problem solving, analyzing, modeling and experimenting emphases of technology education. The percentage distribution of personality types for technology educators as compared with the general population may also provide clues as to the specific personality type represented or attracted to the profession. In this regard, technology educators exhibited the extrovert, intuition, thinking/feeling and judgment categories (ENTJ, ENFJ) approximately twice as frequently as industrial arts teachers and three times more than the general population. In a sense, the profession may be trying to convert the wrong type of person to teach the subject.

The Real Objective

Single-parent families, declining test scores, and the crime rate for teenagers are indices which suggest students of today are a product of a society that is considerably different than 25 years ago. Yet, although education programs have changed since that time, societal needs have not differed to a great degree in the sort of person and participant a democratic society expects.

In a recent study on manufacturing firms conducted by Volk and Peel (1994), employers were asked to indicate the relevant importance of academic and vocational skills required of employees with only a high school diploma. Considering nearly 40 percent of the high school graduates do not enroll in either a two-year or four-year college after graduation (U. S. Department of Education, 1995), combined with the non-college bound population traditionally served by industrial arts courses (Ericson, 1960; Mikush, 1967), Volk and Peel's study pointed out critical areas of educational emphases. A general observation from the study found that skills related to affective domains; that is the attitudes, personalities, and emotions of employees were generally rated higher than those categories dealing with technical or academic concerns. In a similar manner, this emphasis on the importance of affective domains over cognitive and psychomotor domains was also reflected in Rogers' (1995) study of technology education curricular content as identified by trade and industrial teachers. Rogers found that trade and industrial teachers desire students who complete technology education programs to possess "affective domain attributes, such as dependability, punctuality, honesty, pride in workmanship, ability to cooperate with others, and a safe attitude" (p. 71).

In the case where state curriculum guides have become state curriculum mandates, concern should be noted for programs that stress competency-based and other "measurable" items as the only necessary outcomes. Working in a social situation, as opposed to individualized instruction (modules); having pride in your work as being a lasting accomplishment, as opposed to the temporal nature of prototype design and product testing (bridge building); and participating in a program that is built on success, as opposed to failure (competition) are some of the "hidden" experiences and skills students obtain in industrial arts. It may be that this "hidden curriculum" has always been the real strength and true value of industrial arts programs.

Implications

From the philosophical, structural and contextual comparisons made between industrial arts and technology education programs, there are three options for the profession. Each is plausible, yet not equal in implementation or desirability.

The first option is to continue ignoring any association and relationship between industrial arts and technology education. In a sense, this continues the status quo. Also, public and professional confusion over the content and definition of the subject would continue. Objections to this option are based on the fragmented professional base, declining programs and convoluted subject matter that currently exists.

The second option is to recognize the distinctly different objectives, content and approach between the industrial arts and technology education. In this scenario, the two subjects remain only loosely associated and interrelated, with very few common features (see Figure 1). Thus, if one were to walk into either an industrial arts or technology education facility, they would clearly recognize what particular subject is being taught through observing the particular tools, materials and activities. Under this option, teachers would be certified and teach either industrial arts or technology education. This would absolve any claims to subject matter orientation based on name only. This option would also necessitate the creation of a new professional association, solely representing industrial arts teachers. In this manner, a new professional organization would increase industrial arts teachers' political representation and posturing in educational fields. A major drawback from this option would be reduced strength in numbers when lobbying for any technical education-related support.

The third and most attractive option recognizes and accepts the common features of industrial arts and technology education (see Figure 1), thus minimizing their differences. Professional inclusion and tolerance on areas of definition, activities, tools, and objectives would characterize this approach. With industrial arts being criticized, stereotyped and challenged for its educational value, technology education has been myopically depicted as the rightful heir to all subjects relating to technical arts. As this paper has presented, the latter subject has limits on its claims of superiority.

Although industrial arts teachers and programs have been resistant to change, technology education success stories get the promotion and notoriety in professional journals, while the mass of those teaching traditional industrial arts are ignored. As noted by Ritz (1992), "during the 1970s and 1980s, members of our profession have authored numerous publications and have discussed their ideas on implementing technology education programs, programs that were much different than their forerunner, industrial arts" (p. 21). Even with the difficulty of finding model technology education programs to highlight as they are "few and far between" (Ritz, 1992, p. 21), profiles of the majority of industrial arts programs are conspicuously absent. This approach of ignoring the reality and majority of industrial arts programs must be professionally reconciled.

Despite pronouncements that "technology education" was chosen because "the term *industrial arts* gradually became an out-of-date description of what the profession wants to do" (Hughes, 1985, p. 3), perhaps the term "industrial arts" ought to continue, recognizing what most of the teachers are actually doing. Such an admission that there are successful industrial arts programs in schools that continue to offer students experiences that are unique, exploratory, built on problem solving, and character-building would go along way in reestablishing professional dialog and growth.

As another strategy for inclusion, it is proposed special interest groups and topics be encouraged in the American Vocational Association and International Technology Education Association to represent the specific professional interests of industrial arts teachers. This group would be expected to participate in professional debate about curriculum, activities, and strategies more relevant to their particular school setting.

A final strategy would be to explore greater common ground for collaborative efforts and direction. Recognizing and acknowledging the value of hands-on creative and design processes, the success-oriented nature of the curriculum, and the social implications of technology; perhaps a reexamination of the true goals of the subject matter should be made. A democratic society would most likely want students who are expressive, not passive; proactive, not reactive; and questioning, not accepting. To achieve these goals in the context of the broad influence of technology, then perhaps many instructional approaches and content areas can be used. Included may be topics of problem identification, environmentalism, social responsibility, ethics, gender equity, futurism, consumerism, and artisanship. It may be that both industrial arts and technology education have an obligation to prepare students in these important personal and social skills.

Conclusion

For industrial arts educators, their profession has not been a waste of time and resources in education. Industrial arts has maintained a position in schools and demonstrated its value despite claims that technology education is the only legitimate way for students to understand their technological society and themselves. For technology education to claim this exclusivity, is to deny industrial arts its historical significance, current implementation and future potential.

Rationalizing the need to implement technology education based on perceived evolutionary superiority or capitalistic requirements may not be convincing to others in the broader educational arena; given the problem of being non-discipline specific, continued definitional uncertainties within and outside the profession, and lack of acceptance by current practitioners who exhibit a different philosophical and professional orientation. This is not to suggest that those practicing industrial arts are immune from challenges, for negative public and professional perceptions are difficult to change. What will most likely will be required by industrial arts teachers is to proactively reestablish and convey to the public and educational profession a greater awareness, understanding and appreciation of the subject's continued significance.

Discussion between industrial arts and technology education teachers should no doubt continue in areas of instructional strategies, program definition, equipment, activities, and philosophy; for these topics are healthy for any profession. However, this discussion must include educators that represent both ends of the spectrum. Both industrial arts and technology education face similar problems relating to public perception, program legitimacy, stereotyping, and tracking of students. Greater strength may exist in seeking common ground, not continuing policies of exclusion and fragmentation.

It is hoped this examination of industrial arts reaffirms the continued strength, relevance and value of the subject. More importantly, it is also hoped the material presented serves as a catalyst for future dialog, understanding and acceptance by all educators, including technology educators. For educators to relegate industrial arts to the shadows of educational worth and reality, neglects its current status and future potential to contribute to the unique educational experience of students.\

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The Technical Content of Industrial/Technology Teacher Education

George E. Rogers

What technical competencies will the next generation of industrial/technology education teachers possess? At first, this may seem like a simple question. However because of national educational reform movements, colleges and universities which prepare industrial/technology education teachers have changed their teacher education degree requirements and curricula (Volk, 1993). Have these changes created more unified industrial/technology teacher education programs or has the field's teacher preparation become more fragmented? According to Diez (1995), the later is true. He indicated the spectrum of teacher preparation models range from traditional to innovative, both extremes.

Bottrill (1991, p. 6) noted, with regard to industrial/technology teacher education, that: “unfortunately, educationalists have been bound up with education theory and have not kept pace with curriculum development in the field. The impetus has come from educational agencies.” Have these educational change agencies taken into account all the aspects of industrial/technology teacher education?

The term industrial/technology education is utilized throughout this study based on the findings of Zuga's (1991) research. Her survey results indicated that 34% of the field's teacher education programs were entitled technology education, while 62% contained the descriptor “industrial” in the program title. Therefore, the title industrial/technology teacher education is used in this study.

The competencies needed by industrial/technology education teachers have been categorized into three areas by W. R. Miller (1990). Miller identified those competencies as personal, professional, and technical. Curricula in some industrial/technology teacher education programs have been configured similarly. Henak (1991) classified the three program elements of industrial/technology teacher education as general education, professional education, and technical content. Finch, Schmidt, Oliver, and Yu (1991) termed these divisions as general studies, professional education, and technical content.

The general education component, which in many cases is dictated by college and university graduation requirements, has been and continues to be discussed by all of teacher education (Diez, 1995; Grant, 1995). Numerous authors and agencies have indicated their vision of both the general education

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component and a model professional preparation sequence for teacher education programs (Goodlad, 1995; C. D. Miller, 1991; Johnson, Erekson, Dugger, and Blankenbaker, 1990; Holmes Group, 1986).

The professional preparation element of industrial/technology teacher education was examined by Zuga (1991) and Finch et al. (1991). Finch et al., determined that industrial/technology teacher education programs required a mean of 27.5 credit hours for professional education coursework. Of these hours, 9.6 hours were methods courses, 9.9 hours were included in student teaching, with 9.2 hours indicated as other professional education courses.

Zuga (1991) examined only curriculum related courses required in industrial/technology teacher education programs. She noted that 56% of the programs required only one course in curriculum development, while 31% offered two curriculum courses. Her research also indicated that 44% of the professional courses were not offered exclusively to industrial/technology education majors, but were taught to a combination of vocational education students including agriculture education, trade and industrial education, family and consumer science, business education, and marketing education.

Technical Content

Technical content of industrial/technology teacher education has been examined by Henak (1991), C. D. Miller (1991), Finch et al. (1991), Polette (1991), Lewis (1992), and Lewis (1993). Of these authors, only Finch et al., provided information on actual coursework required. The technical coursework was grouped in a single category, thus no differentiation was made concerning the types of technical courses required. Finch et al., surveyed 54 industrial/ technology teacher education programs as to the number of credit hours required in their teacher education programs. The results noted a mean technical course requirement of 50.5 credit hours per program.

Henak (1991) described a visionary profile of the technical content that should be included in teacher preparation. He noted that “the thrust of the content and activities [of the technical component] is on helping students understand impacts, processes, and outputs of present-day technical subsystems used in contemporary industry” (p. 11). Henak identified a 48 credit-hour technical component for industrial/technology education teachers. He grouped these technical competencies into biotechnology, communication, construction, manufacturing, and transportation.

C. D. Miller (1991) conducted a survey of leaders in the field of industrial/ technology teacher education to assess their opinions on both an ideal mixture of teacher preparation courses and a practical mixture of courses. His results indicated that leaders felt an ideal program's technical component should contain 45.6 credit hours, while a practical technical credit requirement was felt to be 42.7 hours. However, no course delineation of the type of technical course content was envisioned by these leaders.

Polette (1991), when discussing how to compose a curriculum plan, noted that traditionally the technical content of industrial/technology teacher education was composed of woodworking, metalworking, electricity/electronics, automotive mechanics, graphics, and mechanical drafting. He concluded that although contemporary program content should include these technical skills, the contemporary focus should shift to include knowledge and skills used in communications, construction, manufacturing, and transportation.

Lewis (1992) surveyed industrial teacher educators to assess what they deemed as relevant content of technology education subject matter. His research noted content in terms of innovative, such as construction, manufacturing, communications, transportation, and power/energy, and traditional, like metalworking, woodworking, and plastics.

Lewis (1992) also noted that the location in which the technical courses were taught has a statistically significant impact on the course's content. Technical courses taught outside of a college of education included social, political, moral, and economical aspects of technology and included less technical skill development than the courses taught in a college of education. Thus, the location of the industrial/technology teacher education program must be considered an important demographic statistic. Finch et al., concluded that in 1991, 64.2% of industrial/technology teacher education technical courses were taught outside of a college of education.

Additionally Lewis (1993) concluded that, industrial/technology teacher education has been concerned with the increase of liberal studies into the teacher education curricula, thus squeezing out technical skill development. Lewis (1994) went on to state:

> I believe we have to rethink especially the technical content aspect of technology teacher education programs. Curriculum research in industry could help here. We need teachers who are technically competent to supervise the construction of a workable solar vehicle in their high school laboratories. ... What this means is that pre-service technology teachers need depth, not breadth, of exposure to the major processes of industry. (p. 53)

Teacher education reform along with changes in industry require that the technical competencies currently being taught in industrial/technology teacher education programs be identified. As indicated there is a lack of relevant data on the current technical content required by the nation's industrial/technology teacher education programs. This study was a survey of the technical content of industrial/technology teacher education program in the United States, thus indicating what technical skills the next generation of teachers are being taught.

Purpose

The purpose of this study was to determine what courses comprise the technical component of industrial/technology teacher education programs currently being offered by the nation's colleges and universities.

Research Questions

More specifically, the research questions examined by this study were:

1. What courses comprise the technical content of industrial/technology teacher education programs across the United States?

2. Is there a difference between the technical content required by teacher education programs in the United States with different program titles: technology education, industrial technology education, and industrial education?

3. Is there a difference between the technical content required by industrial/technology teacher education programs in the United States with regard to their location within or outside a college of education?

Methodology

Population and Sample

The population and sample for this research consisted of the 133 institutions located in the United States listed in the *Industrial Teacher Education Directory* (Dennis, 1994) which offered undergraduate degrees in industrial technology education, technology education, industrial education, or industrial arts education.

A cover letter requesting the institution's program of study and a data gathering sheet were mailed to these 133 colleges and universities. Seventy-eight responses were received from 33 states. Of those institutions responding, four had closed their industrial/technology teacher education programs and 17 of the returned data sheets did not include a program of study. Those 21 colleges and universities were not utilized. Thus, the sample consisted of the 57 responding colleges and universities which offered an undergraduate teacher education program in technology education, industrial technology education, industrial arts education, or industrial education.

Data Analysis

Each university's program of study and response sheet was examined to identify: 1) the title of the program 2) the location of the teacher education program, that is college of education, college of engineering, college of technology, and so forth 3) the titles of the required technical courses, and 4) the total number of required technical credit hours.

Thirty-three of the programs (57.9%) were titled technology education, while 24 programs (42.1%) contained the descriptor industrial in their program title. This indicated a shift from the findings of Zuga (1991). Twelve programs (21.1%) were housed in a college of education, with 45 programs (78.9%) being housed outside a college of education.

The mean number of technical credit hours required was 49.8, with a median of 48 credit hours. The range of required technical credit hours was from 91 to 30 credit hours. Three programs (5.3%) did not have a prescribed technical component in their program of study. These institutions develop a technical program of study for each industrial/technology teacher education major as needed.

Findings

The technical courses required by the responding industrial/technology teacher education programs are displayed in Table 1. Not one common technical course was required by every responding college or university. The most commonly required technical course was electricity/electronics, which was required by 75.4% (*n* = 43) of the institutions. Mechanical drafting was the second most required technical course identified (66.7%, *n* = 38).

Table 1
Required Technical Courses

Technical Course	*n*	%
Electricity Drafting	43	75.4
Mechanical Drafting	38	66.7
Manufacturing	36	63.2
Graphics/Desktop Publishing	32	56.1
Construction	28	49.1
Woodworking	25	43.9
Computer-Aided Drafting	23	40.4
Power and Energy	19	33.3
Materials and Processes	18	31.6
Industrial Safety	13	22.8
Lab Management/Planning	13	22.8
Metalworking	12	21.1
Machine Tool Technology	11	19.3
Communications	11	19.3
Transportation	10	17.5
Automotive Mechanics	9	15.8
Introduction to Industrial/Tech	9	15.8
Welding	8	14.0
Plastics/Composites	6	10.5
Industrial Design	4	7.0
Hydraulics/Pneumatics	3	5.3
Robotics	2	3.5
Biotechnology	2	3.5

N=57

The technical courses suggested by Polette (1991) and Henak (1991), manufacturing and construction, were required by 63.2% and 49.1% of the teacher education programs respectively. Courses in graphics or desktop publishing were required in 56.1% (*n* = 32) of the programs. Woodworking courses were required by 43.9% (*n* = 25) of the colleges and universities. Computer-aided drafting was required by 40.4% (*n* = 23) of the programs.

Hydraulics/pneumatics, biotechnology, and robotics were listed at the bottom of the required technical courses. A course in hydraulics/pneumatics was required by only 5.3% (*n* = 3) institutions, while biotechnology and robotics were included in only 3.5% (*n* = 2) industrial/technology teacher education programs.

Table 2 shows an examination of the industrial/technology teacher education programs by their title; technology education, industrial technology education, or industrial (studies, arts) education. The most frequently required technical course, when the respondents were divided by program title, was electricity/electronics in industrial technology education programs (92.9%, *n* = 13). The chi-square test for independence was utilized to test the relationship between technical course usage with regard to program title (Gravetter and Wallnau, 1996).

Table 2
Required Technical Courses By Program Title

Technical Course	TE		ITE		Industrial	
	n	*%*	*n*	*%*	*n*	*%*
Electricity/Electronics	24	72.7	13	92.9	6	60.0
Mechanical Drafting	20	60.6	10	71.4	8	80.0
Manufacturing	23	69.7	10	71.4	3	30.0
Graphics/Desktop Publishing	18	54.5	8	57.1	6	60.0
Construction	20	60.6	5	35.7	3	30.0
Woodworking	11	33.3	7	50.0	7	70.0
Computer-Aided Drafting	12	36.4	6	42.9	5	50.0
Power and Energy	11	33.3	6	42.9	2	20.0
Materials and Processes	11	33.3	7	50.0	0	00.0*
Industrial Safety	4	12.1	5	35.7	4	40.0
Lab Management/Planning	5	15.2	4	28.6	4	40.0
Metalworking	7	21.2	3	21.4	2	20.0
Machine Tool Technology	4	12.1	4	28.6	3	30.0
Communications	11	33.3	0	00.0	0	00.0*
Transportation	9	27.3	1	7.1	0	00.0
Automotive Mechanics	4	12.1	2	14.3	3	30.0
Introduction to Industrial/Tech	4	12.1	4	28.6	1	10.0
Welding	2	6.1	4	28.6	2	20.0
Plastics/Composites	1	3.0	1	7.1	4	40.0*
Industrial Design	2	6.1	1	7.1	1	10.0
Hydraulics/Pneumatics	0	00.0	0	00.0	3	30.0*
Robotics	1	3.0	1	7.1	0	00.0
Biotechnology	2	6.1	0	00.0	0	00.0
	33		14		10	

*p<.05

Four comparisons tested significant at the $p < .05$ level. A communications course was required by 33.3% (*n* = 11) of the technology education programs, while no industrial technology education or industrial education program required this technical course. This preference of a communications course by technology education programs tested significant via the chi-square treatment, X (df = 2, *n* = 57) = 9.913.

A course in plastics or composites was required by 40.0% of the industrial education programs, while only 3.0% of the technology education programs and 7.1% of the industrial technology education programs required this technical class. Analysis indicated a significant difference between programs with regard to a plastics/composite course, X (df = 2, *n* = 57) = 11.363. Hydraulics/pneumatics courses were preferred by industrial education programs which the chi-square treatment indicated significant X (df = 2, *n* = 57) = 10.592. Materials and processes courses were statistically more likely to be required by industrial technology teacher education programs (50.0%) and technology education programs (33.3%) than industrial education programs (0.0%), X (df = 2, *n* = 57) = 6.861.

Table 3 presents the industrial/technology teacher education programs with relationship to their housing within or outside of a college of education. Power and energy was required by 40.0% of programs outside of a college of education, while only required by 8.3% of programs in a college of education. A technical course in transportation was not required in any college of education program, while transportation was a part of 22.2% of non-college of education programs. However, utilizing the chi-square analysis, no comparison tested significant at the $p < .05$ level.

Conclusions

The results of this study indicated that industrial/technology teacher education programs in the United States required a mean of 49.8 semester hours of technical courses. The data analysis noted only two courses were required by more than two-thirds of the nation's colleges or universities. There appeared not to be a core of technical courses required for an undergraduate teaching degree in industrial/technology education.

Data indicated some difference between teacher education programs relevant to their program title, which should be expected. Four technical course comparisons tested significant via the chi-square treatment at the $p < .05$ level. Research question two, is there a difference between the technical content required by teacher education programs in the United States with different titles; technology education, industrial technology education, and industrial education, would receive a positive response for the courses of communications, plastics/composites, hydraulics/pneumatics, and materials and processes.

This study's results further indicated that the industrial/technology teacher education curricula did not reflect current curriculum trends as indicated by Lewis (1992), Polette (1991), and Henak (1991). The requirement of woodworking, mechanical drafting, and graphics was not significantly different between technology education programs and industrial education programs. Likewise, there was no significant difference between the inclusion of hydraulics/pneumatics, robotics, and plastics/composites between industrial

Table 3
Required Technical Courses Relative to a College of Education

Technical Course	COE	Non-COE

	n	%	*n*	%
Electricity/Electronics	7	58.3	36	80.0
Mechanical Drafting	6	50.0	321	71.1
Manufacturing	6	50.0	30	66.7
Graphics/Desktop Publishing	5	41.7	27	60.0
Construction	7	58.3	21	46.7
Woodworking	3	25.0	22	48.9
Computer-Aided Drafting	5	41.7	18	40.0
Power and Energy	1	8.3	18	40.0
Materials and Processes	2	16.7	16	35.6
Industrial Safety	2	16.7	11	24.4
Lab Management/Planning	3	25.0	12	26.7
Metalworking	3	25.0	9	20.0
Machine Tool Technology	2	16.7	9	20.0
Communications	2	16.7	9	20.0
Transportation	0	00.0	10	22.2
Automotive Mechanics	3	25.0	6	13.3
Introduction to Industrial/Tech	2	16.7	7	15.6
Welding	2	16.7	6	13.3
Plastics/Composites	1	8.3	5	11.1
Industrial Design	0	00.0	2	4.4
Hydraulics/Pneumatics	1	8.3	2	4.4
Robotics	0	00.0	2	4.4
Biotechnology	1	8.3	1	2.2
	n=12		*n*=45	

education programs and those titled technology education. Additionally graphics, a course noted by secondary industrial education teachers as not relevant in today's curriculum (Rogers, 1995), was required in 56.1% (n = 32) of the programs.

In addressing research question three, a chi-square statistical treatment of the data displayed on Table 3 indicated no significant difference between the required technical courses of programs housed within and outside a college of education.

The findings of this study indicated that the field of industrial/technology teacher education lacks consistency in what technical courses are required. This lack of consistency could have a detrimental impact on the field, as graduates from its teacher education programs do not possess a common base of technical competencies. Graduates, practicing teachers, and administrators will be left asking what technical competencies do industrial/technology education teachers need to be successful?

Recommendations

Industrial/technology teacher education must establish national teacher education standards addressing the discipline's technical content. Documents, such as *Elements and Structure For a Model Undergraduate Technology Teacher Education Program* (Henak, 1991), have not been utilized by the teacher education field. The root of this lack of implementation may stem from the non-acceptance of technology education by industrial education teachers (Rogers and Mahler, 1994).

Demographic data also indicated a greater percentage of programs (78.9%) were housed outside of a college of education than noted by Finch et al., in 1991 (64.2%). Inferring from Volk's (1993) analysis, with only 21.1% of the industrial/technology teacher education programs housed in a college of education, the loss of more industrial/technology teacher education programs across the United States is a strong possibility.

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Formative Influences on Technology Education: The Search for An Effective Compromise in Curriculum Innovation

George Shield

Successful curriculum development in our schools and colleges relies on compromise and interplay from a number of interested parties, some of whom are competing for recognition and resources. The interests which these factions represent vary and are not immediately apparent. While to some, the basis of curricular innovation lies soundly in the philosophical ideals of the educator whose sole concern is the successful development of the full potential of the child, to others the curriculum is perceived as having more instrumental aims which include the interests of the state and society at large.

In addition to philosophical foundations, most innovators have to bear in mind the political and economic interests of stakeholders in technology education (e.g., school governors, national governments, industrialists and parents) as well as the classroom practicalities that result from the teaching/learning strategies available. Unfortunately, while these constraints are understood by curriculum planners, they are frequently ignored and the evolution of the curriculum is still a haphazard affair which does not necessarily occur in a logically, ordered, and planned fashion.

The Technology Education Curriculum in the United Kingdom is a prime example of how the evolution of a subject has been distorted both by a philosophy which was allowed to assume credibility without an empirical verification of its practicality and also political imperatives which led to changes being implemented without sufficient preparation (Eggleston, 1991). Fortunately, and in some ways undeservedly, the results of such hegemony have been to some degree ameliorated by the professional practice of teachers. The strategies utilized by these practitioners are frequently implemented unconsciously and rely on craft skills which have been handed down through generations of teachers as well as being developed as part of their stock in trade through experience of "what is possible" within the constraints of life at the "chalk face." The current curriculum (DFE, 1995) is a praiseworthy attempt to rectify errors which would never have occurred if the basic tenets of a "process" model had been used by the curriculum developers during the planning stage of the innovation.

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The imperatives of political philosophy and expediency frequently influence the formation of educational policy. The philosophy of the political right wing for example may expect the concept of entrepreneurship to pervade the technology curriculum and a Marxist philosophy may seek to encourage learning through practical endeavor as fundamental for the development of an educated citizen (McCormick, 1993). The acts of politicians may also however, be a reflection of the concerns of their constituents (e.g., industrialists and parents), their concern over the needs of their country (e.g., the needs of the economy) or the even less altruistic considerations of the ballot box (technology is currently seen to be a “good thing”). It must be recognized that these concerns are legitimate in that politicians are said to be representative of their electorate and that not to represent these views could be deemed a dereliction of their duty. The primacy of the dominant position however may not be coincidental with the best interests of the child or even that of “technology” itself.

Beyond these political concerns at the macro level, there are also the political considerations evident within the institutions and professional organizations which are the providers of technology education at first hand (Ball, 1987). Within England and Wales, the technology curriculum has been inherited, in the main, by teachers who have previously been instrumental in delivering, Craft, Design and Technology, Art, Home Economics, and Business Education; all traditional subjects which bring with them an established background of knowledge, custom and practice. While these subjects may have similarities, they also have considerable differences in philosophy and working practices. If it is further understood that the subject of Craft, Design and Technology has itself emerged, within recent memory, from the traditional handicraft areas of woodwork and metalwork, it can be seen that the potential for conflict within the politics of an institution is great and will be ignored only by the foolhardy.

For whatever the reason or combination of reasons the government of the United Kingdom has, over the last decade or so, produced a range of innovations (Layton, 1995) which have been directly concerned with technology education and which, within established philosophy and historical precedent have proved to be controversial. With the implementation in 1990 of the National Curriculum (Department for Education, 1995) the government took from the hands of the teaching profession responsibility for the content of the school curriculum. This act resulted in the introduction of technology as a compulsory component of the education of all children within the state system.

This development has been surrounded by other curriculum initiatives such as the Technical and Vocational Education Initiative, in which the government of the UK attempted to influence the curriculum of mainly 14 to 16 year old children. They accomplished this in several ways. First, through the provision of enhanced resources attained through success in competition between schools and Local Education Authorities. Second, by the establishment of City Technology Colleges, which are independent schools funded mainly by central government but also through commercial and industrial interests. And finally through independent educational initiatives such as “Learning Pays” by The Royal Society of Arts (Ball, 1991) and The National Commission on Education (NCE, 1993). All of these innovations have been made, at least in part, to enhance the competitive position of British industry in the world economy.

This desire to increase the competitiveness of the nation has influenced not only the curriculum, in that technology is now a compulsory and major component, but also the form the subject should take. The requirement that schools—and to a much greater extent universities—should provide innovative people to fuel the wealth generation of organizations and indeed states have had influence upon both the content and teaching methodologies employed. This necessity is said to require the production of a workforce which is adaptable and which has competence in a number of generalized problem solving skills which may be transferable to meet new and ever more problematic situations. This has been interpreted as reflecting the "process view" of technology. Technology, however, is a very complex subject and the process definition reflects only a partial understanding (Custer, 1995).

In defining technology, and then technology within the school curriculum, it must be borne in mind that perceptions are colored by a number of factors such as culture, occupation, geographic location and education. While to some, technology is an object or artifact, to many it is an activity which is defined substantially by human intervention. The complexity of this intervention and consequently its "concept web" is dictated by the activity undertaken. The development of a space vehicle will call upon the employment of a different and probably wider range of skills and knowledge than say the plowing of a field with an ox. Both will require skill, understanding, and organization but these will be different even though they may be equally important to the participants. Both will also impact upon the environment and consequently society.

Technology is therefore about knowledge, both scientific and also that perhaps best described as experiential, about understanding and also about *doing.* Technology, however, perhaps is most easily categorized as being concerned with implementing ideas. This understanding suggests that while it is possible to recognize how something functions and therefore have a technological comprehension, it is necessary to implement a solution to a problem before a claim can be made for technological capability. The capability, therefore, requires further attributes which may be described as problem solving skills to give life to this comprehension. Knowledge does not, however, stay still. It is constantly changing (some may become redundant) and expanding, as are the demands made upon technologists to meet new challenges.

This perception that technology is a dynamic subject with a body of knowledge that is constantly changing is important to our concept. As the value of redundant knowledge is limited, the content of any course in technology education should not solely be a collection of facts which are likely to be superseded but must include problem solving strategies aimed at bringing about change.

In addition to this instrumental view of technology and its value for the economic well being of society, there is the further supporting philosophy which suggests that the major aim of education should be to enable children to "make sense" of the world around them. The only way they can do this is through implementing strategies which allow them to discriminate between what is of value and that which is spurious. Here the all pervading role of technology in the modern world provides a self-fulfilling imperative in that all citizens of a modern state should know about and understand the role of technology to allow them to function effectively in societies which are technologically driven. If this knowledge is refined so that it becomes process driven, that is technology is about strategies and approaches which will allow the individual to cope with change, so much the better (Toffler, 1970).

Another commonly used argument in support of this designing and making approach, lies in the theory that children learn best through *doing*. Therefore through involving children in practical project work they enhance their technological understanding by applying theoretical principles to “real life” situations. This philosophical ideal has considerable theoretical justification and active learning approaches are an accepted part of the educational scene in England and Wales.

This range of justifications is represented in Figure 1, which shows that these perceptions are in effect extremes of continuums, the opposing ends of which have advocates who are often vociferous in giving voice to equally extreme views.

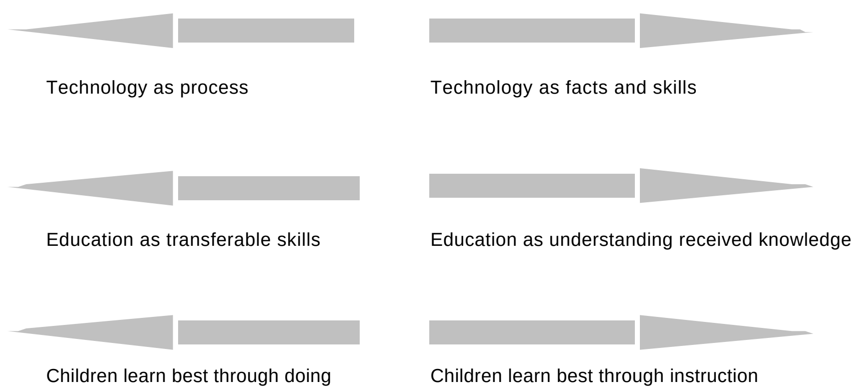

Figure 1. Technology education through a process approach.

These extremist viewpoints can be perceived by the uninformed as having a degree of credibility which is unjustified particularly when examined within the context of the day-to-day life of the average teacher. As in most scenarios, the reality of the situation is one of compromise. This compromise, however, must be made in the light of information gained through a careful examination of as wide a debate as possible rather than the view that is expressed from the loudest bandwagon.

The Practice

While all of the arguments noted above are difficult to refute, both in their appeal to logical thought and also as a reflection of what many would say is good practice, I think it is fair to say that the implementation of national curriculum for technology in our schools has not been as successful as many would wish (Smithers and Robinson, 1992; Department of Education and Science, 1992). But it is also proper to record that some of the deficiencies have been recognized and improvements have been made in recent years (Office for Standards in Education, 1995).

As could be expected, the reasons for this lack of success are many and they vary with their source. From some commentators, the reasons lie in the lack of understanding and expertise or commitment within the teaching force, while from teachers it is frequently the lack of resources which is the main problem. While no doubt there may be more than a smattering of truth in both of these viewpoints, there are more basic and fundamental reasons for the lack of success in implementing a subject which was seen to be exciting and innovative at its conception but more challenging in its implementation.

There was an initial underestimation of the complexity of what was being required of teachers who either by their initial education or philosophical inheritance, found the process model difficult to internalize. This, coupled with what can only be described kindly as complicated and impracticable advice from the innovators, led not only to alienation, but also in some cases to a feeling of guilt from teachers who felt they were failing in the task of implementing "good practice."

This may be illustrated in the confusion which lies between the teaching and learning methodologies they adopt and their attempts at enhancing the children's understanding of technological process. A prime case could be of evaluation when often children (and their teachers) confuse the task of evaluating a technological outcome, (artifact, process, system etc.) with their performance as a designer. While an element of self-appraisal on the part of the child is valuable to guide their own learning, there often appears to be no delineation between the two aspects of their work or clarification of the sub process as a part of technology. This stems from a fundamental shortfall in the teacher's understanding of the philosophy of their subject and consequently a confusion in setting objectives which are achievable.

The most fundamental error which has been made is the translation of a model or algorithm for technology (or design) into a teaching and learning strategy (Norman and Roberts, 1992) for a curriculum subject. While such models may (or may not) describe what technology is, it does not follow that for children to learn and understand such an interpretation requires them to slavishly follow such an approach in the activities which they carry out. In other words it is essential to learn what is meant by, and how to carry out tasks such as technological analysis, as well as doing the analysis as part of a process. If such skills as analysis, synthesis and evaluation are to be developed as the prime function of the learning experience, we must understand how to promote these within the classroom, and this task may be carried out with a technological focus. It seems to me axiomatic that to evaluate a technological product, children must be aware of both techniques and skills to carry out this evaluation as well as having an understanding of technology to use as a yardstick. Neither aspect on its own is sufficient.

Unfortunately it appears that research is at a comparatively early stage in determining both what a process view of technology means to a teacher (as opposed to say a designer or professional technologist) and consequently how this meaning may be translated into professional practice.

Problems also become evident in evaluating the learning activities and planning programs. The evaluation of process learning is difficult (Kimbell et al., 1991). In the pragmatic eyes of the teacher the product of the exercise becomes the file or notebook or portfolio of evidence which may complement the outcome of the technological assignment or task. The objective of the teacher very quickly becomes the production of well presented evidence as opposed to the enhancement of the understanding of the process by their charges.

A further misconception lies in the problems which occur in the management of problem solving within the technology classroom and the school. Perhaps the most exciting and certainly the most demanding feature of a content-free approach lies in the extremes to which its most enthusiastic supporters go to meet their ideals. The ideal becomes the situation whereby children can operate as autonomous individuals in the selection of the task and then bringing it to its successful fruition through the utilization of appropriate resources and the application of acquired skills. This strategy is meant not only to develop problem solving skills but also to equip the child with the psychomotor skills and technical knowledge necessary for further development.

This ideal situation, however, can easily result in difficulties in managing the classroom. If freedom is offered to a group of children to identify a problem (or discover an opportunity for improvement) which can be overcome by designing and making an artifact, within say the context of the school or the home without establishing parameters for either the area of expertise to be employed or resources available (materials to be worked, components used, equipment available) it would appear obvious that the demands made on the teacher would be excessive and consequently that the opportunities for learning could be limited.

In other words a restraining factor must be applied so that the experience can be structured and the child can obtain the greatest benefit from the time available. Even if this management is restricted, a balance has to be reached between freedom of choice and meaningless tasks which are contrived to produce established or pre-ordained solutions.

The complexities of this task at the classroom level are mirrored to some extent by the organization of technology within schools. To facilitate manageable units teachers are grouped, with varying degrees of success, to provide the most viable range of expertise and physical resource needed to facilitate the disparate range of problem based learning experiences which can evolve. These groupings in practice can be quite arbitrary and frequently reflect the managerial problems of the school rather than focus upon a coherent philosophy of technology education. The dissonance which is almost certainly produced by organizational change (Ball, 1987) is often counter-productive in establishing the coherent philosophy demanded by a subject which is dependent upon a range of disparate disciplines.

In addition to the philosophical and management dimensions of curriculum change pedagogical theories must also be considered. While there are times when behaviorist or instrumental theories of learning can be seen to have relevance, particularly in the acquisition of low level facts or knowledge, the complexity of what is required of the learner within current philosophies of technology education apparently demands more than the simple transfer of knowledge by didactic exchange or rote learning. It is due to this recognition that the importance of cognitively contextualizing the concepts to be acquired, becomes significant. This categorizing of new learning within established constructs is not only carried out by the learner as he or she makes sense of the new concept, that is how can it be “catalogued” in terms of previous knowledge or understanding, but is also part of the portfolio of the effective teacher. The need is there for the teacher to identify for the student, or at least refine their understanding, of the most appropriate perceptual cues they are receiving, so that they can develop an increasingly meaningful understanding of the concept with which they are involved.

In other words there is the need for a structured approach to teaching the process so that learning can be effective. Teachers should direct students so that they can draw appropriate conclusions and motivation from the tasks rather than to simply give them the solutions. This higher order learning is the product of negotiation, an initiation into a socially constructed network of beliefs and opinions. It is much more than the transmission of knowledge.

Conceptual understanding is formed through a person's experiences of reality (Stones, 1966) and as this reality is constructed partially through social interaction the increased opportunity for tailor-made learning is valuable. Summers and Kruger (1992) describe how the concept of energy can vary between a chemist, physicist and a biologist, not because these concepts are incorrect but because the emphasis placed on different aspects will vary with the context.

The value of socio-cultural theories of psychological development, particularly scaffolding, are of interest to technology educators, especially the importance of social interaction and the social context (Gredler, 1992; Kincheloe and Steinberg, 1993). The principle of proximal development (Tharp and Gallimore, 1988) has similarities in apprenticeship training, well known in the traditional fields of technology and craft training. In the practice of process methodology in which the teacher works closely with the child in the development of his or her ideas there are echoes of this apprenticeship model. With the timing, quality and quantity of the teacher interaction varying according to the needs of the pupils the “scaffolding” of the learning experience varies to suit the needs of the children at that stage of their development (Tharp and Gallimore, 1988).

Teaching however is also about spontaneous actions based not only on knowledge but also on miscellaneous experiences from a variety of practical sources. The teacher's skill lies not merely in the application of theories but in adapting these understandings to the environment (in its broadest sense) in which they are practicing (Hamilton, 1982; Stenhouse, 1980).

It is a lack of this understanding in implementing curriculum reform which creates doubts about the effectiveness of process methodology not only within the profession but also within society at large. The process driven approach within technology education is one example of where the implementation of fundamentalist ideals without the pragmatic considerations of the practitioner has caused anxiety.

If taken to extremes, the advantages to be gained for children working by themselves engaged in problem solving are not only negated but may result in alienation, if the teacher cannot devote the time necessary to engage the learner in critical discourse. In a group of say twenty children working with one teacher, there is barely two minutes per child (after administrative and organizational tasks are removed) in each hour for personal and meaningful interactions to take place, and in practice most of these interactions are of a low order. From my own observations, an interaction rate—that is different contacts between teacher and child of over 60 per hour is not unusual.

To compensate for this lack of quality time, it appears that what happens is that the teacher often “feeds” the children with established solutions to their problems thus in practice teaching in a traditional didactic fashion. This is not only apparently a contradiction in methodological terms but also an unnecessary waste of the time of the teacher, in repeating the same instructions and advice a number of times, to each individual but also for the children who are waiting for advice.

The subconscious application of a collection of principles and practices which have been successful in the past in meeting novel situations may be part of the technology teacher's stock-in-trade. The use of such strategies would normally mitigate against the introduction of new teaching approaches, particularly when the approaches are ill defined and not sufficiently articulated (Eraut, 1994), conversely they may be the means of salvaging some degree of success.

The teachers may in fact be employing strategies to develop the skill base and subject knowledge of their students through a traditional understanding and in employing this tactic they are applying the findings of Glaser (1993) whose work suggested that in both experts and novices alike, problem solving difficulties can be attributed to inadequacies in their knowledge base.

Technology teachers, particularly those in the UK, have backgrounds in subjects which have been historically based in crafts which have been defined over centuries. Often their view of their subject and frequently their own education has been strongly influenced in ways which are different to that of their “academic” colleagues. This difference is often exhibited through pride in their practicality, that is through not being “merely talkers,” and through a self confidence in their own skill in their craft. Their professional knowledge and skill as teachers has therefore a different root, it has emerged from the experience of having to produce a good product in order to make a living. And while a logical and methodical approach to their work is essential for success, so is knowledge and skill. Such considerations are so ingrained in this professional understanding that to disregard them is not only casting considerable doubt on the integrity of many conscientious practitioners (Rudduck, 1988), but also not even examining the evidence of a methodology which has served us well in the past. This is not however a cry from the heart of a backwoodsman who wants a return to the "good old days," but a statement of the obvious, which one suspects, is often deliberately overlooked.

We need, therefore, to ensure that a core of knowledge is not only made explicit but also taught in a structured manner. This approach coupled with the views expressed earlier that process should also be taught incrementally, is essential if "school technology" is to be given the credibility it deserves.

Further developments which indicate that change in this way is necessary, includes the work by Barlex et al. (1994), which advocates the need for both resource tasks and capability tasks in a program of technology. This approach is similar to the focused tasks and activities of the new National Curriculum (DFE, 1995), an approach which appears to draw heavily on the work of Black and Harrison (1990). These developments are recognizing, in implication if not in direct statement, the need for structured inputs of skills and knowledge and not merely the acquisition of random information on a need-to-know basis.

Conclusion

In conclusion it would appear that there are significant dangers in attempting to implement complex curriculum change through central direction without a considerable degree of planning and preparation. While this may appear to be self-evident, it is unfortunate that a top down strategy of implementation is more often the norm—certainly within the UK—than a more rational and dare it be said problem solving approach which includes the training and participation of the practitioners.

I am sure that the principle of a problem solving foundation to technology education is correct. Such a view is however only the first base in realizing its potential. A deeper understanding is required, not necessarily about the content base of technology, (we are not best equipped to be at the forefront in this field, although a sound subject base is essential) but about the professional issues which are our primary concern. It is one thing to teach a group of children about the principles of structures, but quite another to teach about generic strategies required to analyze the aesthetics of a structure or the socio-economic effects it may have on the neighborhood. Technology teachers are well versed in transmitting "making" skills and technical knowledge, but they must also contribute to the development of strategies which lead to the elevation above the more mundane elements of the process strategy—the deeper understandings said increasingly to be at the core of our subject.

The most basic requirement would appear to be some verification that the proposed changes can deliver what is claimed for them not only through a theoretical overview, which bases its projections upon a wish list, essential as this is, but also grounded upon a planned program of empirical research. Furthermore this research must reflect the scene in our average schools and not merely reinforce the practice of enthusiastic experts working in atypical environments. While technology education has, to a certain degree, benefited from claiming to be all things to all people through the influences mentioned earlier, it must learn to divest some of the claims made for it so that expertise and energy may be directed more meaningfully to an achievable goal. Claims are being made that technology education within our schools is instrumental in enhancing problem solving skills, craft skills and knowledge, aesthetic awareness, graphic and wider communication skills, social awareness and team work (including combating racial and gender prejudice), scientific and technical literacy, industrial and economic understanding, environmental activism, “life skills” and vocational training. This litany of virtue smacks of protesting too much, to the extent that it makes one wonder what the rest of the school is doing. Consequently, although it is obvious that aspects of all of these (and many other) educational experiences impinge on what is being learned through technology (in fact most subjects could include a similar list), it is essential that a rationalization takes place, and quickly.

If this rationalization results in a concentration on technological capability through problem solving, attention must be focused on these aspects and the complexity of both understanding a process view of technology education and the evaluation and assessment of its outcomes. Moreover, the implementation of the work must not be understated.

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Book Review

Raizen, S. A., Sellwood, P., Todd, R., and Vickers, M. (1995). ***Technology Education in the Classroom. Understanding the Designed World.*** **San Francisco: Jossy-Bass Publishers. $32.95, 249 pp. (ISBN 0-7879-0178-4)**

Reviewed by Dennis R. Herschbach

Technology Education in the Classroom, is a timely book. Drawing from a large number of examples, the authors discuss technology education's potential contribution to the K-12 curriculum. The sweep of the text is broad, including references to technology education in other countries in addition to numerous program examples in the United States. The reader can see how technology education is used at different levels of schooling; how the subject field can be integrated with the teaching of science, math and design; how activities can be used to enhance and enrich learning; and how interest and motivation can be an instrumental part of a teaching strategy. The authors present ways to structure curricula which are rich in purpose, expansive, alive, and relevant to kids. The text is a good guide to what technology can be.

This is also a useful book. Reference is made throughout the text to how technology education concepts can be applied in the classroom setting, and the text is crammed with program examples. Although grades K-12 are covered, the main emphasis is on K through the middle school grades. There are 30 separate "classroom vignettes" tightly written descriptions of specific classroom activities used to introduce various technological concepts. These range from such diverse topics as "A Solar Hot Water Heater: Using Science in the Technology Classroom," and "Building Model Bridges: A Design and Technology Challenge," to "The 'Best' Jar Opener," an activity intended to engage students in investigating a practical problem, "Little Whizzers," the construction of a simple toy demonstrating physics concepts, "Green Gunge," a study of water treatment, and "Beyond Occupational Specificity and Gender Bias," a discussion of curriculum reorganization to eliminate gender separation.
Each vignette is designed to address a specific student group, and each has a specific instructional purpose. The vignettes are used by the authors to illustrate the instructional ideas presented.

The authors discuss why technology education is important and how it can be used in the school. Attention is given to curriculum design, teaching and learning strategies, and program planning and implementation. Throughout, the discussion is practical and useful.

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Roughly 40 percent of the volume is devoted to five useful appendices. There is something for everyone. For the reader interested in comparative education, the appendix on “Technology Education in Other Countries” provides a snapshot of concepts and practices in the United Kingdom, Germany, Japan, and the Netherlands. For elementary and middle school educators there is information on how to build instruction around a central theme. The appendix on “Technology at Merlyn High” illustrates to secondary teachers how technology education can be linked with science in a core program. The appendix on “University and School Sites” will be especially helpful to teacher educators. And, finally, there is a comprehensive “Resource List” that should be useful to almost anyone interested in pursuing ways to incorporate technology in the classroom.

The book reflects the diverse backgrounds of the authors. Senta Raizen is director of the National Center for Improving Science Education. Not surprisingly, various threads of science education are woven throughout the text. Peter Sellwood is an education consultant to schools, colleges, and industry, and has worked extensively in the United Kingdom. He brings an international perspective to the work, including a focus on science, design, and technology curricula as conceived in Europe. Ronald Todd, a research professor in the Department of Technological Education Studies at Trenton State College, has a background in industrial arts, technology education and mathematics. His most recent work involves design-related curriculum materials integrating mathematics, science, and technology. Margaret Vickers is director of the Center for Learning, Technology and Work, a Division of The NETWORK. She also brings an international perspective to the presentation, in addition to insights from her work on youth and school-to-work policy. The book is very much the product of the combined interests, professional activities and backgrounds of these four individuals. The richness of the presentation reflects the richness of the combined experience of the authors.

To the authors, technology education is best viewed as an integrative concept. Kids build a mousetrap powered vehicle in order to grasp concepts such as motion, force, and kinetic energy; they fabricate kites to study the physics of airfoils; they create designs to experience the use of different materials; they build a model glider to investigate the strength of materials in comparison to weight; and they construct an electrical device in order to see how theoretical knowledge is applied to circuitry.

However, the reader should not expect to find a technocratic approach to the teaching of technology. Technology education is not viewed as skills to learn or a subject to be mastered. Technology education is not confined to a set curriculum. It is fluid, and experiences (activities) are selected in accordance with the developing interest of students and the need to develop a deeper and fuller understanding of knowledge and its use. Technology education is conceived as the means through which students integrate knowledge and experience. In the Deweyan sense, technological activities are the vehicle through which students construct, use, and reconstruct knowledge.

The strength of the book, however, is also its weakness. It is broad-reaching, it tries to relate to a wide audience, and it is full of useful examples.

What is missing is a coherent curriculum framework. The authors recognize the problem. They observe that technology education is itself a newly emerging field of study, and that “there is a level of confusion about what technology education is,” and often a “lack of coherence” in the instructional activities offered under technology education” (p. 3). While the authors set out to “provide a vision of what a coherent K-12 technology education program for America's schools might look like and what it might achieve” (p. 3), they fall short of this ambitious objective. To be sure, there are plenty of good insights and plenty of important questions to ponder. And while there is a strong case presented for the integrative power of activity-based instruction rooted in technology, one is still left wondering if technology education has some kind of defining structure itself. The authors come closest to identifying what they mean by technology education when they suggest it should “comprise a series of carefully constructed multiyear courses or course sequences; each of these would give students direct experience in designing products, structures, and systems to meet individual and social needs” (p. 3). The various abbreviated “curriculum themes” and the suggested course outlines presented are just that, however: abbreviated and suggestive.

Part of the problem is attempting to provide a coherent curricular framework for an activity-based, integrative subject. This type of curricular orientation does not necessarily have a set framework. But if technology education as presented in this book is going to be something more than a way to help teach science, math, and design concepts, it is going to need to have a clearly defined program rationale and a coherent curriculum framework. The authors are close to accomplishing this, but what they offer is simply not developed enough. Technology education has to be more than just a lot of activities.

Nevertheless, this is an important book. It shows what technology education can be in its fullest and richest instructional application. It points to one direction which can be followed by the field and the text is packed with good ideas and useful concepts and examples. Although the book is not complete in itself, it will no doubt help to develop a more complete concept of what technology education can be. For this reason alone it should be given studied consideration.

Postman, N. (1995). *The End of Education: Redefining the Value of School*. Alfred A. Knopf, $22.00 (hardback), 209 pp. (ISBN 0-679-43006-7)

Reviewed by Ellen Rose

I have before me a copy of Neil Postman's *The End of Education*. My original intent was to review this, Postman's most recent publication, in isolation, referring only superficially, if at all, to his many other books. However, I now realize that such an approach would be a disservice to Postman; for if I have learned one thing from my reading of Postman over the years, it is that he values above all continuity and context over the discontinuity and fragmentation which he sees as endemic of our modern technological culture or "Technocracy." Indeed, I believe it would also be a disservice to the reader if I were to limit my comments to this book--not because the book fails to adequately represent Postman's philosophy but precisely because it *does*. *The End of Education* offers a new perspective on ideas and viewpoints set forth in his other books--not just in those which focus on education, such as *Teaching as a Subversive Activity* (co-authored with Charles Weingartner in 1969) and *Teaching as a Conserving Activity* (1979); but also in publications on media (*Amusing Ourselves to Death*, 1985), technology (*Technopoly*, 1992), language (*Crazy Talk, Stupid Talk*, 1976), and social history (*The Disappearance of Childhood*, 1982). In fact, during his thirty years as "an affectionate critic of American prejudices, tastes, and neuroses" (Postman, 1995, p. 62), Postman has written approximately 20 books which, though apparently addressing diverse topics, in fact centre on a core of recurring themes dealing with the intersection of technology, language, and education.

It would therefore be a mistake to classify Postman's *End of Education* as one of his "books about education" as opposed to one of his "books about media and technology." The reader who is intent on such categories will surely be less inclined to perceive the larger picture and to understand the deeply serious social and moral intent of Postman's work. Educator, media theorist, and communications expert he may be; but these specialties are all subsumed in the larger pursuit of "media ecology," the study of information environments as a whole in order "to understand how technologies and techniques of communication control the form, quantity, speed, distribution, and direction of information; and how, in turn, such information configurations or biases affect

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people's perceptions, values, and attitudes" (Postman, 1979, p. 186). The media ecologist argues, for example, that the emergence of the printing press did not simply result in the same fifteenth century society with the addition of a new machine, but rather in a new society entirely, characterized by new values and understandings, new habits and habits of mind. All of Postman's books are, in one way or another, a study of media ecology, of the way in which we are shaped by our own creations.

As a media ecologist, Postman sees the telegraph and photograph as the catalysts of a profound change which would, a century after their invention, create a dangerous imbalance in the information environment. The introduction of telegraphy into typographic culture disrupted its ecology by creating the idea of "context-free information" (Postman, 1992, p. 67) which had no necessary utility or context; and soon after, with the invention of photography, the reason, logic, and continuity characteristic of expository language began to be sublimated to the immediacy and instancy of the visual image:

> As the twentieth century began, the amount of information available through words and pictures grew exponentially. With telegraphy and photography leading the way, a new definition of information came into being. Here was information that rejected the necessity of interconnectedness, proceeded without context, argued for instancy against historical continuity, and offered fascination in place of complexity and coherence. (Postman, 1992, p. 69)

Television has exacerbated this ecological imbalance, "raising the interplay of image and instancy to an exquisite and dangerous perfection" (Postman, 1985, p. 78). Directing not only what we know, but how we know it (Postman calls TV the "First Curriculum"), television packages all information in entertaining, contextless fragments which we receive mindlessly. If we need proof that this is so, Postman offers advertisements, once comprised of words intended to appeal to the understanding of a rational public, which now consist largely of images intended to manipulate their passions; political campaigns, in which a candidate's success now has more to do with his hairstyle than his political beliefs; and news shows, which are designed to entertain more than inform, and which give prominence to highly visual and haptic events. Achieving its zenith in television, the preeminence of visual imagery "has created an ecological problem, and a dangerous one":

> We have a generation being raised in an information environment that, on one hand, stresses visual imagery, discontinuity, immediacy, and alogicality. It is antihistorical, antiscientific, anticonceptual, antirational. On the other hand, the context within which this occurs is a kind of religious or philosophic bias toward the supreme authority of technicalization. What this means is that as we lose confidence and competence in our ability to think and judge, we willingly transfer these functions to machines. Whereas our machinery was once thought of as an 'extension of man,' man now becomes an 'extension of machinery.' (Postman, 1979, p. 100)

Granted, Postman's contention as a media ecologist that "Technological change is not additive; it is ecological" (Postman, 1995, p. 192) is not new. He is the first to acknowledge that a similar conclusion has been drawn over the years by many others, including the likes of Plato, Louis Mumford, Jacques Ellul, Harold Adams Innis, and, of course, Marshall McLuhan. But I might as well clear the air on this score once and for all: while Postman owes much to the ideas of McLuhan, he is equally indebted to those of Edward Sapir, Sigmund Freud, Aldous Huxley, Northrop Frye, Norbert Wiener, Noam Chomsky, John Dewey, Alfred Korzybski, I.A. Richards, and a host of others; and he is certainly much more than a mere McLuhan "wannabe." Where McLuhan is an observer of culture, maintaining an objective stance, Postman is a media ecologist driven by a profound moral imperative to play a role in maintaining--or perhaps more accurately, regaining--social balance. As a media ecologist, Postman rejects McLuhan's deliberately neutral commentary on the emergence of a new global village, and decries instead what he sees to be the demise of American culture, offering where he can solutions and suggestions for halting the erosion of a literate tradition. And, despite his enormous respect for McLuhan's ideas, he also tacitly condemns McLuhan's use of sensational fragments, or "probes," as a method of "getting a hearing" with the public (Postman, 1969, p. 7). Here, perhaps, is the key to the essential difference between the two men: while both understand that "the medium is the message," that form is content, they differ greatly in what they do with that knowledge. McLuhan used his understanding of how media function to tailor his message to media's requirements. Postman on the other hand deliberately resists pressures to reduce his ideas to contextless fragments, offering instead fully articulated, lucid arguments requiring readers to follow a number of carefully presented premises to a logical conclusion. And while Postman is well aware that his methodology and his sometimes curmudgeonly arch-conservatism prevent him from attracting quite so many followers as the "Oracle of the Electronic Age," it is part of his moral imperative as a media ecologist to champion the values of tradition, whether in exposition or education.

For adherence to the traditional values of a typographic culture is the crux of Postman's philosophy. Beginning in particular with *Teaching as a Conserving Activity* and continuing into *The End of Education*, Postman articulates a serious argument that, given the erosion of our culture by technology, the role of the school should not be to maintain pace with change but rather to provide an oasis of tradition and quietude from which to observe the technological frenzy that is modern society: "Without at least a reminiscence of continuity and tradition, without a place to stand from which to observe change, without a counterargument to the overwhelming thesis of change, we can easily be swept away--in fact, are being swept away" (Postman, 1979, p. 21). Postman rejects the frantic efforts of educators who insist that the school must keep pace with social change, and argues that most of the efforts made on that behalf are mere "educational engineering" based on a shallow educational philosophy: that students should be made "job ready." The deliberately ambiguous title of his most recent book surely contains within it an ironic reference to those, like Ivan Illich (*Deschooling Society*, 1970) and Lewis

Perelman (*School's Out,* 1992), who argue against compulsory education on the grounds that the school and traditional book learning have no relevance in today's high-tech, information rich culture. Postman contends that school as we know it is enormously valuable precisely *because* of its lack of relevance:

> As it is mostly conducted even in the present age, school is one of our few remaining information systems firmly organized around preelectronic patterns of communication. School is old times and old biases. For that reason, it is more valuable to us than most people realize, but, in any case, provides a clear contrast to the newer system of perception and thought that television represents. By putting television and school side by side, we can see where we are going and what we are leaving, which is exactly what we need to know. (Postman, 1979, p. 47-48)

For Postman, adherence to tradition, then, is not a Luddite stance. He is well aware that "We gain nothing but chaos by banning or breaking our machines" (Postman, 1979, p. 101). But as a media ecologist, he argues that tradition is of fundamental importance because it provides the means to an objective, balanced perspective which is our only defense against unmitigated technological advancement. Only through critical insight (what Postman called "crap detecting" in *Teaching as a Subversive Activity*), can we hope to understand how new technologies are shaping our lives and thereby control their effects--disastrous effects which could, without careful stewardship, lead to the demise of American culture. If school is to provide students with critical insight into their culture--if it is to counter the "dull and even stupid awareness" (Postman, 1992, p. 20), the sleepwalking attitude, which currently prevails--then it must do so by providing a neutral forum in which "you [are] positioned some distance away from the influences of your own times" rather than being "held captive in the midst of things" (Postman, 1979, p. 185). True "technology education," as Postman would have it taught, is not instruction on basic programming and the like, but rather on how computers, television, and other technologies are changing the way we think and act:

> As I see it, the subject is mainly about how television and movie cameras, Xerox machines, and computers reorder our psychic habits, our social relations, our political ideas, and our moral sensibilities. It is about how the meanings of information and education change as new technologies intrude upon a culture, how the meanings of truth, law, and intelligence differ among oral cultures, writing cultures, printing cultures, electronic cultures. Technology education is not a technical subject. It is a branch of the humanities. (Postman, 1995, p. 191)

Similarly, Postman contends that instruction in language (specifically, semantics, the study of the relationship of language to reality) must play a crucial role in helping students develop the critical insight which is our best defense against the unmitigated development of new technologies. The study of semantics offers a form of meta-education, in which students learn not just about a subject but about the assumptions and metaphors of which its language is comprised: "[Semantics] helps students to reflect on the sense and truth of what they are writing and of what they are asked to read. It teaches them to discover the underlying assumptions of what they are told. It emphasizes the manifold ways in which language can distort reality" (Postman, 1992, p. 195). Rather than being drilled on the use of metaphor in a poem, students should be given the opportunity to learn the real power of language to create reality: "how metaphors control what we say, and to what extent what we say controls what we see" (Postman, 1995, p. 186).

In our modern day "Technopoly," then--this barren technological desert, lacking any underlying moral wellspring--a school based on traditional values not only provides an oasis from which to view new technologies, but it also provides sustenance that the arid Technocracy cannot provide. As Postman sees it, school can only "help conserve that which is both necessary to a humane survival and threatened by a furious and exhausting culture" (Postman, 1979, p. 25) if it offers a vision of something different than that culture. That vision is contained in what he calls a "narrative" or "god."

In *Technopoly*, Postman defines a narrative as "a story of human history that gives meaning to the past, explains the present, and provides guidance for the future. It is a story whose principles help a culture to organize its institutions, to develop ideals, and to find authority for its actions" (Postman, 1992, p. 172). *Technopoly* deals largely with the way in which technology has deprived us of our narratives, our coherent view of the world and its meaning, and therefore of our moral underpinnings. In *The End of Education*, Postman continues the theme, emphasizing the need for narratives in education lest the school lose its meaning and function:

> Here, I will say only that the idea of public education depends absolutely on the existence of shared narratives *and* the exclusion of narratives that lead to alienation and divisiveness. What makes public schools public is not so much that the schools have common goals but that the students have common gods. The reason for this is that public education does not serve a public. It *creates* a public. . . . The question is, What kind of public does it create? A conglomerate of self-indulgent consumers? Angry, soulless, directionless masses? Indifferent, confused citizens? Or a public imbued with confidence, a sense of purpose, a respect for learning, and tolerance? The answer to this question has nothing whatever to do with computers, with testing, with teacher accountability, with class size, and with the other details of managing schools. The right answer depends on two things, and two things alone: the existence of shared narratives and the capacity of such narratives to provide an inspired reason for schooling. (Postman, 1995, p. 17-18)

The End of Education begins with a description of several narratives that have failed. For example, the narrative of Economic Utility, the idea that "the purpose of schooling is to prepare children for competent entry into the economic life of a community" (Postman, 1995, p. 27), has failed in light of growing evidence that, despite their education, graduating students are more likely to land a McJob than a well-paying, challenging position. And Postman contends that the narrative of Technology, based on a sort of hyper-reaction to the inevitability of new technologies, is a “false god” which inhibits the learning of social skills and which, used as an engineering solution to the teaching of subjects, ultimately fosters the kind of sleepwalking attitude to technology which Postman so deplores.

In accordance with the mandate of the media ecologist to find solutions, Postman goes on to offer “five narratives that, singly and in concert, contain sufficient resonance and power to be taken seriously as reasons for schooling. They offer, I believe, moral guidance, a sense of continuity, explanations of the past, clarity to the present, hope for the future” (Postman, 1995, p. 61-62). Used as the scaffolding upon which to build a curriculum, narratives such as the ascent of humanity, the American experiment, and the use of language to create the world will, he suggests, give school a meaning that it currently lacks and help counter rampant information glut and discontinuity. These narratives all continue themes from Postman’s previous books and stress the notions of continuity, rationality, and human dignity which are central tenets of Postman’s philosophy.

Only by looking at Postman’s latest book in the context of his other writings is it possible to gain a full understanding of its implications. Postman is not just trying to save the schools by finding a inclusive narrative upon which to base all learning; he is trying to save public education because he believes it is the only means by which American culture can be preserved from the rampages of uncontrolled technological development. Ultimately, it is not the end of education that he is concerned about, but the demise of culture and “civilité.”

Nevertheless, it would be a gross inaccuracy to accuse Postman of cynicism and doom-saying; for Postman writes *The End of Education* and all of his books as a romantic, one who maintains “a belief in the improvability of the human condition through education” (Postman, 1969, p. xiii), a faith “that despite some of the more debilitating teachings of culture itself, something can be done in school that will alter the lenses through which one sees the world” (Postman, 1995, p. x). Examining *The End of Education* within the context of the Postman canon makes it clear that this latest publication is a new lesson in a curriculum that Postman has been delivering for many years to those who will listen, a course of study which promotes concepts of knowledge and ways of knowing which include detachment, objectivity, analysis, and criticism; which challenges us to cast a critical gaze upon our technologies and their underlying meanings, and to examine how language and metaphor shape our lives; which invites us to appreciate and cultivate the values of logical thought and historical understanding; and, finally, which implores us to “enter the conversation with enthusiasm and resolve” (Postman, 1995, p. 91). Only an optimist could continue delivering such a course of study for thirty years.

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Miscellany

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