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From the Editor

Passing the Baton at the Intersection of Acronymonium and Heritage Roads

Over the course of my 44 year career I have been interested in polymers. However, as my teaching responsibilities changed, my connection with the technical literature in polymers peaked and waned. If I needed to reconnect with what was happening in that field I knew that it would take several months of reading trade magazines before I could become literate (a truly valid use of the term “literacy”?) about the latest polymer acronyms. This occurred most recently when I began my current position at Millersville University about five years ago. As with my past reentries, I once again became a subscriber to *Modern Plastics*. To my pleasant surprise every acronym is now defined parenthetically in the articles. This dispelled a bit of my feeling that acronyms and esoteric words were two of the many ways in which a discipline or field of study builds a wall around itself, preserving the knowledge niche inside exclusively for those who have somehow earned the right to dwell there.

Long before I began my career, professionals in the field worked hard to establish what is now known as technology education as an essential part of the education of everyone. The bottom line in this quest for acceptance is often defined by the extent to which technology education is a required subject in the schools. Over the years we have both gained and lost in this quest. At this point it is probably a safe supposition that fewer students have a technology education experience now than they did when I began my career.

STEM (Science, Technology, Engineering, and Mathematics) programs have become pervasive in education these days. STEM programs are parallel in some respects to “green” products and “organic” foods – they are everywhere. The promotion and support of STEM has resulted in an unprecedented feeling of elation about finally being recognized as a valuable player in education since the T stands for Technology and technology is what we are all about. The growth of STEM has certainly helped us move forward in many ways, but there have been some unanticipated consequences as well – at least those in our field did not expect them. Even now, many leaders in STEM initiatives have decided that the T does not represent the technology that we know and love but rather it is educational technology, used to augment the teaching-learning process. Moreover, STEM curricula and co-curricular projects have been developed that most of us clearly feel belong in our field, but are not. Science is increasingly using design and make activities to teach about science and technology in concert. In a sense, this should not necessarily be surprising to us since STEM projects have been supported with funding from government agencies, such as the National Science Foundation, that do not necessarily require any connection with our field. Moreover, we made the decision that our curriculum standards would not be exclusive to our field, but would serve all those who wished to develop technological literacy among our citizenry. We could have tried to be territorial about this, as has been the case with many of those required subjects to which we aspire to be like – and I have to admit it requires a lot of lip-biting not to do so. However, the principled end is to develop a universal understanding of technology among everyone, a goal that every citizen should support regardless of what sector of education will actually make it happen.

I have found myself on occasion using a word without giving much thought to what the word really means or implies. This is the case with the word exclusive, one that I have already used several times above. I have stayed at "exclusive" hotels, responded to advertisements for "exclusive" offers, and have attended "exclusive" celebrations and events. What I did not think about is what the word really means, that it *excludes* certain individuals.

Despite the fact that we have not realized the T in STEM like we had hoped, arguably STEM is an exclusive movement in education. Even though others in the movement may not see us properly dressed for the occasion, we nevertheless have at least earned admittance. However, all the other subjects in the school, those that the authors of *Technically Speaking* proposed to be among the deliverers of technological literacy – the non-technical subjects in the school – are excluded. It was written:

> The committee urges that these initiatives be continued, and, in addition, attempts should be made to include technology content in other subjects, such as social studies, civics, history, geography, art, language arts, and even literature (National Academy of Engineering and National Research Council, 2002, p. 104).

Art educators exemplify one group who feel like we have felt many times in the past, like they are on "outside looking in." Platz (2006), is one example of an art educator who proposed that STEM be changed to STEAM in order to include art in the acronym. The same argument that Platz used for inclusion pertains equally to other subjects such as social studies, humanities, and virtually all the subjects not included in STEM.

STEM has appeared so much in educational circles and has been used in so many ways that one has to wonder if it has lost its value. STEM has been mentioned several times in our local newspaper without any definition of what it means, as though the readership already knows what it is. What are the valid hallmarks of a STEM program? Is the exclusiveness of STEM defensible? Has STEM really made a positive difference in the education of our youth? Would students enrolled in STEM programs have pursued careers related to STEM anyway? Does the general public, including the parents of school-age children, know what STEM means or is the acronym really known only by those inside the education knowledge niche? Do the titles and acronyms we continue to develop in general serve a valid purpose in improving communication with those we serve, or are they really the means to simply make us feel better about ourselves?

Certainly students need to be more competent in mathematics and science than they are now. We are committed to the belief that everyone should be technologically literate and we hope that this ideal will reach fruition. Though the data are mixed, perhaps there is a need for more engineers, scientists, and mathematicians than we are currently preparing. However, most consumers will not purchase products unless they are aesthetically pleasing. Everyone needs to be knowledgeable about civics, society, and history in order to responsibly participate in our democracy, albeit our technological democracy. Everyone one needs to have improved communication skills. Moreover, I am convinced by the students with whom I have worked over the years that not everyone who wants to work in engineering or technology needs to know calculus or how to model phenomena mathematically in order to solve technical (or technological) problems, develop creative solutions, and consequently be successful in STEM-related careers and contribute to society. In this regard, Charles F. Kettering, the inventor of the automobile self-starter and head of research and development for General Motors, always comes to my mind. After he had successfully developed the self-starter, he presented his work at a meeting of the American Institute of Electrical Engineers. According to all the theories and formulae of the time, the motor of the self-starter was far too small and the battery and associated wiring were significantly undersized for it to work properly. During the meeting, one engineer stood up and said:

> No wonder this man can make a self starter. He transgresses every fundamental law of electrical engineering. If you want to make a self starter that way you are welcome to it. I am an honorable electrical engineer, and I refuse to do that. (Boyd, 1957, p. 76)

Kettering, an engineer himself, remarked, “All human development, no matter what form it takes, must be outside the rules; otherwise we would never have anything new” (Boyd, 1957, p. 76). Apparently no one at the meeting other than Kettering thought about the short time the self starter operates in order to start the engine. It is imperative that we do not create a curriculum that results in the exclusion of the creative minds of students who have a multitude of interests that span all disciplines, who will become the innovators of the future.

It is unfortunate that few manuscripts have been published recently in our literature about the history of our field, as though our current practices and proposals for the future, either by intent or oversight, are completely disconnected from our heritage. An exception is the article by Scott Warner in this issue. It seems imperative that our current leaders, especially those not grounded in technology education, look to some of our leaders from the past, especially those who argued that technology cannot be studied in isolation from other disciplines – that one of its unique potentials is to unify virtually all disciplines and enable students to make sense of the larger world as a result.

Whenever I get together with my "old cronies" the conversation inevitably ends up being a discussion of whether or not the field is headed in the right direction. It seems to me that we have always been at a crossroad. While I was an undergrad at Montana State University, the crossroad was general education versus vocational education. Then it was hand tools versus machine tools, manual drafting versus computer-assisted drafting, letterpress versus offset press, traditional versus contemporary, modular versus conventional, and so forth.

When I think about where we are now, logic tells me the following story. We decided that our focus was going to be on technological literacy and then developed curriculum standards to achieve this goal. Very significant organizations and individuals rallied around this cause and continue to do so – some understanding who we are and others who do not. Two very influential and powerful groups, the National Academy of Engineering and the National Research Council, stated:

> Short of the widespread adoption of dedicated courses in technology – an unlikely scenario in the committee's view – the inclusion of technology subject matter in other academic areas is one of the surest ways of increasing the visibility of technology in U.S. schools. (NAE & NRC, 2002, p. 104).

The widespread adoption they mentioned has not, in fact, happened. What has been happening, though, is that their vision of the inclusion of technological content in the "other academic areas," especially science, is beginning to be realized. At the other end of the spectrum are courses that could be classified as neo-vocational – "neo" meaning vocational education that goes to the baccalaureate degree level. Project Lead the Way is one example of this approach.

So where does that leave us? It seems that if both ends of the spectrum are realized, then we are left in the middle, arguably where we have been for decades. What students can we attract in this middle ground? If we play our cards right, we may be able to attract the same wide range of students that the industrial arts days attracted a few decades ago: Students who are interested in technology but could not afford the class time or did not want the depth of vocational education. Students who wanted to learn skills and understanding to make them wise consumers of the products they would buy. Students who wanted to express themselves creatively through making something useful and tangible, developing some life-long leisure interests along the way. Students who wanted to understand more about the human-made world in which they live. Students who wanted to be freed from the hours of seat work that they endured for most of the rest of their school day. In fact, these are the ideals that make up much of our heritage.

We have tried so hard to get respect for what we do. However, it seems that most of the criticism to which we have tried to respond has come from within the educational and academic community rather than outside. Starting at the university level, some professors in our field tried to "academicize" their programs, reducing the practical experiences they provided to their students, attempting to make them more like those of their colleagues across the campus, and hoping to consequently reduce the vulnerability of their program. If successful, they then promoted the same approach for the public schools.

The need to be more "academic" spread to the teachers. Ironically, as this was happening, it seemed like those we were trying to emulate were desperately seeking ways to provide more hands-on learning experiences for their students, as if the two were headed in opposite directions. In retrospect, it appears as though some teacher educators and teachers alike abandoned their fundamental beliefs, trying to fit into the rest of the academic community, forgetting about the unique experiences that they could provide to their students – experiences that no other part of the educational enterprise could even hope of providing.

Several things have occurred recently that made me give pause to what we are doing. One was what I read in *Shop Class as Soul Craft* (Crawford, 2009) that I cited in my last From the Editor. Since that time, several other things have occurred that have caused me to reflect. One was the happenstance of hearing the audio portion at the end of an episode of the *Cool Tools* series on the DIY Network that aired on January 11, 2010 in which the speaker said that his organization, The Crucible, was formed because students no longer were learning how to work with tools and materials in school because "shop classes" had been eliminated.

> The Crucible is a non-profit educational facility that fosters a collaboration of Arts, Industry and Community. Through training in the fine and industrial arts, The Crucible promotes creative expression, reuse of materials and innovative design while serving as an accessible arts venue for the general public….The Crucible has thrived and grown to become the largest nonprofit industrial arts education facility in the United States. Together, we have brought the positive creative force of art into our community, each year introducing more people to the rewards of creating with their hands and imagination. (http://www.thecrucible.org/home)

Dean Kamen was recently honored with the Engineering: Inspired Problem Solving award by *Popular Mechanics* magazine. Dean founded the FIRST robotics contest with which many of us in technology education are familiar and in which our students have participated. He is an engineer and an inventor of wide repute. The two-wheeled Segway vehicle is among his many inventions. In an article associated with the award it was written:

> Dean Kamen's first visit to a machine shop was a revelation. He was too young to drive, so he bummed a ride. The smell of oil, the glistening equipment, the grinders throwing sparks – so this is how precision parts were made. When Kamen started his first company, while still in high school, he outfitted his own machine shop in his basement. 'Each time I bought a tool,' he says, 'I extended my capability to do something, to make something' (Ward, 2009, p. 71).

In the interview included in the article, Kamen was asked if there was enough hands-on learning in the schools. He stated that most of what students learn in school is at a high level of abstraction, especially in mathematics and science. He said it was akin to trying to teach someone how to play football by teaching all the rules and strategies over the course of 12 years of schooling, but never letting them "touch the ball or play the game" (Ward, 2009, p. 73).

David Hoff, wrote in response to the Kamen award, stating:

> I agree 100 percent with Dean Kamen….Throughout high school I looked forward to college, thinking I would finally have the chance to practice the theory I was learning. But after I got there, I did not have the opportunities I had expected – it was just more lab reports and textbook homework. I couldn't even use the machine shops to make parts for a robot I was building on my own time. With just one semester left before I complete my B.S. in engineering, the only things I have built are a model of a lathe and a small aluminum truss.
>
> There has to be hands-on learning in schools and universities, or students will lose interest in science and technology. (Hoff, 2010, p. 6).

Assuming, then, that we want to play a role in preparing engineers for the future in our secondary programs, does it make sense to move the theory from collegiate engineering programs down into the high schools? Or does it make more sense to provide the hands-on experiences with real tools and materials that have been our successful heritage, exciting students about engineering and technology – perhaps even exciting them to have the motivation to learn the prerequisite theory for a career in engineering. Might this not be the way to get more Dean Kamen's and more David Hoff's into technology and engineering?

Learning-wise, do we not typically engage in practice first and then develop a consequent interest in the theory? Do children first learn the theory of how to play with blocks before they are allowed to actually build something with them? Do we learn the theory of the internal combustion engine before we are allowed to drive an automobile? Though documentation is a necessary part of the world of business and industry, I have yet to meet a person who really enjoyed doing it. Knowing this, do we have to insist that our students document everything they learned in our classes until it extinguishes all the fun and excitement that they had?

I have been a subscriber to both *Popular Mechanics* and *Popular Science* magazines since I was in high school (and "read" *Popular Science* since I was about six years old). I have been amazed with how much attention both of these publications have been paying to education over the past couple of years. With this new emphasis, could these publications be a way to finally get the public support for what we are doing and trying to do? William Wulf is a member of the Editorial Board of Advisers of *Popular Mechanics*. He is also the President of the National Academy of Engineering and in this role served as the cochair of the Task Force charged with conducting a formal review of our curriculum standards. He has also been involved with ITEA in a number of other ways.

This issue of the *Journal of Technology Education* marks the end of my 11 year tenure as editor. The decision to step down was a very difficult one to make, more difficult than nearly any other big decision I have made in my life. I have been connected with the JTE for over 20 years and it has been a very significant part of both my professional and personal life. It has been a labor of love in all respects and my departure will most certainly leave a huge void within me. I can already feel it and it is much like the “empty nest syndrome” that occurs when the last child leaves home to enter the “real world.”

I have been blessed to have the support of the Editorial Board and the thousands of hours they have collectively devoted to this publication. I will always be indebted to them. Marc deVries, University of Eindhoven, The Netherlands, has been on the Editorial Board since the first issue. Of course a publication cannot be successful with out readers and I am thankful to all the subscribers and those who have downloaded several million articles each year. Heartfelt thanks are also due to ITEA Executive Director, Kendall Starkweather, and founding editor Mark Sanders, my former colleague at Virginia Tech. There is no doubt that I have gained in personal development, knowledge, intellectual curiosity, new friendships, and opportunities far more than the effort I have put into it.

While I was in high school I tried to “find myself” athletically. One of ventures was running relay races. After dropping the baton twice during the handoffs, the coach decided that I needed to explore some other event. I feel confident that I can pass the baton to the next editor with confidence. However, I did place a little piece of paper inside of it with following items written on it, summarizing some of the major points I have tried to make in my From the Editor columns over the years:

- Technology education will prosper to the extent that we can provide unique, problem-based learning experiences to our students with real tools and materials.
- Students learn a wealth of knowledge in our courses in all domains: cognitive, affective, and psychomotor.
- The way we teach our students involves their emotions and consequently the experiences they have will remain with them the rest of their lives.
- The essence of what we *teach* should not be measurable with paper-and-pencil tests.
- The essence of what our students *learn* cannot be measured with paper-and-pencil tests.
- It may be impossible to ever develop a method to measure the most important things that students gain from our courses.

It has been an awesome and rewarding adventure! Thank you most sincerely!

JEL

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Articles

Engineering Professional Development Design for Secondary School Teachers: A Multiple Case Study

Jenny Lynn Daugherty

The effectiveness of teachers has been regarded as crucial to the success of standards-based reform (Fishman, Marx, Best, & Tal, 2003). Research, particularly within science and mathematics, has underscored the need for professional development to help teachers understand (a) subject matter, (b) learners and learning, and (c) teaching methods (Loucks-Horsley, 1999). In addition to focusing on teacher professional development, national reform efforts have also emphasized science, technology, engineering, and mathematics (STEM) education (i.e., *Rising Above the Gathering Storm*, NRC, 2006). While substantial work has been conducted in mathematics and science, the efforts in technology and engineering education are much less mature. This makes sense given the relatively recent development of the *Standards for Technological Literacy* (ITEA, 2000) and recent calls for integrating engineering into the K-12 classroom as both an avenue to technological literacy and as a way to enhance the engineering pipeline (Erekson & Custer, 2008; Lewis, 2005; Wicklein, 2006).

The complexity of engineering and its integration into K-12 education, however, have resulted in a variety of issues requiring sustained empirical research (Johnson, Burghardt, & Daugherty, 2008). One particular area of need given the emphasis on teacher effects on student learning is to research engineering-oriented teacher professional development. A lack of publication on the effective practices of engineering-specific professional development projects makes a study investigating mature efforts necessary. Thus, the purpose of this qualitative study was to explore professional development elements for secondary school engineering education. The research questions that guided this study were:

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1. What are the primary design elements used to deliver engineering-oriented professional development (logistics, format, activities, instructors, and instructional strategies) and why were these elements selected?
2. How do the projects define and evaluate effectiveness?

The focus on the professional development design decisions and determinations of effectiveness for secondary school engineering education are particularly important because they are the elements that “designers of professional development have immediate control over and can modify in order to increase their impact on teachers’ knowledge, beliefs, and attitudes, and subsequent enactment” (Fishman et al., 2003, p. 646). Each design decision is typically connected to a distinct purpose and level of impact (Speck & Knipe, 2005). By understanding the design decisions of specific projects, the connection to secondary school engineering and its impact on teaching and student learning can be better understood.

Review of the Literature

Teacher professional development has been conceptualized in various ways; from a systematic attempt to bring about change (Guskey, 1986) to a continuous process (Clement & Vandenberhe, 2000). Professional development can include practitioner-development, formal education, training, and informal support. Despite the different types, there is a growing demand for professional development that is more closely linked to the genuine demands and resources of teachers; that contains a greater coherence and link to curriculum policy; and that justifies the tremendous expenditures dedicated to it (Evans, 2002; Shaha, Lewis, O’Donnell, & Brown, 2004). Researchers have estimated that professional development costs approximately $19 billion annually (Bredeson, 2003).

A consensus has emerged concerning a set of principles and processes that differentiate effective teacher professional development (i.e., Darling-Hammond & McLaughlin, 1995; Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). Guskey (2003) conducted an analysis of many of these lists and concluded that the most frequently cited characteristic of effective professional development was the enhancement of teachers’ content and pedagogical knowledge. In addition, many of the lists included research-based approaches; having a well-defined image of classroom learning and teaching; and continuous evaluation and improvement. Effective processes included collaborative participation; in-depth, active learning opportunities; and engaging teachers as adult learners and in leadership roles.

In addition to an emphasis on integrating these effective practices, the research on teacher professional development in science and mathematics has evolved into addressing specific teacher needs. Professional developers in science education have largely focused on the need for science teachers to increase their content knowledge and experience using inquiry in the classroom (Johnson, 2006). Likewise, within mathematics education, professional developers are being called upon to develop teachers' knowledge of the content and effective pedagogy, as well as "to provide opportunities for teachers to develop their own identities as teachers of mathematics" (Peressini, Borko, Romagnano, Knuth, & Willis, 2004, p. 67).

Technology teacher professional development, however, has been less well explored. Compton and Jones' (1998) study of two technology education projects led them to conclude that there should be a focus on teachers' conceptualizations of technology education, pedagogy, and technological practice. Bybee and Loucks-Horsley (2000) articulated four key components of technology teacher professional development. Technology teachers need: (a) to develop technology skills; (b) to learn about how to teach technology; (c) tools and motivation to continue their own learning; and (d) long-term professional development to support standards-based reform. With K-12 engineering education being a relatively new phenomenon, research specifically on engineering professional development is lacking. Although initiatives have emerged to assist teachers in this endeavor, little has been documented of their approaches or effects. It is critical to understand the professional development design decisions that lead to effective professional development experiences for teachers preparing to teach engineering.

Method

This study consisted of five case studies of projects designed to prepare secondary teachers to deliver engineering education. Multiple case studies allow comparative analysis so that similar cases can be compared and contrasted (Stake, 2006). This research design was appropriate for this study because of the nature of the research questions. The focus was on describing the design decisions and practices involved in the professional development of teachers for secondary school engineering education. By coming to know each project through an in-depth analysis, this study was able to answer the research questions, as well as draw significant comparisons across the cases and against the research literature.

A discriminate sampling technique, where the researcher deliberately selects persons, sites, and documents to maximize comparative analysis (Strauss & Corbin, 1998), was used to select the five cases for analysis. Based on the review of literature and research questions, the following criteria were developed to help guide the case study selection process.

1. *Engineering-Oriented Content*: The cases had to contain elements that were interesting, applicable, and useful for engineering-oriented professional development at the 9-12 (secondary school) level. Engineering was defined as including a focus on: (a) preparing students for postsecondary engineering education or (b) providing a broad base of technological literacy for all students. A focus on secondary school level projects was included because of the predominance of initiatives targeting this grade level.

2. *Illuminative Professional Development Design Practices*: The initiatives needed to have a reputation for attempting to include “best practices” (e.g., standards based, pedagogically sound, and assessment based), as well as creative design practices, that could illuminate and inform future professional development in this area.
3. *Maturity*: Priority was given to mature initiatives with an established track record for delivering professional development over a sustained period of time (at least two years).

In order to identify the cases, the researcher asked acquaintances, who were actively involved in technology and engineering education, to identify individuals who had national reputations in K-12 engineering education and who would be knowledgeable about teacher professional development projects. Interviews with 15 of these individuals were conducted to assist the researcher in identifying projects. The individuals were asked to identify projects and rank the top three sites that best fit all of the criteria. It was assumed that the process for identifying and selecting the sites was appropriate given the lack of publication and the limited advertisement of engineering-oriented professional development projects.

The identified projects were rated based on the number of times mentioned and by the rankings provided. A total of five projects were selected for inclusion in the study because they were ranked highly by multiple informants. Five cases were deemed sufficient enough to be able to analyze different approaches to engineering-oriented professional development and allow for in-depth comparisons across projects without being too cumbersome. The cases selected for inclusion into this study were *Engineering the Future: Science, Technology, and the Design Process*™, *Project Lead the Way*™, *Mathematics Across the Middle School MST Curriculum*, *The Infinity Project*[sm], and *INSPIRES*.

The data collection process for each case study consisted of the following phases: (a) pre-visit, (b) on-site, and (c) post-visit. The pre-visit data collection phase consisted of two elements: (a) structured telephone interviews with the project’s leaders, and (b) an analysis of the project’s documents. The structured hour-long telephone interviews with the project’s leaders were conducted to collect factual data about the project to help provide the “back story” and inform the on-site data collection. The project leaders were also asked to supply evaluator reports, curriculum, and related documentation of the project. These documents were reviewed to better understand the project’s development, philosophy, and approach to professional development. The data gathered from the interviews and documents were synthesized and developed into the foundation of the case study report prior to the on-site visit.

The on-site data collection was conducted over the span of two days. The rationale for conducting on-site visits was to (a) obtain first-hand reports from the projects’ participants, (b) directly observe the professional development activities and interact with project leaders and participants, and (c) document and validate information obtained from the pre-site interviews. In order to ensure the triangulation of data, the on-site data collection for this study consisted of the following three methods: (a) observations conducted during the Summer of 2008, (b) teacher questionnaires, and (c) interviews (teacher focus groups, instructors, and project leadership).

The first on-site day consisted primarily of observations guided by an observation form. The researcher and a co-observer independently documented the day's activities with field notes and compared these notes at the close of each day. Eisenhardt (1989) outlined two key advantages for the use of multiple investigators: (a) it adds to the richness of the data, and (b) the task of converging observations enhances the confidence in the findings. At the end of the first day, a survey questionnaire was also administered to all of the teachers. The questionnaire was developed based on the need to better understand the teacher participants' demographic characteristics, their motivations to attend, and what they had learned. The same questionnaire was administered at all of the sites, providing data for comparison across the cases.

On the second day, focus group interviews of the teachers, interviews with the professional development instructors, and follow-up interviews with the project leadership were conducted. When possible, the focus groups were comprised of existing small groups of teachers. All of the teachers were asked to be in a focus group, with all but a few electing to participate. Teachers were asked about what they were learning, how it would influence their teaching, and strengths and weaknesses of the experience. The interviews with the instructors were intended to provide information about the materials, the delivery of the instruction, and their training. By the end of the second day, if unanswered questions remained, informal interviews of the project's leadership occurred. All interviews were audio-recorded and transcribed by a professional transcriptionist. The background report prepared from the pre-visit data, the observation notes, and the analysis of the transcripts were compiled into case study write-ups.

During the post-visit data collection phase, member checking was conducted to ensure the accuracy of the case study write-ups. The project leaders were asked to examine their project's case study report and provide feedback on any inaccuracies related to the project's history and development. Inaccuracies were reconciled via a telephone conversation. Afterward, full descriptive case studies were prepared for each case. The background report, the analysis of the transcripts, and a descriptive narrative of each on-site visit were integrated into separate case studies. This approach allowed the researcher to gain a rich familiarity with each case, resulting in the emergence of unique patterns within each case before pushing "to generalize patterns across cases" (Eisenhardt, 1989, p. 540).

About the Cases

The five case studies are presented in an abbreviated form in the order they were visited. The findings from the individual case studies are then compared and summarized across the research questions. As Stake (2006) pointed out, what multiple case studies "have most to offer is a collection of situated case activities in a binding of larger research questions" (p. 90).

Engineering the Future: Science, Technology, and the Design Process™ (EtF)

The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston began the EtF project to develop a full-year course designed for all students in their first years of high school. Professional development emerged from the field testing of the curriculum. Currently the professional development is comprised of two designs: (a) in-person workshops and (b) online courses. The in-person workshops are structured around a combination of mini-lectures, hands-on activities, and reflections. Each of the four days of the workshop observed for this case study was devoted to one of the four projects in the course. The instructor structured the professional development experience around the five E's (engage, explore, explain, elaborate, and evaluate). The evaluation included daily plus-delta activities and a summative feedback form. In addition, online courses enable the project to introduce, train, and support teachers using the curriculum nationally.

Project Lead the Way™ (PLTW)

PLTW is an instructional project that is designed to prepare students to be successful in post secondary engineering and engineering technology programs. There are three elements of PLTW's professional development design: (a) self-assessment and pre-core training, (b) core training in the form of summer training institutes, and (c) continuous training. Teachers take a skills self-test and questionnaire to determine their readiness for core training in three basic areas: (a) mathematics, (b) science, and (c) computer literacy. The two week (80 hours) Summer Training Institutes (STIs) are conducted at an affiliate training center; typically a university. There are STIs for each of the PLTW's courses within the middle school (*Gateway to Technology*) and high school programs (*Pathway to Engineering*). Master teachers and affiliate university professors lead the STIs. The master teachers assist in developing the "scope and sequence" of the workshop that will be used at all STIs across the country. Continuous training is provided to the teachers in the form of university based level II training and a virtual academy.

Mathematics Across the Middle School MST Curriculum Project (MSTP)

MSTP is a National Science Foundation (NSF) Mathematics Science Partnership (MSP) project. The primary focus of the project is mathematics infusion into technology education classrooms through engineering design problems. There have been three distinct phases of the MSTP project's approach to professional development. The first phase utilized a train-the-trainer approach. The second phase had teachers meeting twice (A workshop and B workshop), and between implementing a mathematics-infused lesson, bringing examples of student's work to the second workshop. The third phase, which was observed for this case study, was to result in an experimental control group research study designed to measure the impact of a mathematics-infused design lesson. The workshop, facilitated by a lead teacher and supported by a mathematics education expert, provided the teachers with the experience of working through the lesson, which also emphasized virtual and physical modeling.

The Infinity Project[sm]

The Infinity Project[sm] is a partnership between Southern Methodist University (SMU) and Texas Instruments that resulted in a year-long, upper level high school course titled *Engineering Our Digital Future*, and an adapted version for 9th and 10th grades. The instructional materials include a textbook, lab materials, an instructor's guide, and a technology kit utilizing LabVIEW software. Classroom support is provided through the project's professional development institutes, which are week long (40 hour) sessions hosted by SMU or other university partners. Institutes include hands-on instruction by master instructors in the use of the hardware, software, and textbook features of the curriculum. Open lab time was built into the format of the institute, which was structured around the textbook's chapters. The primary focus of the institute is on learning how to use the LabVIEW software. The evaluation component of the institute included a pre-test/post-test assessment. Teachers are asked to complete the assessment before they attend the institute and then at the end of the institute they are asked to complete it again.

INSPIRES

INSPIRES is an NSF-funded project with the purpose of "Increasing Student Participation, Interest, and Recruitment in Engineering and Science." The *INSPIRES* curriculum targets core engineering skills and concepts in order to better prepare students to pursue engineering and technology related careers. At the time of the on-site visit for this case study, the *INSPIRES* project had completed three of its five stand-alone modules, which are centered on specific engineering design challenges. As they completed a module, the project's leaders conducted two-day teacher workshops. The observations conducted for this case study were completed at a workshop focused on the *Engineering Energy Solutions: A Renewable Energy System Case Study* module. The workshop consisted of an overview of the project and then experiencing the curriculum in the same order and format that it is to be implemented in the classroom. The teachers also work through the web-based tutorials and interactive simulations that are included in the module. The workshop begins and ends with an evaluation survey.

Cross-Case Analysis

In order to address the study's research questions, the complete case studies were synthesized by conducting a cross-case search for patterns of design elements and determinations of effectiveness. It was assumed that the triangulation of data, validation measures, and the member checking process were appropriate to generate accurate and valid case studies from which to address the study's research questions.

Research Question 1

The first research question was focused on the primary design elements used to deliver engineering oriented professional development and the reasons these design elements were selected. The relevant categories that emerged as a result of the cross-case analysis included: philosophy towards engineering, format in number of days, the online component, teacher recruitment, design model, instructional design, and instructors. Table 1 provides a side by side comparison of each project across these design elements.

The five projects involved in this research study had philosophies guiding their approach to engineering-oriented education at the secondary school level, which impacted their design decisions. The philosophy of EtF and MSTP was oriented toward engineering as an avenue toward technological literacy for all students. For example, the EtF course is designed for students, whether college-bound, whether they plan to attend a tertiary education institution, or enter the workforce directly. Although there were elements within these projects of increasing all students' awareness and interest, the philosophy of PLTW, *The Infinity Project*sm, and *INSPIRES*, was oriented more toward developing students' aptitudes toward pursuing post-secondary engineering. For example, *The Infinity Project*sm is advertised as an "early college engineering education project."

Table 1
Major Engineering-Oriented Professional Development Design Elements

	Projects				
Design Issues	**EtF**	**PLTW**	**MSTP**	**The Infinity Project**	**INSPIRES**
Philosophy	Techno-logical literacy	Pre-engineering	Techno-logical literacy	Pre-engineering	Pre-engineering
Online	Course	Virtual academy	Blackboard	Blog	Modules
Teacher recruit-ment	Self selection	School agreement	Self selection	School agreement	Self selection
Model	Curriculum-linked	Curriculum-linked	Partner-ship	Curriculum-linked	Curriculum-linked
Instruc-tional design	Scaffolded problem solving	Scaffolded problem solving	Scaffolded problem solving	Self-guided learning	Self-guided learning
Instructors	Project leaders	Master teachers & engineering faculty	Master teachers & mathe-matics consultants	Master teachers	Project leaders (engineer-ing faculty)

The length of the in-person aspects of the professional development differed among the projects, including two and four day; one and two week formats. In addition to in-person workshops, all of the projects included an online component from courses to blogs. The online component of most of the projects was designed to provide additional follow-up support to the teachers after they had attended the in-person workshop. Teacher recruitment, another important design decision, differed among the projects. EtF, MSTP, and *INSPIRES* sent direct mailings marketing their workshops to area schools so teachers could self select. PLTW and *Infinity* required an agreement to be completed by the school district administrator, who identified the teachers to attend the professional development. Table 2 summarizes the characteristics of the teachers who attended the workshops and completed the survey across two dimensions: (a) subjects taught and (b) gender. Across the five projects, the majority of the teachers were male (71%) and taught technology education, industrial technology, pre-engineering, or computer science subjects (*n* = 47).

Table 2
Teacher Characteristics

Project	Total	Gender	Subjects Taught
EtF	2	Female: 0 Male: 2	TE, IT, Pre-engr, Computer: 1 Mathematics: 0 Science: 1
PLTW	12	Female: 1 Male: 11	TE, IT, Pre-engr, Computer: 11 Mathematics: 1 Science: 0
MSTP	11	Female: 0 Male: 11	TE, IT, Pre-engr, Computer: 11 Mathematics: 0 Science: 0
The Infinity Project	26	Female: 11 Male: 15	TE, IT, Pre-engr, Computer: 13 Mathematics: 14 Science: 9
INSPIRES	12	Female: 6 Male: 6	TE, IT, Pre-engr, Computer: 11 Mathematics: 0 Science: 2
Totals	63	Female: 18 Male: 45	TE, IT, Pre-engr, Computer: 47 Mathematics: 15 Science: 11

All but one of the five projects in this study pursued curriculum-linked instructional design models, focusing on the knowledge, skills, and abilities deemed necessary to implement a specific set of curriculum materials. For example, these projects devoted significant amounts of time to providing training on specific software or tools used in the curriculum. However, there were different decisions made concerning how much of the curriculum to cover. For example, the EtF project devoted each day to a module, covering all of the modules in the curriculum. On the other hand, *INSPIRES* devoted an entire workshop to just one of its modules. PLTW and *The Infinity Project* designed their workshops around having the teachers experience the entire scope of a course. MSTP was the only project not based on a set of specific curriculum materials but did focus on the implementation of a specific lesson.

In addition, there were two patterns of instructional design that emerged: (a) scaffolded problem solving and (b) self-guided learning. EtF, PLTW, and MSTP's approach was to scaffold problem solving activities on top of developing skills and knowledge related to the hands-on activities. For example, PLTW's overall approach was to provide instruction on specific tools using a demonstration and lecture, and then teachers would move on to more open-ended design problems after the "basics" were learned. The other instructional design pattern observed could be categorized as self-guided learning. Teachers were introduced to the content of the curriculum and then given time to work through the activities at their own pace. For example, *The Infinity Project*sm instructor briefly reviewed PowerPoint presentations and then the majority of time was spent on computers, completing the labs within the curriculum at the teachers' own pace.

An important decision related to instructional design is the selection and preparation of the instructors used to deliver the professional development. There were three types of instructors, with some projects using a combination: (a) master teachers, (b) project leaders, and (c) higher education faculty. PLTW, MSTP, and *Infinity* had master teachers, who had implemented the curriculum for an extended period of time, deliver the professional development instruction. The project leaders for EtF, *INSPIRES*, as well as MSTP, served as instructors. In addition, engineering faculty served as instructors on PLTW and *INSPIRES*. MSTP also included a mathematics consultant as part of its team of instructors.

Research Question 2

The second research question was oriented toward how projects defined and evaluated effectiveness. All of the projects included a summative evaluation by distributing surveys to the teachers, asking feedback about the delivery of the workshop. PLTW, *Infinity*, and *INSPIRES* administered surveys to the teachers prior to and at the conclusion of the workshop. All of the projects incorporated formative evaluations into their format, though it was obtained mostly informally through discussions. A formal process was pursued by EtF with the daily completion of plus/delta comment cards. All of the projects created online environments to provide a venue for teacher support during implementation. In addition, PLTW, *Infinity*, and MSTP had a formal plan in place to follow up with the teachers during the school year.

Despite these measures, the projects did not articulate or had not completed comprehensive evaluation plans that accounted for multiple stakeholders and that carried through to implementation in the classroom to measure impacts on student learning. The primary focus was on the teachers' perceptions of the experience and their ability to train the teachers to implement the curriculum as intended. For example, all of the projects designed their professional development approach around teachers experiencing aspects of the curriculum or lesson, as well as learning specific tools, to improve implementation. This contributed to the project's ability to evaluate the effectiveness of their project by maximizing the likelihood that teachers would implement as intended.

The teachers across the five projects, who participated in the focus groups, largely agreed on three aspects that contributed to effective professional development experiences: (a) hands-on activities, (b) teacher collaboration, and (c) instructor credibility. All of the projects devoted a majority of their time to hands-on activities. This was appreciated by the teachers when asked about what was particularly effective about the workshops. In addition, the hands-on activities allowed the teachers to work together. The ability to collaborate with other teachers both at the in-person workshops and via the online environments was consistently commented on as effective aspects of the professional development. Many of the teachers also commented on the credibility of the instructors, both the master teachers and engineers, as effective elements.

Discussion

Based on the five case studies, consistent decisions concerning design elements emerged, which were linked primarily to curriculum implementation. The assumption being that that "good" curriculum translates into "good" professional development and "good" teaching. Although this focus is one of the oldest professional development strategies, it has been criticized as a "de-skilling" process in that teachers are not developed beyond the curriculum. As Ball and Cohen (1996) argued, the "adoption of new materials is rarely seen as one component of a systemic approach to professional development" (p. 7). With little to no extensions of learning beyond the curriculum, the transfer of training to other aspects of teaching is assumed to be low. What do teachers learn and can implement into their particular community of practice beyond, or in addition to, the curriculum?

In terms of effective professional development practices, across the projects there was an emphasis on active engagement and collaborative learning. This focus aligns with the literature, which points to the need for adults to be actively engaged, as well as for teachers to develop a sense of collegiality and collaboration (Gordon, 2004; Guskey, 2003). The research literature, however, indicates the need for the design of more comprehensive experiences for teachers, with an emphasis on what happens before an in-service training event and afterwards (Craft, 2000). Comprehensive experiences include a focus on content and how students learn that content, meet for an extended duration of time, and include teachers as partners in its design and implementation.

Engineering at the secondary school level is a new and emerging phenomenon. As is apparent in this study, there are different ways to approach its inclusion into the high school classroom. The projects articulated two different philosophies: (a) technological literacy and (b) pre-engineering, which greatly impacted the professional development design. Those projects that aligned with technological literacy indicated that the emphasis was on developing critical thinking and problem solving capabilities in all students. Engineering was seen as one avenue to help accomplish this goal, with little connection to the engineering discipline or engineering-specific content. A pre-engineering philosophy was also evident, with strong connections to post-secondary engineering, designed to encourage students into the "pipeline."

These two distinct philosophies are important because it gets to the heart of what is meant by engineering at the secondary school level and has implications for how teachers should best be prepared. How engineering is conceived impacts the design of curriculum, instruction, teacher preparation, and professional development. For example, the instructional design decisions made by the projects, whether to scaffold learning or provide self-guided learning experiences, appear to be connected to these different approaches to engineering. The pre-engineering projects mirrored post-secondary engineering education approaches, emphasizing self-guided learning. Technological literacy projects mirrored K-12 technology education pedagogy, providing scaffolds to learn tools and knowledge to complete hands-on activities. Research needs to be conducted to better understand how teachers and students best learn engineering so as to effectively design the professional development instruction.

In addition, the philosophy of engineering may impact where in the secondary school curriculum engineering is best suited. The engineering projects explored in this study attracted science, technology, and mathematics teachers. Due to the discrepancies in their pre-service teacher education, teachers' capabilities vary across and within these three disciplines; for example, in their mathematics abilities and skills. However, the professional development projects in this study lacked any overt attention to these discrepancies and focused little on reflecting on engineering related content, skills, or abilities. If pre-college engineering moves toward an engineering content focus, professional development would need to face the challenge of meeting the needs of teachers with varying levels of science, technology, engineering, and mathematics backgrounds.

Implications and Recommendations

Based on the findings of this study, there are important implications for secondary level engineering professional development. Even when anchored on curriculum, the professional development design should include more comprehensive needs assessments, evaluation, and follow-up. Projects should incorporate rigorous evaluation into the design of their professional development so that they can provide a better understanding of how teachers learn engineering, change, and impact student learning. Secondary level engineering-oriented professional development should also move toward more comprehensive designs to account for the minimal teacher preparation in engineering at the pre-service level. A clear vision of teaching and learning engineering needs to drive the design of the professional development. Teachers' needs, whether mathematics, science, technology, or a combination, should inform the design and should be continuously monitored. The design should be a collaborative venture between professional development providers and the teachers so as to account for the particular contexts within which the teachers operate. This process should include key stakeholders such as school administrators, guidance counselors, and parents.

In terms of recommendations for research, a study of engineering-oriented professional development projects that are not curriculum-based and inclusive of the entire K-12 spectrum is warranted. Another recommendation is to study the link between teacher participation in engineering professional development and student learning outcomes. As Fishman et al. (2003) pointed out, to "create excellent projects of professional development, it is necessary to build an empirical knowledge base that links different forms of professional development to both teacher and student learning outcomes" (p. 643). This link has not been thoroughly explored and with increasing calls for the integration of engineering, it is important that this be emphasized in future research.

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An Analysis of Children's Literature featured in the "Books to Briefs" Column of *Technology and Children*, 1998-2008.

Patrick N. Foster

Introduction

Beginning in 1998, the editors of *Technology and Children* (*T&*C) have included 72 different children's books in a regular feature called "Books to Briefs." These columns are offered to teachers as a means of integrating design and technology activities into elementary-school curricula via children's literature. Each "Books to Briefs" column includes a bibliographic reference to a single children's book (Figure 1, label A) and a summary of the book (label B). The body of the column begins with a section addressed to the student (label C), including the design challenge, which identifies a problem to be solved and a context in which the problem is situated. Since December 1999, every "Books to Briefs" column has included implementation suggestions directed to the teacher (label D). Every column also identifies a suggested grade level for the activity. Some "Books to Briefs" columns also identify limitations on the challenge, allowable resources, or assessment criteria.

From the inception of "Books to Briefs" (in *T&*C volume two, number four) through the end of *T&*C volume 12 in 2008, the column was overseen by the same department editor. During this time, the department editor wrote 18 columns (25%); the remaining columns were produced via a process of manuscript solicitation and editing. More than half of "Books to Briefs" authors (53%;
n = 38) were undergraduate education majors at the time their articles appeared.

Purpose and Approach

The purpose of this study was to evaluate the first eleven years of "Books to Briefs" columns, both as elementary reading-related activities and as technological literacy activities. Two broad research questions were addressed:

1. To what degree are "Books to Briefs" activities consonant with generally accepted principles of elementary reading instruction?
2. How robust are these activities as design challenges? To what degree do they exhibit the characteristics of good technology activities?

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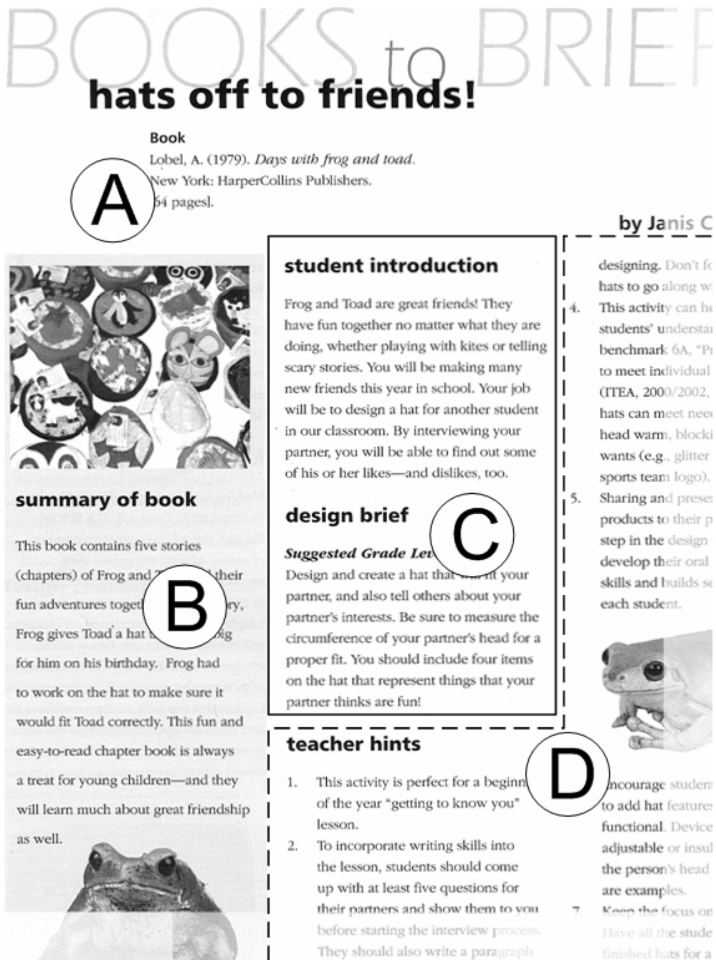


Figure 1. Detail of a “Books to Briefs” column (Churchill, 2006).

The first stage of this study was the development of a database which included information related to the “Books to Briefs” design briefs and the books upon which they were based. Information about the books was collected from print and online editions of Fountas and Pinnell (e.g., 2006) and *Children’s Books in Print* (e.g., 2009); and from the online databases at *amazon.com* and *lexile.com*. Data about the design briefs were obtained from Brusic’s (2007a) unpublished database of the contents of *T&C* Volumes 1 through 11, and directly from the “Books to Briefs” articles.

The second stage of the study was the analysis of data in which the research questions were clarified and additional sub-questions were developed. These analyses were the basis for the recommendations presented at the end of this article.

"Books to Briefs" as Reading-Related Activities

To what degree are "Books to Briefs" activities consonant with generally accepted principles of elementary reading instruction? The following sub-questions were developed to facilitate analysis:

1. Do "Books to Briefs" columns represent a balanced variety of children's literature?
2. Do the activities support the view of reading as a process?
3. Are the activities social and collaborative?

These questions are based on Zemelman, Daniels, and Hyde's (2005) analysis of best reading practices, Martinez and Roser (2001)'s summary of the findings of more than 100 research studies of children's responses to literature, and the work of Carbo (2008).

Breadth of "Books to Briefs" Trade Books

In some respects, the 72 trade books were diverse. There was a wide variation in book length and book age, and only three authors had more than one book appear in "Books to Briefs." There was, however, one striking example of uniformity: all but ten of the books (86%) were fiction.

While a preponderance of fictional books is not unusual in elementary classrooms, it is an emphasis which many teachers, reading specialists, and designers of standardized testing wish to reduce (e.g., Vent & Ray, 2007).

Even when finer categorizations of genre are used, the books appear rather homogeneous. For example, under Huck's classification of children's literature (e.g., Kiefer, Hepler & Hickman, 2007), a majority of "Books to Briefs" columns (51%; n = 37) fall into one of nine genres. Under the Donovan and Smolkin categorization (2002), three-quarters of the books were classifiable as storybooks (n = 55; 76%) (Table 1).

Balancing Easy and Hard Books

In reviewing the literature, Zemelman and associates found that "studies show that young readers need much more of what adult readers sometimes call 'beach books'—easy, predictable, enjoyable quick reads" (p. 47), in addition to more challenging texts. Three sources were used to compare the grade level of each design brief with the reading level of the corresponding trade book:

- The Flesch-Kincaid readability index (Flesch, 1948), available for some books via *amazon.com* (Weeks, 2005)
- The Lexile Score (Reed, et al., 2007)
- The Fountas and Pinnell (e.g., 2006) grade-leveling system

Table 1
Genres of "Books to Briefs" Books

	Donovan and Smolkin Category			
Huck Genre	**Storybook**	**Informational**	**Dual-Purpose**	**Totals**
Contemporary Realistic Fiction	13	0	1	14
Historical Fiction	2	0	3	5
Modern Fantasy	34	0	3	37
Non-Fiction	0	6	4	10
Picture Books	1	0	0	1
Traditional Literature	5	0	0	5
Totals	55	6	11	72

The Lexile score of a text estimates its difficulty and can be converted into a grade-level range. Compared to the Flesch-Kincaid Index and other traditional means of computing readability, the Lexile framework is an advanced algorithm that cannot be performed by hand. Like Lexile scores, the Fountas and Pinnell reading level of a text is proprietary and is based on an "examination of text features and the unique blend of these features in any one book" (2008, n.p.). This includes readability factors as well as more subjective variables such as literary themes and typography. At least one of these three measures of reading level was collected for 62 (86%) of the books (Figure 2).

It may be inferred from Figure 2 that in many cases, students are challenged to read a book above their grade level. Perhaps this suggests the belief that creative, experiential activities can encourage learners to tackle texts above their tested "reading level." It may also imply that a design-brief activity might be seen as *scaffolding* (Reutzel & Cooter, 2004)—as a means of helping the reader approach or negotiate a difficult or novel text.

Of course, the children in nearly every classroom represent a range of reading abilities. For example, Blackorby and associates (2004) found that 27% of the students in a large, longitudinal study of mainstreamed elementary classrooms were rated by teachers as above-average readers, while 30% were below average.

But even given the typical variance in reading levels, it seems clear that the trade books in "Books to Briefs" activities are not what Zemelman, Daniels, and Hyde would consider 'easy' for children at the grade levels for which the "Books to Briefs" challenges were written.

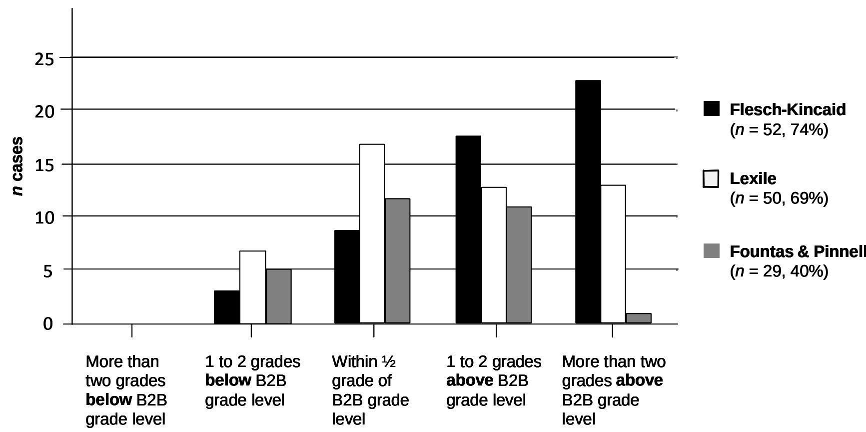


Figure 2. Comparison of averages of grade ranges recommended in "Books to Briefs" (B2B) articles with those suggested by selected sources.

Reading as a Process

The literature supports teaching children that reading is a progression beginning with prior knowledge, followed by making predictions to be tested during reading. Making sense of the text itself is a step that may involve seeking help from printed sources or from other people. The process continues with "post-reading activities"—a step shown to have positive impacts on reading skills (e.g., Atay and Kurt, 2006, p. 255). "Books to Briefs" activities are applications intended to follow reading, and thus appear to be ready-made for this final step.

To be a valuable use of class time, post-reading activities must bolster students' comprehension of the book they have just read. As opposed to decoding text during reading, comprehension is "understanding the meaning of what has been read" (Friend & Bursuck, 2006, p. 507).

Since each "Books to Briefs" is based on a specified book, each could be used by teachers to build comprehension. However, not all "Books to Briefs" design challenges are closely related to the text upon which they are based. In twenty "Books to Briefs" columns (28%), the design challenge is nearly identical to a problem faced by a main character in the book (Table 2).

In a majority of design challenges, however, the problem relates to the book only insofar as they share a topic. Reutzel and Cooter refer to such activities as "extending meaning" projects (2004, p. 408): they are not intended to bolster reading comprehension, but might improve children's reading skills and, in many cases, to broaden their understanding of the book's content.

Table 2
Relationships between design challenges and children's book (N = 72)

Problem faced by a main character in the book	"Books to Briefs" design challenge	*Reference*
Students are challenged to address a problem related to the subject of the book *(n = 49; 68%)*		
Mother has a job at a diner, which is where she earns money in hopes of getting a new chair one day. …The day finally comes when…the family is able to get their own very special chair.	Invent your very own special chair for a favorite doll…or toy (e.g., stuffed animal) from home.	*Slaughter, 2002, p. 17*
This book is about a young boy named Alexander who is having a terrible day. …he expresses a desire to move to Australia where he believes all of these bad things will not happen. Eventually, he gets through the day…	Help Alexander get to the "down under" continent. …design and build a vehicle that can travel three feet between two designated points in our classroom (representing the U.S. and Australia).	*King, 2001, p. 19*
Students are challenged to solve the same problem faced by a character in the book *(n = 20; 28%)*		
Mother tells Sal to fill her pail with blueberries, but Sal...came home with no blueberries because she kept eating all of them.	Design and make a pail that will hold blueberries, but, will not allow Sal to easily get the berries back out…until she goes home.	*Claggett, 1999, p. 12*
The possum has a real liking for eggs and Mattie…comes home and discovers that the eggs she put in the crock are missing...	Design an egg holder that cannot be broken into by a possum.	*Robertson, 1999, p. 6*
Students are challenged to address a problem in the book, but in a different context *(n = 3; 4%)*		
Mike Mulligan and his steam shovel, Mary Anne… dig a basement for a new town hall… But Mike and Mary Anne are trapped…Mary Anne is turned into the furnace for the new building, and Mike accepts a job as the building janitor.	What would have happened to Mike and Mary Anne if they got trapped [during an earlier job]…Build a model of one of your best ideas…	*Carlson, 2004, p. 16*

Collaborative and Social Approaches to Reading Instruction

Among the five strategies to "reduce the worst practices and increase the best" identified by Carbo (2008, p. 58) is to "provide student-responsive environments," especially for young children and "global, tactile, and kinesthetic learners" (p. 60). This includes mitigating traditional strategies like seatwork by using varying student groupings.

As identified in Table 3, in about a third of the design briefs (n=27; 37.5%), part or all of the design challenge is to be carried out collaboratively among students. Another 21 (29%) are described as individual activities. In the remaining cases, student grouping is not addressed.

Table 3
Proportions of "Books to Briefs" design challenges specifying collaborative activity, individual, both, or neither

Type of design challenge	*n*	%
Collaborative activity	22	31%
Individual activity	21	29%
Requires collaboration and individual work	5	7%
Not specified	24	33%

In four of the books, a main character is faced with a problem that he or she faces alone, such as Henry David Thoreau's construction of a cabin in the woods (Varnado, 2003). In these design briefs, individual activity is either suggested or implied.

Conclusions

The design challenges can be useful after-reading activities. In the hands of an elementary-level teacher trained to teach reading, "Books to Briefs" columns offer relevant, low-cost, hands-on activities that could be important components of the reading process. While not every activity represents best reading practices, K-5 teachers with access to all 72 activities have between 19 and 40 design briefs designed for their grade level to choose from (depending on grade level). Many of these activities encourage, or can be adapted to encourage, collaboration among students. Although some activities are more closely related to the children's book than are others (Table 2), "Books to Briefs" columns could profitably be used to bolster comprehension, and could have additional positive effects, such as on student attitudes toward reading.

"Books to Briefs" challenges are not primarily designed as reading-related activities."Books to Briefs" should not be mistaken for a comprehensive framework for reading instruction. Insofar as each design challenge "is a technological problem solving activity that stems from a book" (Brusic, 2007b, p. 1), these activities are not designed specifically to support reading comprehension. Activities that support reading as a process must help the

student negotiate the text, but most "Books to Briefs" challenges are more fairly characterized as thematic extensions of the trade books.

Alternately, "Books to Briefs" columns may be viewed as scaffolding (Reutzel & Cooter, 2004), but this should be done with the recognition that scaffolding implies that the student can, and perhaps should, be weaned off such activity. This is especially true of hands-on activities. Friend and Bursuck (2006), for example, discuss the value of using "manipulatives and models" to help special-needs students "make connections between the abstractions often pursued in school and the real-life products and situations these abstractions represent" (p. 169). However, they urge teachers to "move their students beyond the concrete level when they are ready" (p. 170). "Books to Briefs" activities are useful in reading instruction, but they are intended to be more than temporary aids. Specifically, they are also intended as technological-literacy activities.

"Books to Briefs" as Technological-Literacy Activities

In a recent analysis of best practices in technology education, de Vries (2007) assigned eleven topics (ethics in technology, design approaches, etc.) to teacher educators from around the world, who analyzed the accounts of eight model programs in terms of the assigned topic. As the topics were not derived from analyzing model programs, de Vries cautions, "the aim of our analyses was not to be complete" (p. 10). Nonetheless, the "characteristics of best practice" (p. 8), which focus on content and method, may be relevant in evaluating "Books to Briefs" activities, including

- "Synthesis of different content dimensions" (procedural, conceptual, etc.);
- Use of different strategies for different design problems;
- "Engaging pupils…in authentic learning;"
- Varying modes of assessment. (p. 10)

As technology activities, "Books to Briefs" are most appropriately judged on the degree to which they enable teachers to meet goals such as those identified by de Vries. Ideally, "technology activities are experiences where students can design something, beyond just building according to directions or learning drafting techniques" (Britton, De Long-Cotty & Levenson, 2005, p. 48).

By definition, the focus of every "Books to Briefs" column is a unique *design brief*—a design challenge addressed directly to students (cf. ITEA, 2004). While the inclusion of a design challenge goes a long way toward identifying an activity as supporting technological literacy, design is not the only skill important in technological activities (e.g., Kim & Roth, 2008). Among technology educators (e.g., ITEA 2005, Brusic 2007b) there appears to be agreement that technological literacy activities should, by definition, focus on technological content as opposed to "activities that are really math or science in technology's clothing" (Britton, De Long-Cotty & Levenson, 2005, p. 49).

To organize the analysis of "Books to Briefs" columns as technological-literacy activities, the following questions were used.

1. To what degree do "Books to Briefs" activities promote technological content?
2. What approach to the design process is represented among the activities?
3. To what degree are the design challenges open-ended, and to what degree are they structured?

Technological Content

One way to evaluate the centrality of technological content in an activity is to identify the technology content standards to which it relates. As *T&C* is a national publication, reference is made to the *Standards for Technological Literacy* (*STL*; ITEA, 2000). Activities that are based on specific benchmarks within the standards would appear to be better examples of technological literacy activities than those that only support or reflect standards. By this measure, the technological content of "Books to Briefs" columns is difficult to judge; only 29 of the articles (40%) identified one or more standards supported by the activity. [1] Half of these (*n* = 15) identify one or more specific benchmarks within the standards (Table 4).

Since mention of standards and benchmarks is often vague and usually made in the "teacher hints" section of a "Books to Briefs" column, references to standards often appear to be an afterthought. The following is representative:

> [Teacher Hint #9] Address some of the technological literacy content standards (ITEA, 2000/2002) through this activity. Standard 20 is a good starting point for this activity since it focuses on construction technologies. (Needham, 2007, p. 12)

While the activities can, and perhaps should, reflect national content standards, each "Books to Briefs" column must be based on a children's book. Every column accomplishes this, and between a quarter and a third relate quite closely to the book (Table 2). "Books to Briefs" activities are technology activities; perhaps in some cases, children may be acquiring technological abilities, not technological knowledge.

"Books to Briefs" activities may also be judged by the relationship of each activity to the theme of the *T&C* issue in which it appeared. *T&C* themes are either explicitly technological (e.g., "Building Big") or are applications of technology (e.g., "Exploring Air and Space"). Three-quarters of the activities published since thematic issues began in 2000 (45 of 58) have focused on concepts directly related to the theme (cf. Brusic, 2007a).

[1] However, it should be noted that the ITEA standards did not become official until after the first twelve "Books to Briefs" columns had been published.

Table 4
Comparing the number of standards with "Books to Briefs" citations

Standards cluster	Number of standards	Citation of specific benchmarks within standard	Identifying standard only	Sum
Nature of Technology	3	1	4	5
Technology and Society	4	5	5	10
Design	3	5	5	10
Abilities for a Technological World	3	4	1	5
The Designed World	7	12	6	18

Design-Process Elements

The well-established conception of the design process presented to K-12 technology students has the following general steps: defining or understanding the problem; design, research and development; product testing; and making the final product (e.g., Gradwell, Welch, & Martin, 2008, p. 26-34). Every "Books to Briefs" activity involves the first two of these steps; all but one also involves making a product (Table 5). The only common design-process element not widely present among the "Books to Briefs" activities was product testing.

Testing Design-Brief Products

In all, half of the "Books to Briefs" articles specified one or more means of assessing the product of the challenge. Some involved testing under actual conditions (e.g., "we will test our bird feeders by observing if birds visit them" (Fiorella, 2000, p. 18)). In other cases, the product is to be tested under simulated conditions. For example,

> …we will use a large green eraser to represent Froggy. ...After the rafts are completed, we will join Froggy down the lake (a small test pool) and try out our rafts (Suggs, 2001, p. 20)

As discussed earlier, more than half of the "Books to Briefs" books can be classified as fantasy, so it is not surprising that many of the design-brief products do not lend themselves to formal testing. Some authors, then, have designed other means for students to present their final products, such as a group critique (Banks, 2006) or a poster presentation (Bitting, 2006). Table 6 identifies the quantities of activities that specified each type of product testing.

Approaches to the Design Process

In reviewing published K-8 technology-education materials, Britton and associates (2005) classified activities' approaches to the design process, ranging from low-impact "warm-up" exercises to robust design and construction activities (adapted in Figure 3).

Most "Books to Briefs" activities are what Britton, De Long-Cotty, and Levenson call "redesign/ modify/improve" activities. These design challenges specify an existing type of product (e.g., paper airplane, picture frame) to be made by the children. In these cases, students are more engaged in modifying than in the kind of product development implied by the concept of the "design process" outlined by Gradwell and associates or described by the *STL*s. In some cases, students test their product or participate in other parts of the design process, but few "Books to Briefs" rise to the "scaffolded" or "full-scale design and make" levels, each of which usually involves students "in all the design steps, plus revisions, and results in a product," or in some cases, a prototype (p. 49).

Table 5
Product Examples (N = 72)

Product Category	Examples
Container (n = 20)	• a pail that will hold blueberries, but will not allow Sal to easily get the berries (Claggett, 1999, p. 12) • a carrying case that would allow your pet to see and hear what is happening on the field trip (Halstead, 2001, p. 20)
Mechanical solution (n = 19)	• a tool or machine that will help [Mr. Putter and Tabby] get pears from the tree (James, 2002, p. 19) • a paper airplane that is balloon-powered (Betler, 2005, p. 10)
Model (n = 13)	• a space motel that will withstand all of the conditions of living in space (Pilson, 2003, p. 17) • a model of a memorial…to honor the people who lost their lives at the Triangle Shirtwaist Factory (Brusic, 2002, p. 11)
Other physical product (n = 14)	• a good that a needy family … might be able to make and sell in a nearby market (Brusic, 2005, p. 17) • a hat that will fit your partner, and also tell others about your partner's interests (Churchill, 2006, p. 14.)
Electronic / graphic design (n = 5)	• a simple web page entitled "Life in Outer Space" (Diaz, 2003, p. 16)
Repair (n = 1)	• a solution to repair the hole in the hot-air balloon (Sianez, 2008, p. 16)

Table 6
Product Assessments

	Type of Product Testing			
Relationship of Product Testing to Design Brief	**Product tested under actual conditions**	**Product tested under simulated conditions**	**Product displayed**	**Totals**
Integrated into activity	14	14	10	38
Suggested as an option	0	3	2	5
Totals ($N = 72$)	14 (19%)	17 (24%)	12 (17%)	43 (60%)

Note: Each design brief is included in a maximum of one category. Design briefs with both integrated product testing and optional assessment suggestions are counted under the applicable "integrated into activity" category.

On the other hand, every design brief examined in this study was too comprehensive to be classified as "short/focused/practical/warm-up." Thus, among the design approaches, "Books to Briefs" activities fall between the extremes identified in Figure 3.

<table>
<tr><td></td><td colspan="5">Approaches to the design process</td></tr>
<tr><td rowspan="2">Activity focus</td><td colspan="5">← Teacher-directed Student-centered →</td></tr>
<tr><td colspan="2">Discrete design skills only</td><td>Segment(s) of the design process</td><td colspan="2">Complete design process, including revisions</td></tr>
<tr><td>Britton, et al., category</td><td>Short/ focused/ practical/ warm-up</td><td>Investigate/ disassemble/ evaluate</td><td>Redesign/ modify/ improve</td><td>Scaffolded</td><td>Full-scale design and make</td></tr>
</table>

Figure 3. Categorization of technology activities' approaches to the design process, based on Britton, *et al*. (2005).

As noted in Table 6, some kind of assessment is described or suggested in a majority of the "Books to Briefs" columns. Most of these design challenges, however, are "one-shot' activities" (Foster, 2006, p. 21) which do not include revising the design. Britton and associates consider design revision—as distinct from the standard design cycle—a hallmark of high-quality technology activities. Only two "Books to Briefs" columns mention design revision, and in neither case is iterative design or testing a focus.

Open-endedness of the Challenge

Britton and associates also classified activities by degree of structure; those with the least structure were termed "open-ended explorations" (p. 49). By definition, all design activities have structure; at a minimum, the challenge issued to the student limits the activity. Moreover, most have evaluative criteria (although not all specify how the product is to be assessed), so the most open-ended design-brief activities will specify the fewest constraints beyond those necessary for assessment.

Three types of structure were each included in at least one-third of the "Books to Briefs" activities (Table 7). First, some design briefs had built-in checkpoints past which students could not proceed without teacher approval. Second, the authors of some design briefs put specific limitations on the kinds of materials students could use to address the challenge. Finally, some design briefs contained inessential product constraints—conditions placed on the product beyond those necessary to the challenge.

Many activities contained more than one type of structure identified in Table 7. For example, because the book's main character keeps losing several small toys, Landahl's (1998) design brief challenged second- or third-graders "to design and create a … special container to hold at least five items in separate compartments" (p. 14). Student's containers are to be tested by placing five classroom items into them. Students are given additional instructions, including that the "toy container may not be bigger than 2"x2;"" and that "you must draw your design idea first" (p. 14).

Table 7
Types of Structures

Structure	*n*	%	Examples
Process checkpoints	31	43	• Design must be approved by teacher before student can begin working with materials (*n* = 20) • Specific research requirements must be met before proceeding in the activity (*n* = 4)
Inessential product constraints	29	40	• One or more maximum product dimensions, which are not necessitated by assessment (*n* = 16) • Design must include at least one moving part (*n* = 3)
Specific limitations on materials	25	35	• Materials must meet a criterion (e.g., must be recycled, must be wood-based, etc.) (*n* = 10) • Exact materials to be used are listed (*n* = 8)

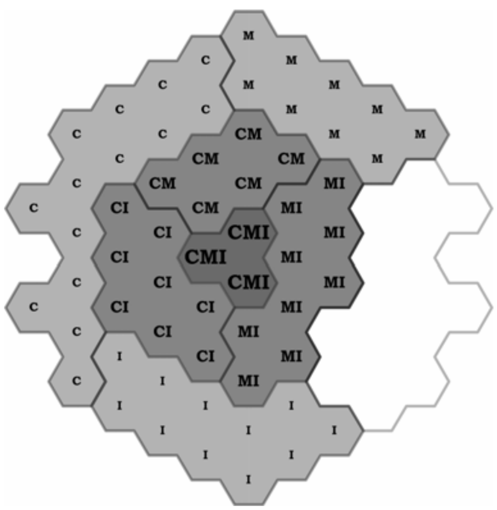
The essential structural element of this activity is that the container holds five items. This requirement is integrated into the scenario and is tested at the end of the activity. The "may not be bigger than 2"x2"" size requirement is an inessential product constraint because it is not mandated by the scenario and it is not required for testing the product. Similarly, the requirement that students produce a drawing before assembling the product is a process checkpoint included to add structure to the activity.

Figure 4 is an illustration of the types and degree of structure of "Books to Briefs" activities. The Landahl activity is represented by one hexagon labeled

'CI.' As illustrated in Figure 4, fourteen "Books to Briefs" activities (19%) are maximally open-ended, and nearly half (n=34, 47%) contain only one type of additional structure. This is in line with Britton and associates' recommendation of "balance" among activities that are structured, partially structured, and open-ended (2005, p. 50).

Each hexagon represents one of the 72 "Books to Briefs" activities. Letters indicate the type(s) of structure built into the activity:

C	Process checkpoints
I	Inessential product constraints
M	Specific limitations on materials



Colors approximate the degree of structure built into the activity:

	n	%
No additional constraints	14	19
One additional type of structure	34	47
Two additional types of structure	21	29
Three additional types of structure	3	4

Figure 4. Types and degree of structure

Conclusions: "Books to Briefs" as Technological-literacy Activities

"Books to Briefs" activities are more representative of technology education methods than of standards-based technological content. While most of the activities include technology concepts, very few appear to have been developed based on technology content standards. Thus, with one exception,[2] "Books to Briefs" does not deliberately support the Standards for Technological Literacy. In fact, these activities do not appear intended to support any organized system of technology content. Rather, they exemplify the view of elementary-school technology education as a method of teaching, in which the

[2] Standard 11 of the *STL* (ITEA, 2000): "Students will develop the abilities to apply the design process" (p. 115).

subject may be technology, literature, or any other. In the hands of an elementary-level teacher without technology-education training, these activities could promote among children those segments of technological literacy related to abilities, as opposed to those related to knowledge.

The design challenges encompass a range of design approaches and activity sophistication appropriate for the K-5 level. As technological design activities, "Books to Briefs" challenges vary in quality. As noted in Table 6, only fourteen (19%) challenge students to design, build, and test a full-scale product. On the other hand, all 72 activities integrate multiple elements of the design process and none fell into the least-sophisticated category of Britton and associates' design approaches.

The challenges were also diverse in terms of degree of structure: about a fifth were very open-ended, while a third were moderately to highly structured. As a whole, these 72 design briefs allow for teachers to choose activities which match "the pedagogical needs of the particular students in the educational setting," taking into account students' and teachers' prior experiences with technology activities (Britton, De Long-Cotty & Levenson, 2005, p. 50).

Recommendations

Based on the foregoing analyses, the following suggestions are offered as a way of increasing the degree to which "Books to Briefs" columns represent best practices in education.

1. *Increase the degree to which the activities bolster reading comprehension.* For example, select books with challenges that can be approximated in a K-5 design activity; then ensure that the design challenges are closely related to problems faced by important characters in the book. Where possible, develop challenges that encourage students to return to the text after reading. When students produce a physical product, have each member of the team write a brief description, akin to a museum placard, explaining the relationship of the product to the story.
2. *Increase the range of literature among the books chosen for the column.* This could be addressed by including biographies and other nonfiction books with suitable challenges, and by increasing the breadth of fiction (especially historical fiction).
3. *Discontinue identifying connections to knowledge-based content standards.* It is clear from the "General Guidelines for Books to Briefs Manuscripts" basing "Books to Briefs" activities on technological knowledge benchmarks (i.e., standards 1 - 10 and 14 - 20 of the STL) is beyond the scope of these columns; authors are to "point out linkages to National Standards…where appropriate" (Brusic, 2007b, p. 2). But since nearly all recent "Books to Briefs" columns (including all from 2007 and 2008) include references to technological knowledge standards, some readers may expect that the "Books to Briefs" feature is intended to deliver standards-based knowledge about technology.

Potential authors may also develop this expectation. “Books to Briefs” activities, by nature, promote the exact technological skills and abilities described in STL standard 11, “students will develop abilities to apply the design process” (ITEA, 2000, p. 119). This standard has seven elementary benchmarks (Table 8). Each “Books to Briefs” activity should be designed to support one of these benchmarks, which should be identified with the target grade range in each column.

4. *Include a procedure for assessing the product of each design challenge.* If possible, this should involve testing the product under realistic conditions. Ideally, the activities would include teacher hints for iterative design and testing.
5. *Encourage the implementing teacher to select the degree of structure for each activity*. Minimize the constraints described in the design challenge addressed to the students, but provide the teacher with a range of potential structural elements, such as product or material constraints and process checkpoints, in the “teacher hints” section of each article.
6. *Make the entire “Books to Briefs” collection available online, free.* Although such a move seems very unlikely to reduce subscriptions to T&C, a 12- or 24-month embargo could be placed on the web publication of activities.

Table 8
Elementary-level benchmarks

Grades K–2	Grades 3–5
A. Brainstorm people’s needs and wants and pick some problems that can be solved through the design process. B. Build or construct an object using the design process. C. Investigate how things are made and how they can be improved.	D. Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem. E. The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many. F. Test and evaluate the solutions for the design problem. G. Improve the design solutions.

Final Thoughts

With a few exceptions, “Books to Briefs” activities compare favorably to best practices in K-5 reading and technological literacy. This is especially true of the more recent columns.

Since comprehension is so central a goal of elementary reading instruction, “Books to Briefs” activities may be fairly judged by the degree to which they support comprehension, and here the results are mixed. On the other hand, "Books to Briefs" activities are also low-risk entry points for elementary teachers to introduce technological design to their students—and as technology activities they are largely successful. However, teachers must have access to the activities—both as ready-made activities and as examples upon which teachers may develop their own. This is the impetus for the final recommendation, not derived directly from the analyses conducted for this study.

Digital access would allow teachers to choose from the widest range of "Books to Briefs" activities, and could encourage users to post new design briefs or modified versions of the existing activities, including translations into other languages. Perhaps most importantly, this could also be an important step toward promoting technological literacy among all children.

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Technology Adoption for Use in Instruction by Secondary Technology Education Teachers

Joe W. Kotrlik and Donna H. Redmann

Introduction

We have come a long way from using just desktop PCs in the 1980s to using a wide variety of technology for instructional purposes such as the Internet, the iPod, blogging, laptop computers, podcasting, e-learning platforms (e.g., Moodle, Blackboard), interactive whiteboards with video-capture technology, streaming videos, and using iPod as a digital notebook. We have also moved from a local classroom to a global classroom via distance learning technology.

An example of a school system with a 21st century infrastructure is Saugus Union in California. Saugus Union has remained on the cutting edge of technology (THE 2006 innovators, 2006). Examples of their use of technology in instruction include PDAs and interactive whiteboards, podcast lesson reviews via students' MP3 players, and broadcasts streamed via the Internet. A key component to their success has been technology specialists who deliver ongoing professional development. Saugus Union's futuristic philosophy has allowed the district to improve communication and collaboration among students, staff, parents, and the community.

Unfortunately, this is not the norm. Not all school systems are operating with this innovative use of technology even though 99% of full-time teachers had access to computers or the Internet somewhere in their schools by 1999, according to a National Center for Education Statistics (NCES) study (Roward, 2000). Then, about the same time as the NCES report, Stanford University Professor Larry Cuban bemoaned the status of technology use in education by writing a book entitled, *Oversold and Underused: Computers in the Classroom* (2003). Recently, writing in the Phi Delta Kappan, Allen (2008) discussed one of the issues addressed by *A Nation at Risk*, namely, that schools were not adequately preparing students to address the country's needs for highly skilled workers in new and evolving fields. Allen implied that although education has spent large amounts of money on technology for instruction, perhaps education has not kept pace with the use of technology in schools over the last 25 years.

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Technology Adoption Research

Research could not be found that addressed how technology teachers are integrating technology in their instruction. However, several studies have been conducted in other areas of career and technical education. For example, Thomas, Adams, Meghani, and Smith (2002) conducted a national study of the effects and consequences of Internet usage in schools with career and technical education programs in which they concluded that the Internet was a transformative agent that enhanced teachers' professional development opportunities, equalized student opportunities, changed learning, altered social status, and modified teaching-learning systems. Studies related to technology adoption in career and technical education clearly indicate that career and technical education teachers should adopt technology for use in instruction (Chapman, 2006; Redmann & Kotrlik, 2004; Womble, Adams, & Stitt-Gohdes, 2000). Redmann and Kotrlik (2004) also found that agriscience, business, and marketing teachers were actively exploring the potential for uses of technology in teaching and learning, were adopting technology for regular use in instruction, but were not actively experimenting with technology.

Abbot and Fouts (2001) found that over half of the teachers they studied did not routinely use technology in teaching and learning. Cuban, Kirkpatrick, and Peck (2001) found in a study of high school teachers, administrators, and students that access to technology by itself ". . . seldom led to widespread teacher and student use" (p. 813). The lack of technology use in teaching and learning may be related to the adoption of innovations. How quickly individuals adopt change is related to whether they value the new approach when compared to their existing approach (Rogers, 2003). The adoption of technological change is usually accomplished in three stages: adoption, implementation, and continuation (Fullan, 2001). Fullan indicated that teachers need time to merge their improved knowledge into their instructional practice as a basis for the acceptance of innovations.

Variables Related to Technology Adoption

Technology Adoption Barriers

Brinkerhoff (2006) reported that teachers often fail to build on technology's instructional potential due to barriers such as institutional and administrative support, training and experience, attitudinal or personality factors, and resources. Barriers can be defined as ". . . any factor that prevents or restricts teachers' use of technology in the classroom" (The British Educational Communications and Technology Agency [BECTA], 2003, ¶1). BECTA reported that teacher-level barriers included lack of time, lack of necessary knowledge, and lack of self-confidence in using technology. Administrative-level barriers included access to equipment, technical support, availability of up-to-date software, and institutional support. BECTA (2003), Redmann and Kotrlik (2004), and Mumtaz (2000) concluded that technology unavailability was an important factor inhibiting the use of technology by teachers. Park and

Ertmer (2008) expanded on the barriers identified above by stating ". . . a lack of a clear, shared vision was the primary barrier. Additional barriers included lack of knowledge and skills, unclear expectations, and insufficient feedback" (p. 631).

Technology Anxiety

Technology anxiety has resulted from equipping teachers with technology but failing to provide appropriate teacher training or to consider curricular issues (Budin, 1999). Technology anxiety has been found to explain variation in technology adoption by career and technical education teachers (Redmann & Kotrlik, 2004). Redmann and Kotrlik concluded that technology adoption increased as technology anxiety decreased.

Technology Training and Availability

Vannatta and Fordham (2004) found that the amount of technology training was one of the best predictors of technology use. However, it is interesting to note that BECTA (2003) reported that training is focused on teaching basic skills rather than addressing the integration of technology in the classroom. Regarding technology availability, Mumtaz (2000) and BECTA (2003) found that a lack of technology availability was a key factor in preventing teachers from using technology in their instruction.

Gender

Anderson (1996) reported in his analysis of studies of computer anxiety and performance that several studies concluded gender was a significant factor in explaining differences in computer anxiety and attitudes toward computers, while other studies found that no relationships existed. Kotrlik, Redmann, Harrison, and Handley (2000) found that gender did not explain any variance in the value placed on information technology by agriscience teachers.

Age and Teaching Experience

Waugh (2004) concluded that technology adoption decreased as age increased. In regard to teaching experience, Mumtaz (2000) reported that a lack of teaching experience with technology was a factor that resulted in teachers avoiding the use of technology and an NCES study (Smerdon et al., 2000) reported that more experienced teachers were less likely to utilize technology than less experienced teachers.

Need for the Study

Organizational and political realities support the need for technology-based instruction (Bower, 1998; *No Child Left Behind Act*, 2001) and technology educators must continue to explore the incorporation of technology in instruction. This study addressed technology education teachers' use of technology in their instruction. The results should contribute to efforts to enable the instructional use of technology to achieve its maximum possible impact.

Purpose and Research Questions

This study addressed secondary technology education teachers' use of technology in instruction. The research questions were:

1. What are selected demographic and personal characteristics of technology education teachers?
2. To what extent have teachers adopted technology for use in their instruction?
3. What barriers exist that may prevent teachers from using technology in their teaching?
4. Do teachers experience technology anxiety when attempting to use technology in instruction?
5. Do selected variables explain a significant proportion of the variance in teachers' technology adoption? The variables used in the regression analysis were the teachers' technology anxiety level, perceived barriers to technology adoption, technology resources available to the teacher, training sources used, age, years teaching experience, and gender.

For the purposes of this study, technology was defined as "high-tech media utilized in instruction such as computers, e-mail, Internet, list-serves, CD-ROMs, software, laser disc players, interactive CDs, digital cameras, scanners, digital camcorders, etc."

Method

The population for the study consisted of all secondary technology education teachers in Louisiana. Each mailing consisted of a questionnaire, cover letter, and stamped, addressed, return envelope. The sample size was based on Cochran's formula (Snedecor & Cochran, 1989). Three data collection efforts were used - two mailings of the questionnaire and a telephone follow-up of non-respondents in which a random sample of non-respondents were asked to complete and return the questionnaire. Sixty-seven out of 134 teachers returned their surveys for a 50.0% response rate.

To determine if the responses were representative of the population and to control for non-response error, inferential t-tests were used to compare the scale means of the technology adoption, barriers to technology integration, and technology anxiety scales for those responses received during the phone follow-up to those received by mail as recommended by Gall, Gall, and Borg (2002). These scales are described in the instrumentation section below and these scales were selected for non-response analysis because they were the primary variables of interest in the study. No statistically significant differences were found between the means by response mode for these variables (see Table 1); therefore, the data were considered representative of the population and the mail and phone follow-up responses were combined for further analyses.

Instrumentation

The instrument contained three scales: technology adoption for use in instruction (15 items), barriers to technology integration in instruction (7 items), and technology anxiety experienced while attempting to use technology in instruction (9 items). All scales and other items used in the instrument were developed by the researchers after a review of related research literature. The face and content validity of the instruments were evaluated by an expert panel of university faculty and teachers enrolled in doctoral programs. The instruments were pilot tested with career and technical education teachers enrolled in a comprehensive graduate program in career and technical education. The reliability of the three scales was calculated using Cronbach's *alpha*: technology adoption, $\alpha = .98$, barriers, $\alpha = .84$, and technology anxiety, $\alpha = .98$. All scales possessed exemplary reliability according to the standards for instrument reliability for Cronbach's alpha by Robinson, Shaver and Wrightsman (1991).

Table 1

Analysis of Scale Means for Responses Received from Technology Education Teachers via Mail versus Responses Received via Telephone Follow-up

Scale	Mail Respondents	Telephone Follow-up Respondents	Levene's Test for Equality of Variances				
	m (n/sd)	***m (n/sd)***	***F***	***p***	***t***	***df***	***p***
Technology Adoption[a]	3.67 (44/1.13)	3.78[b] (22/.99)	.95	.33	-.39	47.45	.70
Barriers to Technology Integration	2.03 (42/.67)	2.06[c] (22/.60)	.65	.42	-.19	62	.85
Technology Anxiety	1.91 (43/1.01)	2.07[d] (22/.85)	.77	.38	-.64	63	.52

Notes: [a] Equal variances were not assumed for the *t*-test for technology adoption because the Levene's Test for Equality of Variances resulted in a statistically significant *F* value.
[b] Technology Adoption Scale: 1 = Not Like Me, 2 = Very Little Like Me, 3 = Some Like Me, 4 = Very Much Like Me, 5 = Just Like Me.
[c] Barriers to Technology Integration Scale: 1 = Not a Barrier, 2 = Minor Barrier, 3 = Moderate Barrier, 4 = Major Barrier.
[d] Technology Anxiety Scale: 1 = No Anxiety, 2 = Some Anxiety, 3 = Moderate Anxiety, 4 = High Anxiety, 5 = Very High Anxiety.

Data Analyses

Descriptive statistics were used to analyze the data for research questions 1-4. Forward multiple regression was used to analyze the data for research question 5. The effect sizes for the correlation and multiple regression analyses were interpreted according to Cohen's (1988) guidelines.

Results

Research Question 1 – Personal and Demographic Characteristics

The ages of the technology teachers ranged from 29 to 71 years and averaged 48.70 years (*SD* = 8.73). Most (57 out of 67) of the teachers were male (57 or 85.1%) while only 10 were female (14.9%). The number of years teaching experience ranged from 2 to 35 years with the average teacher having 21 years (*M* = 21.15, *SD* =9.72). The main source of technology training used by the teachers was 'self-taught' followed by workshops/conferences (Table 2).

Table 2
Sources of Technology Training Used by Technology Education Teachers

Source	#	%
Self-taught	64	95.5
Workshops/conferences	61	91.0
Colleagues	55	82.1
College courses	35	52.2

Note: *N* = 67. The teachers were asked to place a check mark (Y) beside each type of technology training they had used.

The technology available to teachers presented in Table 3 shows that over two-thirds had a school email account (97.0%), a computer with an Internet connection both at school (94.0%) and at home (82.1%), and a videocassette, CD or DVD recorder (68.7%). Almost one half had a digital video camera (46.3%) while fewer than one-third had students with school email accounts (28.4%), GPS (Global Positioning System) (19.4%), or a PDA (personal digital assistant) (4.5%).

Research Question 2 – Technology Adoption

The teachers' adoption of technology for use in instruction was measured using the authors' Technology Adoption Scale. The teachers responded to 15 items using an anchored scale: 1 = Not Like Me At All, 2 = Very Little Like Me, 3 = Somewhat Like Me, 4 = Very Much Like Me, and 5 = Just Like Me. The means and standard deviations for the items in the technology adoption scale, along with the interpretation scale, are presented in Table 4.

The highest rated item in this scale was "I have made physical changes to accommodate technology in my classroom or laboratory," which they indicated was "Very Much Like Me" (*M* = 4.25, *SD* = .98). The second highest rated item was "I emphasize the use of technology as a learning tool in my classroom or laboratory," which they also indicated was "Very Much Like Me" (*M* = 4.06, *SD* = 1.10). The lowest rated item was "I use technology based games or simulations on a regular basis in my classroom or laboratory," which they indicted was "Somewhat Like Me" (*M* = 2.78, *SD* = 1.43). The mean for the scale was 3.71 (*SD* = 1.08), indicating that the teachers perceived the items in the scale overall to be "Very Much Like Me." The scale mean also indicates that technology education teachers had not adopted technology for use in instruction at the highest level, "Just Like Me".

Table 3
Types of Technology Available to Technology Teachers for Use in Instruction

Technology Available for Use in Instruction	#	%
Teacher has school email account	65	97.0
Teacher has computer with Internet connection at school[a]	63	94.0
Teacher has computer with Internet connection at home[a]	55	82.1
Video Cassette, CD, or DVD Recorder[a]	46	68.7
Interactive DVDs or CDs[a]	40	59.7
Teacher has access to enough computers in a classroom or lab for all students to work by themselves or with one other student	38	56.7
Laser disc player or standalone DVD or CD players[a]	35	52.2
Digital video camera[a]	31	46.3
Students have a school email account	19	28.4
GPS (Global Positioning System)[a]	13	19.4
Personal Digital Assistant (e.g., Palm, IPAQ, Blackberry)[a]	3	4.5

Notes: *N* = 67. The teachers were asked to place a check mark (Y) beside each type of technology that was available for their use in instruction.
[a]The number of technologies available to each teacher ranged from 0 to 9 and was totaled to create an available technology score for use in the regression analysis for research question 5.

Research Question 3 – Barriers to Integrating Technology in Instruction

The Barriers to Integrating Technology in Instruction Scale was developed by the researchers and used to determine the magnitude of barriers that may prevent technology education teachers from integrating technology in their instruction. The teachers responded to seven items using the following anchored scale: 1 = Not a Barrier, 2 = Minor Barrier, 3 = Moderate Barrier, and 4 = Major Barrier. The means and standard deviations for the items in the Barriers to Integrating Technology in Instruction Scale, along with the interpretation scale, are presented in Table 5.

Overall, the teachers were experiencing minor barriers as they integrated technology in instruction (Scale *M* = 2.04, *SD* = .64). They experienced moderate barriers with "Availability of technology for the number of students in my classes" (*M* = 2.64, *SD* = 1.14), with the "Availability of technical support to effectively use instructional technology in the teaching/learning process" (*M* = 2.59, *SD* = 1.02), and with having "Enough time to develop lessons that use technology" (*M* = 2.55, *SD* = 1.13). The statement with the lowest rating was "Administrative support for integration of technology in the teaching/learning process" (*M* = 1.83, *SD* = 1.01), which indicated they were only experiencing minor barriers.

Table 4
Responses to the Items in the Technology Adoption Scale

Item	*N*	*M*	*SD*
1. I have made physical changes to accommodate technology in my classroom or laboratory.	67	4.25	0.98
2. I emphasize the use of technology as a learning tool in my classroom or laboratory.	67	4.06	1.10
3. I expect my students to use technology so they can take on new challenges beyond traditional assignments and activities.	67	3.97	1.28
4. I expect my students to fully understand the unique role that technology plays in their education.	67	3.97	1.13
5. I discuss with students how they can use technology as a learning tool.	67	3.88	0.90
6. I expect my students to use technology to enable them to be self-directed learners.	67	3.81	1.22
7. I design learning activities that result in my students being comfortable using technology in their learning.	67	3.81	1.30
8. I expect students to use technology to such an extent that they develop projects that are of a higher quality level than would be possible without them using technology.	67	3.81	1.22
9. I regularly pursue innovative ways to incorporate technology into the learning process for my students.	67	3.70	1.33
10. I incorporate technology in my teaching to such an extent that it has become a standard learning tool for my students.	66	3.68	1.43
11. I am more of a facilitator of learning than the source of all information because my students use technology.	66	3.59	1.36
12. I assign students to use the computer to do content related activities on a regular basis.	67	3.57	1.32
13. I use technology to encourage students to share the responsibility for their own learning.	67	3.43	1.26
14. I incorporate technology in my teaching to such an extent that my students use technology to collaborate with other students in my class during the learning process.	66	3.35	1.43
15. I use technology based games or simulations on a regular basis in my classroom or laboratory.	67	2.78	1.43

Note: *N* = 67. Scale interpretation ranges for the scale means: 1 = Not Like Me at All (1.00-1.49), 2 = Very Little Like Me (1.50-2.49), 3 = Somewhat Like Me (2.50-3.49), 4 = Very Much Like Me (3.50-4.49), and 5 = Just Like Me (4.50-5.00). Scale *M* = 2.78 (*SD* = 1.43).

Table 5
Responses to Barriers to Integrating Technology in Instruction Scale

Item	*N*	*M*	*SD*
1. Availability of technology for the number of students in my classes.	67	2.64	1.14
2. Availability of technical support to effectively use instructional technology in the teaching/ learning process.	66	2.59	1.02
3. Enough time to develop lessons that use technology.	67	2.55	1.13
4. Scheduling enough time for students to use the Internet, computers, or other technology in the teaching/learning process.	67	2.43	1.05
5. Availability of effective instructional software for the courses I teach.	67	2.37	0.97
6. My ability to integrate technology in the teaching/learning process.	67	2.09	0.87
7. Administrative support for integration of technology in the teaching/learning process.	65	1.83	1.01

Note: *N* = 67. Scale interpretation ranges for the scale means: 1 = Not a Barrier (1.00-1.49), 2 = Minor Barrier (1.50-2.49), 3 = Moderate Barrier (2.50-3.49), 4 = Major Barrier (3.50-4.00). Scale *M* = 2.04 (*SD* = .64).

Research Question 4 – Teachers Perceived Technology Anxiety

A researcher-developed scale, the Technology Anxiety Scale, was used to determine the anxiety technology teachers feel when they think about using technology in their instruction. The teachers responded to 12 items using the following anchored scale: 1 = No Anxiety, 2 = Some Anxiety, 3 = Moderate Anxiety, and 4 = High Anxiety, and 5 = Very High Anxiety. The means and standard deviations for the items in the Technology Anxiety Scale, along with the interpretation scale, are presented in Table 6.

The technology teachers were experiencing some anxiety as they integrated technology in their instruction. The scale mean (Scale *M* = 1.97, *SD* = .95) and all item means were in the "Some Anxiety" range. They were experiencing their highest anxiety level with the question, "How anxious do you feel when you cannot keep up with important technological advances?" (*M* = 2.15, *SD* = 1.09). They reported their lowest anxiety level when asked, "How anxious do you feel when you think about using technology in instruction?" (*M* = 1.75, *SD* = 1.06).

Research Question 5 – Explanation of Variance in Technology Adoption

Forward multiple regression was used to determine if selected variables explained a substantial proportion of the variance in the adoption of technology for use in instruction. The Technology Adoption Scale mean was the dependent variable in this analysis. Based on the review of literature, six teacher demographic or personal variables were identified as potential explanatory variables: age, gender, years of teaching experience, perceived barriers to integrating technology in instruction, technology anxiety, training sources used, and technology available for use in instruction. The training sources used by the teachers are presented in Table 2. The training sources score was calculated by

Table 6
Technology Education Teachers' Responses to Technology Anxiety Scale

Item	*N*	*M*	*SD*
1. How anxious do you feel when you cannot keep up with important technological advances?	67	2.15	1.09
2. How anxious do you feel when you are not certain what the options on various technologies will do?	67	2.10	0.99
3. How anxious do you feel when you think about your technology skills compared to the skills of other teachers?	66	2.05	1.27
4. How anxious do you feel when someone uses a technology term that you do not understand?	67	2.04	1.04
5. How anxious do you feel when you hesitate to use technology for fear of making mistakes you cannot correct?	67	2.03	1.06
6. How anxious do you feel when you are faced with using new technology?	66	1.98	1.06
7. How anxious do you feel when you try to understand new technology?	67	1.97	0.98
8. How anxious do you feel when you try to use technology?	67	1.91	1.00
9. How anxious do you feel when you try to learn technology related skills?	67	1.88	0.99
10. How anxious do you feel when you avoid using unfamiliar technology?	67	1.87	0.95
11. How anxious do you feel when you fear you may break or damage the technology you are using?	67	1.76	1.10
12. How anxious do you feel when you think about using technology in instruction?	65	1.75	1.06

Note: *N* = 67. Scale interpretation ranges for the scale means: 1 = No Anxiety (1.00-1.49), 2 = Some Anxiety (1.50-2.49), 3 = Moderate Anxiety (2.50-3.49), 4 = High Anxiety (3.50-4.00), 5 = Very High Anxiety (4.50-5.00). Scale *M* = 1.97 (*SD* = .95).

assigning one point for each of the four training sources. The technology types included in the technology available for instruction variable are shown in Table 3. The score was computed by assigning one point for each of nine types of technology.

The correlations of the seven demographic and personal variables with the Technology Adoption Scale score are shown in Table 7. Due to the minimum number of observations needed per variable for the regression analysis, it had been determined *a priori* that only those variables that were significantly correlated with the adoption scale score would be utilized in the regression analysis.

The data in Table 7 show that the adoption scale score is moderately correlated with four of the ten variables, namely, barriers to technology integration (r = -.32), technology anxiety (r = -.42, technology availability (r = .43), and the use of colleagues as a training source (r = -.31). Therefore, these four variables were utilized in the forward multiple regression analysis. The sample size was adequate for this analysis. According to Hair, Black, Babin, Anderson, and Tatham (2006), a minimum of 5 observations per variable was required, but 15-20 observations for each potential explanatory variable were desirable in a forward regression analysis.

Table 7
Correlations of Selected Variables with Teachers' Technology Adoption Scores

Variable	*r*	*p*	*N*
Age	.04[a]	.793	60
Gender	.06[a]	.619	67
Years Teaching Experience	.02[a]	.859	67
Barriers to Technology Integration	-.32[b]	.011	64
Technology Anxiety	-.42[b]	<.001	65
Technology Available	.33[b]	.006	67
Training Sources:			
Self –taught	-.02[a]	.853	66
Workshops/conferences	.19[a]	.122	66
College courses	-.04[a]	.751	66
Colleagues	-.31[b]	.012	66

Notes: $N = 67$
[a]Negligible association according to Cohen (1988).
[b]Moderate association according to Cohen (1988).

Multicollinearity did not exist in the regression analysis (see Table 8). Hair et al. (2006) stated, "The presence of high correlations (generally, .90 and above) is the first indication of substantial collinearity" (p. 227). None of the independent variables had a high correlation with any other independent variable. Hair et al. (2006) also stated, "The two most common measures for assessing both pairwise and multiple variable collinearity are tolerance and its inverse, the variance inflation factor [VIF]. … Moreover, a multiple correlation of .90 between one independent variable and all others …would result in a tolerance value of .19. Thus, any variables with tolerance values below .19 (or above a VIF of 5.3) would have a correlation of more than .90" (Hair et al., 2006, pp. 227, 230). None of the tolerance values observed was lower than .19 and none of the VIF values exceeded 5.3.The three variables entered into the forward multiple regression analysis combined to explain 37% of the variance (R^2) in technology adoption in instruction. The variable "technology anxiety" entered the model first and accounted for 17% of the variance, followed by "technology available for instruction" which accounted for an additional 13% of the variance. Colleagues as a training source entered the model last, explaining an additional 7% of the variance. Technology adoption increases as technology available (Standardized b =.35) increases, as technology anxiety decreases (Standardized b = -.40), and when teachers use colleagues as a training sources (Standardized b = -.27). A regression model that explains 37% of the variance represents a large effect size (Cohen, 1988). "Barriers to technology integration" did not explain additional variance in technology adoption. The multiple regression analysis is presented in Table 8.

Table 8
Forward Regression Analysis Model Explaining Variance in Technology Adoption in Instruction Scale Mean

	S	*df*	*MS*	*F*	*p*
Regression	27.57	3	9.19	11.43	<.001
Residual	46.66	58	.80		
Total	74.23	61			

					Change Statistics		
Explanatory Variables in Model	***R***	R^2	**Adjusted** R^2	***SE***	R^2 **Change**	***F* Change**	***P* of *F* Change**
Technology anxiety	.41	.17	.15	1.02	.17	12.01	.001
Technology anxiety, technology availability	.55	.30	.28	.94	.13	11.13	.001
Technology anxiety, technology availability, training source: colleagues	.61	.37	.34	.90	.07	6.68	.012

Excluded variable

Variable	**Beta In**	***t***	***p***	**Partial *r***
Barriers to technology adoption	.02	.20	.843	.03

Notes: $N = 67$

Dependent variable: technology adoption. Technology Adoption Scale: 1 = Not Like Me at All, 2 = Very Little Like Me, 3 = Somewhat Like Me, 4 = Very Much Like Me, and 5 = Just Like Me.

Technology Anxiety Scale: 1 = No Anxiety, 2 = Some Anxiety, 3 = Moderate Anxiety, 4 = High Anxiety, 5 = Very High Anxiety.

Technology Available variable potentially ranged from 0 to 9 points, but the actual range was 0 to 8 points since none of the respondents had all nine types of technology.

Barriers to Integration Scale: 1 = Not a Barrier, 2 = Minor Barrier, 3 = Moderate Barrier, 4 = Major Barrier.

The combined variables included in the multiple regression model represent a large effect size according to Cohen (1988): $R^2 > .0196$ - small effect size, $R^2 > .13$ - moderate effect size, and $R^2 > .26$ - large effect size.

Conclusions, Recommendations and Discussion

Just over half of technology education teachers use college courses for technology training purposes while most use self-taught, colleagues and workshops/conferences as technology training sources. These conclusions are similar to those by Redmann and Kotrlik (2004), with one exception: technology education teachers utilized colleagues as a training source at a much lower level than the secondary career and technical education teachers.

Most teachers have a school e-mail account, a computer with Internet connection at school, a computer with Internet connection at home, and a VCR, CD, or DVD Recorder. Over half have interactive DVD or CD players, access to enough computers in a classroom or lab for all students to work by themselves or with another student, and laser disc or standalone DVD or CD players.

Technology education teachers have substantially adopted technology for use in instruction, but they are not making the maximum use of technology. This conclusion is supported by the scale mean for the technology adoption scale being at the “Very Much Like Me” level, but not up to the “Just Like Me” level. This level of technology adoption may be related to the availability of technology for use in instruction. Some technology teachers have not had access to the latest technology for use in their classrooms and labs, while others have and are using many types of technology. The adoption of technology for use in instruction at this level could be reflective of the concerns voiced by Budin (1999) who indicated that teachers should question how technology should be utilized in the curriculum, what teachers should know about the use of technology in teaching, and how the impact of technology adoption should be assessed.

Technology education teachers are experiencing minor barriers to technology integration and some technology anxiety as they strived to integrate technology in their instruction. This agrees with the results of the national study conducted by the National Center for Education Statistics in which it was concluded that teachers were encountering barriers in their efforts to integrate technology in instruction (Smerdon et al., 2000).

Individually, perceived barriers to technology integration and technology anxiety have moderate negative associations with technology adoption, while technology availability and using colleagues as a training source have a moderate positive relationship with technology adoption. As perceived barriers and technology anxiety increase, technology adoption in instruction by technology education teachers decreases; as technology availability increases and as technology teachers use colleagues as training sources, technology adoption increases. However, only three of these variables, barriers to technology integration, technology anxiety, and the use of colleagues as a training source combine to explain a large proportion of the variance in technology adoption. Technology adoption increases as barriers and technology anxiety decrease, and as technology teachers use colleagues as a training source. The conclusion regarding using colleagues as a training source is supported by

Park and Ertmer (2008) who found, in their study of the barriers that middle-school teachers faced when implementing technology-enhanced problem-based learning, that one of the differences between typical and expert teachers was collaboration with other teachers. These conclusions also support the research reported by Redmann and Kotrlik (2004) in which technology adoption was related to barriers to technology integration and technology anxiety; however, technology availability did not contribute to the explanation of variance in technology adoption in their study. These conclusions partially support the research by Smerdon, et al. (2000), in which they found that the major issues in integrating technology into instruction included access to technology and barriers to the integration of technology.

Efforts must be made to encourage and support technology teachers as they work to integrate technology in the teaching/learning process. Local school districts, the state department of education, and college faculty must continue to take responsibility for leading the efforts needed to implement these improvements successfully. This may involve developing a shared vision among these stakeholders as recommended by Park and Ertmer (2008).

Technology teachers must proactively embrace learning opportunities. Teachers must use knowledgeable colleagues to assist them in developing the skills needed to integrate technology in their instruction and continue to use conferences, workshops, college courses, and self-directed learning to stay current. These efforts on the part of teachers should result in increased technology adoption. Major responsibility for leadership, training, technology, and technical support must be taken by school systems as they work to reduce or eliminate barriers to technology integration. These recommendations may also have implications for state departments of education and university teacher education programs.

Technology education research should explore factors that may impact teachers' individual or collective learning in a technology supported learning environment, e.g., the efficacy of specific technologies, a shared vision by stakeholders, learning task types, instructional approaches, interdisciplinary activities/learning communities, technology anxiety, and technology barriers. Researchers should seek to identify optimal approaches for teacher training for technology education.

In the future, several questions should be addressed. What should the future structure of technology teacher education look like? What impact do philosophical, organizational, political, and other local realities have on technology adoption and how the technology education profession should address these realities? The answers to these questions should help create and support a productive future for technology education, and ultimately, the preparation of students for a more technologically complex work environment.

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Middle School Children's Thinking in Technology Education: A Review of Literature

Thomas M. Sherman, Mark Sanders, Hyuksoo Kwon, and James Pembridge

We began a project to understand what happens in middle school technology education classrooms in 2006 (Sanders, Sherman, Carlson, Kwon, 2007) in order to document the goals that technology education teachers pursue, the instructional strategies they use to teach children to meet these outcomes, the measures they use to assess achievement of these goals, and the learning actions that they believe students must engage to master their goals. We chose to focus on middle school because it is the school age when most children are introduced to organized, formal technology education curricula. In addition, middle school is often considered the time to begin focusing on influencing thinking with goals such as "teaching problem solving" (Sanders, 2001; Sanders, Sherman, Carlson, & Kwon, 2006). We believe it is important to understand middle school children's thinking in order to develop appropriate curriculum, to organize and deliver effective teaching, and to ensure that the goals established by the profession are pursued within the developmental abilities of middle school age children. Of course, understanding how children of all ages think and how they learn to use their intellectual abilities well is important. Our choice to limit our initial investigations to middle school was based on the idea that this is an especially fecund developmental period that may be a gateway for many students to begin developing the sophisticated thinking associated with problem solving and to decide to pursue further studies in technology education.

As part of this project, we identified and reviewed articles appearing in four technology education journals from 1995-2006 — Journal of Technology Education, Journal of Technology Studies, Journal of Industrial Teacher Education, and the International Journal of Technology and Design Education — that addressed middle school age teaching and students' thinking/learning. In

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this report, we present our review of articles appearing in these four journals that addressed middle school children's thinking. The review is divided into four sections: The first section summarizes investigations of middle school children's
problem solving/design, the second summarizes reports on gender issues, the third addresses laboratory/teaching context, and the final section reviews other issues raised in these journals relating to middle school children's thinking.

Middle School Children's Problem Solving Processes

Eight studies (Barak & Maymon, 1998; Lavonen, Meisalo, & Lattu, 2002; Jones, 1997; Michael, 2001; Mioduser & Kipperman, 2002; Twyford & Jarvinen, 2000; Welch, 1998; Welch & Lim, 2000) investigated aspects of the intellectual processes in which middle school children engage when addressing problem solving or design assignments in technology education. Five studies (Jones, 1997; Mioduser & Kipperman, 2002; Twyford & Jarvinen, 2000; Welch, 1998; Welch & Lim, 2005) compared the ideal problem solving heuristic presented in technology education text books with the thinking processes middle school children actually use when given problem solving/design problems. Lavonen, Meisalo, & Lattu (2002) and Barak & Maymon (1998) focused on the extent to which children would collaborate/work as teams while problem solving. Michael, 2001 explored the impact of computers on creativity. One study (Michael, 2001) employed experimental methods; the others are based on various qualitative approaches. Five studies appear to have well established reliability (Lavonen, Meisalo, & Lattu, 2002; Michael, 2001; Mioduser & Kipperman, 2002; Welch, 1998; Welch & Lim, 2000) by providing independent validity data while others (Barak & Maymon, 1998; Jones, 1997, Twyford & Jarvinen, 2000) leave the issue of reliability unclear. This section is divided into two parts: the first part addresses the studies that compared the ideal or text book problem solving heuristic with children's actual intellectual processes (Jones, 1997; Mioduser & Kipperman, 2002; Twyford & Jarvinen, 2000; Welch, 1998; Welch & Lim, 20005). The second part addresses the remaining studies (Barak & Maymon, 1998; Lavonen, Meisalo, & Lattu, 2002; Michael, 2001).

Middle School Children's "Natural" Problem Solving Thinking Processes

The central focus of these five studies (Jones, 1997; Mioduser & Kipperman, 2002; Twyford & Jarvinen, 2000; Welch, 1998; Welch & Lim, 20005) was the extent to which middle school children's untutored problem solving thinking mirrors the ideal process recommended in technology education text books. These studies emphasize the intellectual processes that children employ rather than physical or manual skills. Data for these studies were gathered by observing children as they worked on assigned problem solving/design tasks by asking children to think aloud and by interviewing them following the completion of the task or the time allocated for the task expired. The contexts for these studies were relatively unstructured in terms of how the students worked on their tasks. However, all the problem solving/design tasks included constraints such as time allowed to complete the task, the type of task the children were given, and materials available to complete the task. All students appeared to have been enrolled in at least some technology education classes prior to participating in these studies.

One consistent finding from studies of children's natural or untutored problem solving (Mioduser & Kipperman, 2002; Welch, 1998; Welch & Lim, 2000) was that students do not follow the ideal process presented in technology education text books. Nonetheless, middle school children did generate solutions using sophisticated intellectual skills following a build-test-revise-test-revise routine until reaching a solution or running out of time. This finding appears to hold if students are working in groups (Welch, 1998; Welch & Lim, 2000) or alone (Mioduser & Kipperman, 2002), and if given a short time frame of one or two hours (Welch, 1998; Welch & Lim, 2000), or a longer time ((Mioduser & Kipperman, 2002). The main contrast between the ideal and the actual processes children employed is the lack of preparatory planning and the types of models they sometimes built. Jones (1997) also found that middle school children generally did not plan and tended to act first. Untutored students appear to define their understanding of the relationship between the task, their skills, the available materials, and the time allotted by building what they initially believe to be the end product. Depending on what they produce, they shift their criteria of success and revise the product. This appears to be an "understanding by doing" (Twyford & Jarvinen, 2000) problem solving process which is complex and dynamic and in contrast to the ways the official process is portrayed in text books.

The ideal process may be counterproductive as a teaching strategy. Mioduser and Kipperman (2002) pointed out that most texts emphasize the steps in the ideal process to the extent that "…little room is left…for reflection, formative evaluation and resourceful decision-making beyond the detailed guidelines prescribed in a range of teaching materials" (p.124). They also questioned the efficacy of teaching the theoretical model while ignoring the "intellectual toolbox" (p. 134) necessary to implement the text book process. Because, there is scant evidence that experts follow the theoretical problem solving process proposed in technology education text books, further concerns emerged about presenting it to children as a guide for their problem solving. Rather than a sequence of stages characteristic of the commonly used text book prescriptive process, Mioduser and Kipperman (2002) suggested a functional approach (Mioduser, 1998) that defines an interconnected set of intellectual actions to develop problem solving/design solutions (identify, define, explore, implement, evaluate) that is more consistent with middle school age children's prior knowledge and natural tendencies. Welch and Lim (2000) and Twyford and Jarvinen (2000) echoed the idea of following students natural approaches because the "do-test-refine-test-refine" loop "…appeared to increase students' understanding of the problem" (Welch and Lim, 2000, p. 42) they were presented. In other words, the prior knowledge learners bring with them about how to solve problems "…clearly guide analysis and are a part of their interaction with peers." (Twyford and Jarvinen, 2000, p. 45). Thus, prior knowledge can be a powerful foundation to connect novice problem solving skills with progressively more sophisticated intellectual and operational strategies. Welch (1998) observed that "…the bulk of students' untutored technological problem-solving skills will have been acquired in the natural world: building sand castles, using commercial construction kits, constructing with found materials, and so on" (p. 254). Presenting a theoretical ideal problem solving routine that is alien to middle school children's experiences may be so unauthentic that students view it only as an esoteric exercise singularly useful to meet teachers' assigned artificial tasks.

Some evidence indicates that students will do as they have been taught in response to problem solving assignments regardless of the utility or benefits of following the text book model of problem solving. As a result, it is likely that routines such as following the theoretical problem solving model in the textbook will not transfer beyond the particular classrooms in which they are taught. For example, Jones (1997) noted that students are influenced by the culture of their classrooms. When their instruction focuses on building models, models become their "product" rather than the object the model represents. Barak and Maymon (1998) observed that students "…worked continuously and without time constraints, staying behind to work during recesses and after school hours (p. 11)" to complete an assigned project that was similar to the expectations they were required to meet during the whole school year. Finally, Atkinson (2000) observed, "In order to receive high marks teachers have encouraged pupils to provide evidence of each stage of the assessed process, whether it was appropriate to the efficient design of an artifact or not" (p. 260). It may be more productive to let young students follow their noses in terms of process and for teachers to focus more on promoting genuine thinking skills such as evaluating and revising. Over time, middle school children may learn more elaborate processes by imitating teachers as they present repetitive process modeling and multiple trials with projects. Questions such as, "How could this be better? What were you thinking when you decided to do this? What ways did you change your design as you built it and why? and, Can you think of different ways to think about what you did? may lead learners to consider not only what they do but the role of their intellectual skills as they engage in design/build learning.

These studies hint at two additional important issues. The first is the extent to which the ideal problem solving process is an accurate representation of the way problem solving/design is done by experts. The authors of the studies reviewed here portray the ideal problem solving/design process presented in technology education text books as a linear and uniform set of actions though there is virtually no evidence in the problem solving literature that supports the implied assumption that experts or novices, for that matter, ever think in this manner. Twyford and Jarvinen (2000) found that students may best learn to "do" technology by "doing" it. This includes recognizing that, "The pupil's mind changes and develops through active participation" (p. 45). Thus, it may be that the text book ideal conception of problem solving/design is inaccurate and should be abandoned as a teaching strategy. In contrast it may be more successful to focus on empirically verifiable intellectual skills, behaviors, and experiences typical of middle school children. Twyford and Jarvinen (2000) found that students vary widely in their experience, understanding, and vocabulary such that the same assignment will be interpreted in very different ways; focusing on "pragmatic" decision making and "constantly analyzing variables" (Twyford and Jarvinen, 2000, p. 45) may be more beneficial because all children are likely to have at least rudimentary abilities to engage these intellectual processes.

The second issue alluded to in these studies is the wisdom of teaching problem solving/design as a defined process, such as the text book heuristic, no matter how it is defined or portrayed. Because developmental theories offer little information and few strategies to teach specific intellectual routines, it may be preferable to provide middle school children with loosely structured opportunities to engage their design/build instincts and focus more on learners' intellectual actions than what they produce. After all, how realistic is it to expect or to teach middle school children to behave intellectually and/or physically like adult experts? For that matter, how realistic is it to find adults (teachers and others) who have the experiences and skills to behave in ways that are consistent with experts? Expertise gains its status by virtue of being unusual. Thus, expert problem solvers and the physical and intellectual processes they use may not provide the best model for teaching children the initial characteristics of problem solving and design.

Three additional observations are worth considering. First, in all of these studies, students appear to have been specifically chosen because they were enrolled in technology education classes or had demonstrated some skills or experiences that predicted they would be successful on the required assignments in the studies. Students in these studies were selected based on their experiences with similar projects, their advanced verbal abilities to work well in groups, or the probability they would be highly motivated. None of these studies involved students who were representative of the full range of abilities, interests, and prior knowledge that could be expected in public education middle school classrooms. Second, all of these studies limited the time available to students to complete the assigned projects; time available ranged from one hour to 24 hours total. These relatively short experiences may not provide sufficient time for expansive reflection, evaluation, or revision, the intellectual skills crucial for sophisticated problem solving even for middle school age children. Thus, it may be that the tasks and processes that children used in these studies are so constrained by time and the nature of the projects that they offer only the most tenuous implications for "normal" classrooms. Finally, one of the eight studies (Michael, 2001) was conducted in the United States indicating that generating implications for teaching problem solving/design in the United States should be done very cautiously. Some studies claimed that the children "enjoyed" the problem solving activity assigned; however, no evidence of enjoyment was presented other than the investigators' introspective interpretations of the children's behaviors.

These studies illustrate that middle school age children can solve problems using practical and sophisticated intellectual skills. It may be helpful to embed these thinking strategies in more authentic contexts that are realistic about the availability of material, the viability/appeal of the tasks, and the nature of support for resolving problems as children pursue solutions. That is, rather than present problem solving as a single well-defined linear routine, it may be more successful to teach problem solving as a messy, interactive, and ongoing series of situational decisions that focus at the same time on immediate design/build imperatives and the ultimate goals. Thus, making paper towers with an unlimited supply of paper, designing and building projects personally chosen, and having expert/teaching advice available for process and design/build questions may meld the advantages of learning by doing with doing for learning.

Other Issues Associated with Problem Solving

Three studies investigated the impact of computers on creativity (Michael, 2001) and teamwork behavior (Barak & Maymon, 1998; Lavonen, et al, 2002). Michael (2001) addressed the impact of computers to foster creativity in an experimental study; the results indicated that computers have no impact on creativity. Barak & Maymon, (1998) and Lavonen, et al (2002) provide little useful information on the emergence of teamwork "naturally." Incomplete descriptions make the report by Barak & Maymon (1998) problematic for generating reliable conclusions. The results from Lavonen, et. al (2002) indicated that middle school children appeared to be able to collaborate on computer programming problem solving tasks when specifically taught to engage in teamwork behaviors. In this study, students were taught to work in pairs to use proprietary programming software ("Empirica Interface, Empirica Control"). As is consistent with the findings reported above, these children did as they were taught; according to the authors, the software allowed them to engage in "physical thinking" (Lavonen, et al, 2002, p 152). These findings appear very limited in scope beyond the general conclusion that middle school children's thinking is unlikely to conform to the text book model of problem solving.

Gender

Studies by Weber & Custer (2005) and Silverman & Pritchard (1996) investigated the effects of gender on middle school children's preferences and choices in technology education using survey, observation, and interview methods. Though neither of these studies discovered many differences, females tended to prefer "designing" and males tended to prefer "utilizing" (Weber & Custer, 2005). Silverman & Pritchard (1996), though not uncovering gender based issues in middle school children's choices to pursue technology education beyond middle school, provided some perspective on three contextual issues that may be influential.

One of these contextual issues is the classroom environment in which gender stereotyping may have subtle impacts on females' decisions to pursue technology education. Classrooms may have a residue of discomfort that lurks below the surface but is still bothersome. A second issue is the apparent inability of at least some teachers to respond appropriately to control or counteract stereotypical behavior by males. Some teachers indicated they did not know how to respond to apparently minor provocations. A third issue may be the dynamics of interactions between males and females at middle school age. The teaching methods appear to be quite different in technology education versus other classes in that students are engaged in hands on activities; neither gender may have the experience to know how to appropriately behave under conditions where close and cooperative contact with peers is required.

Two studies investigated attitudes toward technology education in Hong Kong and Thailand using variations of the Pupils' Attitude Toward Technology (PATT) scale. Volk and Ming (1999) reported a number of gender based significant differences; however, these findings are problematic due to the use of multiple *t*-tests and the absence of power statistics. ANOVA analysis yielded a pattern that both male and female children who had more experiences and exposure to technologies were more likely to be interested in technology. Becker and Maunsaiyat (2002) conducted a validation study of a version of PATT for Thailand. The students used to validate the Thai version were "…lower secondary school students from one private school and three public schools in the Bangkok metropolitan area" (p. 11). They concluded that, "Overall, the patterns of attitudes and concepts of technology among US and Thai students were similar based on the results of this study" (p. 18). It may be that students' responses are a function of the questions asked more than the attitudes children hold or of location.

A contribution of these studies to understanding gender issues is to point to a need for more sophisticated investigations that clearly conceptualize differences based less on stereotypical preferences for types of projects or teaching methods and more on contextual factors and characteristics such as prior knowledge, learning goals, and motivation. One problem with these gender differentiation studies is that the conception of "technology" tends to be very traditional involving computers or some type of construction tool/machine. Thus, the differences observed, when they are observed, may be more oriented to particular types of technologies rather than toward technology as a concept. There may also be cultural differences that do not hold implications from one culture to another; these cultural differences may be between as well as within specific countries. One conclusion that appears to emerge from all of these studies is the importance of providing opportunities for children to experience a wide range of broadly based technology oriented intellectual and practical activities.

Laboratory Context

Three studies (Culbertson, Daugherty, & Merrill, 2004; Rogers, 2000; Weymer, 2002) investigated middle school children's response to different classroom/laboratory situations all of which included some aspects of curriculum delivered through a modular laboratory program. Weymer (2002) examined the impact of various personal characteristics on children's performance in modular technology education. He used a collection of existing data as well as several specific instruments to correlate students' "(a) prior knowledge of the MTE [modular technology curriculum] content, (b) verbal ability, (c) quantitative ability, (d) intrinsic motivation, and (e) cognitive style with regard to performance on a posttest instrument" (Weymer, 2002, p. 36). The modular technology unit taught "engineering structures" using "CAI" (computer assisted instruction). This study is problematic due to methodological flaws such as the involvement of the investigator with the participants, selection bias, and possible invalid use of instruments. The author's goal was to identify a profile of "how students' individual differences affect performance in MTE" (p. 42). Weymer (2002) concluded that "Students with low verbal ability, lacking prior knowledge, and preferring the field dependent cognitive style were especially at risk…" (p. 45).

Rogers (2000) examined the achievement differences between middle school children who were in "industrial technology education" in "traditional laboratory," "modular laboratory," and "contemporary laboratory" settings. Some unexplained methodological problems plague this study: different group sizes, lack of explanation of the instructional programs in the different settings, and inadequate school demographic information. Rogers (2002) found that the "contemporary laboratory instruction provided significantly better achievement than modular technology education in the areas of general industrial technology education knowledge, drafting technology, manufacturing processes, construction technology, and power/energy" (no page number) following a "nine-week industrial technology education course" (no page number).

Culbertson, Daugherty, & Merrill (2004) compared middle school (seventh and eighth grade) children's standardized test performance on reading, writing, arithmetic, mathematics, and reasoning following enrollment in one trimester, one-half trimester, or no enrollment in a modular technology education unit purported by the publisher to address these core skills (p. 13). The results "indicated that no significant difference existed between the achievement gains shown by each of the three groups in any of the five subject areas" (p. 17). Data were not collected to indicate student learning as a result of being enrolled in the technology education program.

One issue that emerges from these studies is possible confusion about the nature of modular programs. Two extreme views are that modular programs require little more than slavish adherence to directions (e.g. Pullias, 1997) and that modular programs provide opportunities for "self-sufficient" work (Shendow, 1996). While contributing little to resolving the efficacy of modular learning programs, these studies emphasize the possibilities that there may be unexamined consequences that are not necessarily meritorious from using modular programs. In addition, they raise questions as to the comparability of teacher lead and modular curricula particularly as technology education pursues outcome goals such as problem solving/design learning.

Other Investigations of Middle School Children

Three additional studies explored other middle school children issues in these journals. Schallies, Wellensiek, & Lembens (2002) attempted to create a developmental pattern of middle school children's understanding of technology and science in Germany. Using a questionnaire, they found that children's conceptions become somewhat more complex as they grow older; but, in general, the conceptions about technology and science of students of all ages are "not of sufficient clarity or depth," children tend to get their information about science from "media," and children demonstrate a "reductionist view of science and technology" (p 53-54). Because this research was carried out in southern Germany the findings may not be valid outside of Germany.

Boutin and Chenien (1998) and Chenien, Boutin, & Letteri (1997) reported on a program intended to teach Canadian middle school children to enhance their cognitive skills, self-esteem, academic performance, and attitudes toward school…" (no page number). The impact of the program was assessed by comparing dropout rates after two and one-half years. They report that the program resulted in decreased dropout rates and increased cognitive skills for students with high probability of dropout. Teachers reported that they were unprepared to teach these skills though they also reported that the training they received resulted in changing their teaching strategies. Technology education programs or students were not targeted in either study; thus, it is unclear if these results would apply specifically to children enrolled in technology education classes.

Conclusion

These studies raise important questions about influencing middle school children's thinking in technology education classrooms that should be pursued by technology education professionals. Among these questions are: Does teaching a defined heuristic as commonly appears in technology education text books promote or hinder children learning to solve problems? Does teaching a defined heuristic frustrate children using their prior knowledge to become more successful problem solvers? Can problem solving be more effectively taught and learned if instruction focuses on the intellectual skills needed to analyze, monitor, and revise than a defined heuristic? How can technology education teachers build on the prior knowledge children bring with them to teach specific intellectual skills that can be applied in tasks requiring sophisticated thinking such as problem solving/design? What intellectual skills do children need to learn and apply in order to develop problem solving strategies? Can all children learn and apply these problem solving/design skills and strategies?

In addition, it appears that the context in which technology education is taught may have an important impact on what and how children learn, another line of research that technology education professional should pursue. In particular, the role the teacher assumes may be critical in developing positive and supportive learning environments as well as in choosing and presenting content. While the evidence is modest, among the questions raised are: What is the impact of modular laboratory curriculum on children's intellectual skills and strategies? How can teachers promote positive interactions between all children in grouped assignments? Can technology education programs identify curricula that successfully stress learning intellectual skills?

Finally, these investigations illustrate the value of examining variables like children's thinking in technology education learning. Such investigations can be pursued both in classrooms and in more controlled circumstances. Of all the content included in technology education curricula, teaching children to use their intellectual abilities may be among the most important. These investigations indicate that much more knowledge is needed to develop a more complete picture of what and how to influence middle school children's intellectual processes.

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The Soul of Technology Education: Being Human in an Overly Rational World

Scott A. Warner

Introduction

I grew up in a small town located just north of Gettysburg, Pennsylvania. Proximity offered me plenty of opportunities to visit the historic town and its surrounding battlefields. Like most visitors to Gettysburg, I would try to imagine what it must have been like to be there on those three days in July of 1863. Many of the battlefield landmarks, including the Peach Orchard, Devil's Den, Seminary Ridge, and Little Round Top invoked powerful mental pictures for me. The one site that inspired the most overwhelming sense of history was the line of trees that represented the starting point of Pickett's Charge. It was there that approximately 13,000 Confederate soldiers lined up in preparation for marching across a mile of open field against a heavily armed and protected Union position. The men who formed up behind the line of trees to begin the march must have been frightened of the almost certain doom they faced. To this day, I cannot help but be amazed at the courage it must have taken for each of them to do their duty. The noted Civil War author Shelby Foote once said, "If you stop to think about it, it would have been much harder not to go then to go. It would have taken a great deal of courage to say [to General Lee] I ain't goin'. Nobody's got that much courage" (Ward, Burns, & Burns, 1990). By this point in the Civil War the soldiers who took part in Picket's Charge were deeply committed to the friendships they had formed with their fellow soldiers, resolute toward fighting to save a Southern way of life and its culture, and in possession of an undying belief in the invincibility of General Lee as their commander. These factors, both large and small, compelled each man to form rank and march forward into the great grinding jaws of the Union Army on that hot July day.

It is sometimes hard to understand how rational people can become swept up in events that, in hindsight, seem irrational. However, throughout the course of the human experience larger forces that appear to be beyond the control of the individual often sweep us up and move us in directions that we would not choose under different circumstances. Pickett's Charge is just one dramatic example.

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Just like the armies of the Civil War fought to determine the future of the United States, opposing forces are currently struggling to determine the future direction of technology education. Even a casual examination of the current literature and a listing of the topics presented at conferences indicate that efforts are well underway to make engineering education the model against which to measure technology education curricula (ITEA, 2007; ITEA, 2008a; Custer and Erekson, 2008; ITEA, 2008b). These efforts represent political, economic, and cultural forces compelling the profession to move in directions that, in the opinion of this author, will not be in the best interest of all students. Some see technology education from a broad, holistic perspective. Others focus on the world of engineering. In this struggle for the direction of technology education, members of the profession must ask themselves how they see technology education curricula contributing to a better understanding of humankind's ongoing relationship with technology.

Technology reflects through its many artifacts and systems the spirit and humanistic qualities and values of its designers, makers, and users (Norman, 2004). In *Standards for Technological Literacy* (ITEA, 2000), four of the standards were devoted specifically to technology and society. Those four standards (4, 5, 6, and 7) explored the non-technical aspects of technology and the relationships between technology and the social/cultural milieu in which it exists. Unfortunately, even those four standards generally overlooked the role of humanistic qualities and values such as emotions, intuition, and aesthetics in the development and use of technology. In the first chapter of *Standards* the definition of technological literacy reads as follows:

> Technological literacy is the ability to use, manage, assess, and understand technology. A technologically literate person understands, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and how it shapes society, and in turn is shaped by society…. A technologically literate person will be comfortable with and objective about technology, neither scared of it nor infatuated with it. (pp.9-10)

If technology reflects the spirit and humanistic qualities and values of its designers, makers, and users, then the ability of a technologically literate person to be objective about technology may be difficult at best. It is important to recognize that historically humanistic qualities and values have played an integral role in both the creation and the use of technology. Furthermore, later in this article a brief review of the history for the profession of technology education will show that such qualities and values also have played both an explicit and subtle role toward the study of technology.

Once again referring to *Standards*, the study and use of design is clearly a cornerstone toward building technological literacy. Design, in its various forms, was the explicit focus of four of the standards (8, 9, 10, and 11) and an underlying component of the other sixteen standards. In discussing design, *Standards* repeatedly addressed the creative act. However, it was done so with clinical detachment. Creativity and design are human activities heavily laced with emotions and subjectivity (Norman, 2004). In the words that follow I will show that this matter-of-fact presentation of creativity and design in *Standards* indicates an attitude toward the study of technology that is significantly different from the approaches taken by progressive educators of the past, as well as a few individuals from the present. Should technology educators ignore or reject the value of studying the role of humanistic values related to the creation and use of technology, they would significantly reduce the richness of the subject.

Thorndike verses Dewey: A Battle of Ideas

To determine whether technology education curricula should include the emotional, spiritual, and intuitive aspects of the human experience with technology, it is helpful to determine if those humanistic characteristics and values ever had a historical precedent. An investigation of educational philosophy is one place to start such a determination. Two contemporary publications have specifically addressed the philosophical struggles that have fundamentally shaped the nature of American education for the last century. The struggles have been between educational philosophies that represent a humanistic view and those that represent a mechanistic view to the processes of teaching and learning. The most recent article was written by Gibboney (2006) for the *Kappan* and was entitled *Intelligence by Design: Thorndike versus Dewey*. The second document was written by Lewis and Zuga (2005) and was entitled *A Conceptual Framework of Ideas and Issues in Technology Education*. Each of these documents contributed to an understanding of how contemporary models of both general education and technology education have taken their current form.

Lagemann (1989) is quoted in the opening passages of Gibboney's (2006) work to summarize the main point of the article. Lagemann's quote reads: "One cannot understand the history of education in the United States during the twentieth century unless one realizes that Edward L. Thorndike won and John Dewey lost" (p. 170). Most technology educators have a working familiarity with the educational philosophy of John Dewey. Gibboney described Dewey's humanistic approach to teaching and learning in the following passage:

> Dewey believed subject matter in schools exists to make the quality of democratic life as good as it can be under given conditions. He asserted that a teacher ought to try to arouse a continuing interest in learning throughout a student's life…. [Dewey] argues that the goal of schools ought to be developing an attitude – the love of learning. And ultimately, schools should be judged on how well they meet this difficult goal. In other words, what is transferred when a student learns something that is truly important is intangible and immeasurable by test. It is an attitude, the desire to learn. (p.170)

Arguably, Thorndike's work is not as well recognized by technology educators. At best, his name may be one that is vaguely remembered from a distant college course on educational psychology. However, his approach to understanding the workings of intelligence and the processes of teaching and learning could very well claim to be the foundation of contemporary public education, most notably in recent years with the *No Child Left Behind* legislation and the extensive use of standardized tests to measure what students have learned. In short, Thorndike's perspective on the proper approach to teaching and learning was very mechanistic in nature. Gibboney summarized Thorndike's beliefs in this area by stating:

> [Thorndike] believed in the possibility of a science of education so powerful that experts alone would be able to decide what to teach, how to teach it, and how to evaluate it…. [He also] believed that such value-laden matters as setting the aims of education could be done efficiently by experts, using the kind of science he was developing. (p.170)

Gibboney later drew the distinctions between Dewey and Thorndike in very succinct terms by writing "Thorndike saw humans in the image of the machine; Dewey saw them in the image of life" (p.170).

Several factors may have contributed to the ultimate success of Thorndike's mechanistic approach in the struggle for the compass of American education. Though the ideals of progressive education espoused by Dewey were actively embraced by academics, they did not easily fit into the broader American culture. That culture was being driven by the measurable and mechanistic paradigm of the twentieth century industrial revolution, the simplified world of politics, and the increasingly prevalent sense of progress that was defined by the rules of science. Gibboney described this effect by stating, "Thorndike and his successors surely won the minds and hearts of their countrymen. Dewey, ignored in the rough and tumble of legislative halls and teachers' meetings, has lived on in a few protected scholarly havens" (p.171). In the second half of the twentieth century other social-cultural forces were at work such as the political climate created by the Cold War. For example, in the late 1950's and through the 1960's the space race between the United States and the Soviet Union resulted in a major drive in public education to produce engineers and scientists (Lopez & Schultz, 2001). Those efforts compelled American public schools, as well as colleges and universities with science and engineering programs, to produce graduates that would enter these respective fields quickly, thus addressing the needs of the market place as perceived by the general public (Flemming, 1960). In both subtle and obvious ways, the curricula and the philosophies of schools at all levels were changed by these many forces (Herschbach, 1997). As a result, Thorndike's mechanistic view slowly overwhelmed the progressive, humanistic views of educational leaders such as Dewey.

Thorndike and Dewey: The Ripples Move through the History of Technology Education

A natural question resulting from this brief overview of American education is how did these philosophical struggles manifest themselves in technology education? Even a brief review of literature for manual training and industrial arts, the immediate predecessors of technology education, reveals that influential writers and thinkers from those fields had a deep investment in the worth of teaching about technologies within the context of humanistic qualities and values. Selected examples of this type of philosophical foundation, beyond John Dewey, can include Calvin Woodward (1887), who reminded his contemporaries that:

> The word "manual" must, for the present, be the best word to distinguish that peculiar system of liberal education which recognizes the manual as well as the intellectual. I advocate manual training for all children as an element in general education. I care little what tools are used, so long as proper habits (morals) are formed, and provided the windows of the mind are kept open toward the world of things and forces, physical as well as spiritual. (p. 202)

Almost 40 years later, with the transition from manual training to industrial arts fully underway, Frederick Bonser and Lois Mossman (1924) (as cited in Miller and Smalley, 1963) stated that:

> Since the desire for beauty in all that we possess or produce is so fundamental, it is readily seen that the industrial arts and the fine arts are closely and vitally related. Any attempt to separate them completely is artificial. (p. 72)

This passage clearly indicated that Bonser and Mossman identified connections between the study of technology and the humanistic values of beauty and aesthetic pleasure, values so prevalent in the fine arts. In succeeding passages, Bonser and Mossman discussed in detail the values and objectives of industrial arts, which included "(1) a health purpose; (2) an economic purpose; (3) an art or aesthetic purpose; (4) a social purpose; and (5) a recreational purpose" (p.72). Though each of these values and purposes had varying degrees of measurability, a significant component of the mechanistic approach advocated by Thorndike was designed to help students become "efficient in the selection, care, and use of the products of industry, and to become intelligent and humane in the regulation and control of industrial production" (p.72) and were thus primarily humanistic in their goals and objectives.

Between 1940 and 1980, the humanistic qualities and values espoused by Dewey were still on the front page of the professional discussions in the literature. Hornbake (1957), Wilber (1967), and Maley (1973) were leaders in the field who advocated the study of industries and their processes and products within the scope of general education. Time and time again they discussed the importance of the values learned by young people who took industrial arts classes. Topping the list of values discussed in the writings of these individuals and their peers was the importance of learning the principles of democracy. Like Dewey, each of these authors believed that the use of industrial arts education in the general education curriculum contributed toward the overall development of a young person's ability to grow and mature into a fully informed and participating member of a democratic society. Bode (1942) (as cited in Miller and Smalley, 1963) perhaps summed it up best when he stated, "The task confronting our teachers of industrial arts is to make their subject-matter a gateway to a philosophy of life in an industrial democracy" (p.100).

These progressive voices were not the only ones speaking to the profession in the first half of the twentieth century, however. One individual in particular, who seems to have had a rather twisting philosophical journey, was William E. Warner. Warner left a large footprint on the profession through such activities as founding the Epsilon Pi Tau honorary society and the American Industrial Arts Association, mentoring numerous graduate students over the course of a long career, and the development and presentation to the profession of *A*

Curriculum to Reflect Technology (Warner, et al, 1947). This curriculum project, released to the profession in 1947, represented one of the first major efforts to specifically address the study of technology using industrial arts curricula as the means. Ironically, early in his career Warner took courses at Teachers College, Columbia University with both Dewey and Bonser (Lux, 1981). With such mentors, it would be natural to assume that Warner also would advocate industrial arts curricula that were humanistic in nature. However, as Lewis and Zuga (2005) noted, "Perhaps, it [was] because of his essentially conservative nature that he was able to promote a view of industrial arts as a technology based field of study and ignore the social prescriptions for the curriculum which were so evident in the work of Bonser and Mossman" (p.22). Warner's curricular efforts, and the work of his protégés, lead to a broad acceptance of mechanistic thinking toward the teaching and learning processes developed and used by industrial arts. For example, Wilber, one of Warner's protégés, is credited with being the first to define and apply the concepts of behavioral psychology to the field of industrial arts (Thorndike was a behavioral psychologist). Lux (1981) asserted that a "review of standard practice today would document that most industrial arts teachers indeed start their syllabi with lists of behavioral objectives. [Wilber] heavily impacted upon theory, [and] affected the documentation teachers produce to describe their courses and curricula…" (pp.215-216). As noted earlier, Wilber still incorporated humanistic qualities in much of his writing. However, like Warner, he contributed to the steady march away from the humanistic approach advocated by Dewey and Bonser.

Beginning in the 1950's, the tide began to change significantly for industrial arts. Lewis and Zuga (2005) described the reaction of industrial arts leaders toward the social-cultural milieu of that time with this passage:

> Given the backdrop of society and culture in the United States during the 1950's and 1960's, it is easy to see how the leaders in industrial arts education began to distance themselves from the work of Dewey and social reconstruction. Dewey had come into question during the McCarthy era and his ideas were not in favor. Tradition in industrial arts leaned towards industry as a result of many years of alliance with vocational education. Even Warner and his followers, who fought to establish an industrial arts organization separate from the American Vocational Association, did not separate themselves from industry and corporate America, nor did Warner and Olson's students who became the next generation of leaders in industrial arts. [Donald] Maley, [Paul] DeVore, [Donald] Lux, and [Willis] Ray all had ties to William Warner and his influence by either being his students, being students of Warner's students, or working with him. So, as innovation in industrial arts took hold, many of the ideas of Warner and Olson made their way into the thinking and prescriptions for the field by the leaders who created their own curriculum plans and collaborated on the Jackson's Mill compromise. (p.26)

Maley and DeVore: Carrying Forward the Deweyan Heritage

With perhaps the notable exceptions of Maley and DeVore, the shift in industrial arts away from the humanistic approach to education advocated by

Dewey would continue unabated. Lewis and Zuga (2005) described Maley as "the most Deweyan of the new generation of leaders" (p.26). His focus was unquestionably on the student and how the industrial arts curriculum could aid his or her intellectual, social, and cultural development. The program that bore his stamp was *The Maryland Plan* (Maley, 1973). It set the standards for a generation of student-centered industrial arts programs (Kirkwood, Foster, & Bartow, 1994; Rudisill, n.d.). DeVore could be described as a standard bearer among his generation of professional leaders for the value of the study of technology. As early as the 1960's DeVore was calling for the organization of the content of the study of technology into categories that described the human activities of production, communication, and transportation (Kirkwood, Foster, & Bartow, 1994; Lewis & Zuga, 2005). DeVore's humanistic credentials were found in his writings, which "re-introduced into the literature of the field, ideology and sociology with respect to the study of technology" (Lewis & Zuga, 2005, p. 28). Although these individuals significantly influenced the transformation of industrial arts into technology education, their Deweyan perspectives seemed to diminish with the compromises that were necessary to facilitate that transformation.

The Jackson's Mill Industrial Arts Curriculum Theory (Snyder & Hales, 1981) represented a benchmark in the creation of content organizers for the study of technology. These organizers included manufacturing, construction, transportation, and communication. Ultimately, the document represented a compromise between various interpretations of industrial arts curricula and the study of technology. Lewis and Zuga (2005) identified the three primary factions of compromise being between the interpretations of the group advocating the *Industrial Arts Curriculum Project* (IACP), DeVore, and Maley (represented by his supporters and former students at the Jackson's Mill gathering). From the humanistic perspective, the *Jackson's Mill* document presented the profession with a conceptual framework that encompassed the adaptive systems of ideology, sociology, and technology, any one of which could be used as the platform for the exploration of technology. However, the real importance of the *Jackson's Mill* document, and later *A Conceptual Framework for Technology Education* (Sterry & Savage, 1991), is that these documents started the process of moving industrial arts toward the study of technology as the subject matter for the field.

Technology Education Embraces the Standards Movement

Perhaps the most significant movement to formalize the study of technology was initiated through the release of the document *Technology for All Americans: A Rationale and Structure for the Study of Technology* (International Technology Education Association, 1991), which served as the conceptual precursor of *Standards for Technological Literacy* (International Technology Education Association, 2000). The increasing acceptance of *Standards* as the de facto measure of technology education curricula across the United States (Russell, 2005) indicates a profession that has embraced the mechanistic perspectives to intelligence, learning, and teaching advanced by Thorndike. The perception that the profession even needed a set of standards indicated that the educational culture of the last twenty years had taken a conservative path; a path that was mechanistic in its expectations of accountability by measurements (Herschbach, 1997). The humanistic view of these matters seems, for the most part, to have been relegated to history books about progressive education. The mechanistic influences on the development of *Standards* can be seen in the funding agencies, *The National Science Foundation* and the *National Aeronautics and Space Administrati*on (Lewis, 2004), and the individuals who reviewed the document while it was under development: members of the *National Academy of Engineering* (Pannabecker, 2004).

Standards represented an important contribution to the intellectual and philosophical underpinnings for the content of technology education. They also represented the latest example of a continuing struggle for the values embraced by the profession. Though the document still included aspects of the humanistic origins, they were a mere shadow of what they could have been when viewed from the Deweyan perspective. Essentially, Thorndike's mechanistic view continues to dominate the values of technology education.

Contemporary Voices of Descent

Within the profession of technology education there are still a few voices representing the human aspects of the study of technology. Herschbach (2009) identified several of the key individuals who have applied concepts of critical theory and constructivism toward the pedagogy and curricular content of technology education. The writings of Braundy (2004), Pretzer (1997), Seemann (2003), Duncan (1996), Hansen (2000), Hatch (1988), Kolodner (2002), and Satchwell and Loepp (2002) were identified as representative examples of critical and postmodern writings in the contemporary professional literature. Two individuals who were highlighted as representing the leading edge of these philosophical perspectives were Stephen Petrina and Karen Zuga. Herschbach noted that Petrina (1993a, 1993b, 1998, 2000a, 2000b, 2004) created an extensive list of publications. These writings:

> First, …questioned the limited scope of the concept of technological literacy. Second, [Petrina] argued that technology education grounded in an instrumental, essentialist framework fails to convey an understanding of the larger historical, sociological, political, and human dimensions of technology, an understanding that is crucial to an informed citizenry. Third, [Petrina] offered an alternative vision of technology education that takes as its starting point the human and cultural dimensions of technology. (p. 208)

Zuga's contributions (1992, 1999) contained a theme of critical feminist theory. This theory called into question the masculine dominance of the language, the activities, and interpretations of the nature of technology within technology education. Herschbach observed that:

> Zuga (1999) argued for a fundamental restructuring of technology education, a fundamentally different technology education for women and a rethinking of

> both content and practice. She observed that the development of technology itself is an activity directed toward the control of nature and the material world. A different technology education would not only help "dispel the dominance of masculine thinking" (p.64), but would also sensitize individuals to the often overpowering influence of technology on our lives and its potentially destructive effects on the natural world. (p. 211)

Progressive authors and thinkers, like Petrina and Zuga, continue to carry a torch for technology education that represents a program of study that is broad and encompassing of all of the elements of what it means to be human in a technological world. However, their perspective is being overwhelmed by increasing pressures to embrace a model of technology education that seems to be a page right out of Thorndike's vision of education. That model is fashioned after engineering.

The Influence of Engineering on the Value System of Technology Education

Pannabecker's (2004) interpretation of the influence of engineering toward *Standards* carried with it words of caution for our profession. His analysis found the mechanistic model of teaching and learning, as controlled by experts and endorsed by Thorndike, deeply entrenched in *Standards*. Pannabecker wrote:

> How might the influence of engineering relate to the ideological emphasis on the "effects" of technology in *STL* standards 4, 5, and 7? By designing these standards around "effects," the development of technology can be separated conceptually from social values, thus reinforcing the evaluation of technology as "end result." The artifacts can then be controlled and fixed by engineers. It might be government agencies that employ engineers to evaluate the technologies and recommend "fixes," but engineers remain in control of fixing, redesigning, or retrofitting the technology. This approach contrasts with an instructional model that integrates social conscience or responsibility within the design and construction process, and that sanctions the expression of critical reflection (such as "whistle-blowing") for both engineers and the public.
>
> Instead, *STL*'s dominant tone is one of implied neutrality, but with the "engineer in control." Although ethics is mentioned a few times in the *STL* narrative of standards 8-13 (pp.97, 98, 104, 111), it is clearly not central to the standards of design and development. This is subtle politics that isolates the discourse of social responsibility from the design and construction process, focusing social responsibility at the end use, or "effects" stage. Historians labor to uncover and understand these kinds of politics, the study of which should be included in teacher preparation and graduate programs in technology education. (p. 76)

If Pannabecker's observations are correct, then technology education should move with caution in developing closer ties with engineering or risk completely severing all ties to its humanistic heritage.

One final caution on this matter comes from the field of engineering itself. Florman's (1994) work entitled *The Existential Pleasures of Engineering* discussed how that profession had lost some of its own humanistic anchors. The author described the difficulties that engineering schools had in keeping promising students in their programs. He also described how the culture of engineering school had evolved a mentality that advocated that engineering education be organized as a type of filtering mechanism. Florman observed that:

> Young people are dropping out of engineering school for the same reason they shunned it in the first place: The program is laborious and in many respects disagreeable. The "hands-on" approach is largely gone, increasingly replaced by scientific theory. "Research" is in while "teaching" is out, a casualty of the way engineering education has been funded for several decades….
>
> Once the major problem has been identified, the solution seems stunningly obvious. We should stop looking at engineering school as a boot camp designed to eliminate all but the most dogged recruits. We should stop making the first two years the obstacle course they have become – consisting of calculus, physics, and chemistry. We should bring practical, creative, "fun" engineering into every year, particularly the first, and teach mathematics and the sciences as enabling complements to engineering rather than isolated afflictions to be endured. We should help young people perceive how important technology is in the scheme of things. We should advise and nurture the students at every step along the way, paying particular attention to the needs of women and under-represented minorities. Thus will we attract talented young people to engineering, keep them from dropping out, and at the same time improve the quality of our graduates. (p. xv)

This passage reads like a list of all the things that technology education should try to avoid. His suggestions for reforming the culture of engineering school resemble the types of things that a humanist like Dewey would have encouraged. In light of this, perhaps the tables should be turned and the conversation should be about how engineering education would benefit by adopting the humanistic models of the study of technology instead of how technology education would benefit by being more like engineering education.

A Whole New Mind: Reclaiming the Soul of Technology Education

Sirotnik (1983) summarized the dominant American public school paradigm of the late 20th century by stating, "…the 'modus operandi' of the typical classroom is still didactics, practice, and little else" (pp16-17). With the current pressures of standardized testing, school accountability, and adequate yearly progress the application of the types of mechanistic teaching practices that were so prevalent more then two decades ago are still, sadly, the basic method of operation in most classrooms and in most schools. However, even under these pressures a mechanistic approach to teaching, especially in technology education, is questionable in value. Caine and Caine (1991) argued that the role of emotion toward the learning process was essentially ignored by the dominant school paradigm. They, like the progressive educators from technology education's past, advocated the value of making connections between the material being taught and student interests. Johnson (2006) noted that with the changing landscape of the global marketplace the emphasis ought to be on helping students to develop right brain thinking patterns instead of the analytical, logical patterns that are the primary focus of an engineering education. Johnson noted that, "Successful players in this new economy will increasingly be required to develop and use the right-brain abilities of high concept (seeing the larger picture, synthesizing information) and high touch (being empathetic, creating meaning)" (¶ 3). The author then builds on the writings of Daniel Pink in his book *A Whole New Mind: Moving from the Information Age to the Conceptual Age* (2005) to elaborate on how schools can teach students to become successful players in this new economy:

> [Pink suggests] we work toward developing in ourselves (and by implication, in our students), six right brain 'senses' to complement our left-brain, analytic skills. We need to realize the value of:
>
> - Not just function, but also design.
> - Not just argument, but also story.
> - Not just focus, but also symphony.
> - Not just logic, but also empathy.
> - Not just seriousness, but also play.
> - Not just accumulation, but also meaning.
> - And I would add a final conceptual age skill to Pink's list:
> - Not just knowledge, but also learning.
>
> In the age of educational accountability, we seem to be gearing all of our instructional efforts to helping students master left-brain skills, because that's what the tests measure, of course. But to what extent should we also be helping kids develop design sense, storytelling abilities, synthesis, feelings for others, humor, and the ability to detect the importance of the information they learn? Our society and educational system sadly sees many of these opportunities that develop conceptual-age skills as extras – frills that often are the first to be cut in times of tight budgets. It's tragic that by doing so, we are doing a disservice to our students as future workers and citizens. (¶ 4-5 & 7)

Johnson's message is especially pertinent to the field of technology education. The list of conceptual age values is laced with terms and concepts that would resonate with a progressive educator such as Dewey. The list could almost be identified as a comparison between engineering education and the ideals of a humanistic approach to technology education. Reflective educators should recognize that diverse thinking, learning, and teaching styles are important variables in determining the value of a subject matter and a program.

It is important to recognize that technology education can naturally offer an alternative to the dominant paradigm of American education. Wolk (1998), who came from an elementary education background, described project-based education as the best means of achieving the ideal blending of knowledge, experience, and thinking skills advocated most recently by Pink (2005) and Johnson (2006) but also by Dewey (1916, 1938) generations earlier. Wolk's own observations were that project-based education, "offers the possibility of truly breaking free from traditional schooling, of making learning a meaningful and democratic experience" (p. 96). The author later defined a project in the following way:

> To me, projects are open, long-term, integrative inquiries done in a social setting that [is] created and/or developed with much student input and

> ownership. I strive for our projects to be *authentic* [italics in original source] as possible, meaning they're for real purposes, using "real world" sources. (p. 96)

Wolk's interpretation of project-based education was constructivist in philosophy. Furthermore, the process of learning was as valuable to him as content knowledge. This was emphasized in his writing when he stated that:

> No longer is the process simply a means to an end. It is knowledge in itself. This vision not only offers different methods for teaching, it profoundly changes *the purpose of school* [italics in original source]. The ideals and attitudes that are learned through the democratic process become an important part of the intended curriculum. (p. 97)

The structure of Wolk's interpretation of project-based education had components that included students and teachers involved with planning, research, documentation, development and creation of artifacts, presentations, and assessment. In short, Wolk's project-based education is simply design-based technology education by another name. His model of excellence is one that represented the type of progressive ideals that technology education can emulate and readily replicate, if the profession should choose to move in that direction.

Conclusions

If technology education is to become a vital part of the general education curricula, it must recognize the importance of the humanistic aspects of teaching and learning. To achieve this goal it will need to examine the story it wishes to tell. If we choose the storyline written by Edward Thorndike then we will never be able to teach technology education with the full richness it deserves. An alignment with engineering could limit our profession achieving diversity among the students and narrow the content in our courses. Taking this direction would further enhance the mechanistic and analytical views of teaching and learning advocated by Thorndike. If, however, we choose the storyline written by John Dewey, we put out the welcome mat to all students in the public schools as we not only talk about, but also live the philosophy of a democratic classroom. In the battle for the heart of American education, Thorndike may be winning, but in the long-term conflict for the soul of technology education we have to ask, do we want to embrace the machine or the human?

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