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From the Editor

Engineering Education, Technology Education: Does it Matter? Are We Pursuing the Same Goals?

This edition's editorial is quite different than past editorials; I have planned a reflection (of sorts) for you. Below are a series of citations from scholarly technology and engineering publications. What I would like you to do is to answer each question with the best possible choice given.

1. Perhaps the most constant feature of _____ education has been the demand for change.
   A. Technology
   B. Engineering

How did you answer question one? According to Seely (1999), in his historical examination of engineering education between 1900 and 1965, the answer should be engineering. Could you have also chosen technology as your answer?

2. The combination of classroom instruction with practice in laboratories and shops describes _____ _____.
   A. Technology education
   B. Engineering education

The answer for question two, according to the original citation, is engineering education. In between the times of 1863 and 1878, Stillman Robinson was an engineering professor at the University of Illinois. Robinson educated his students with both knowledge and skill by designing and building such artifacts as steam engines and a tower clock, Seely (1999); Robinson balanced the theoretical with a hands-on approach – the verb of engineering. Could you have also chosen technology education as your answer?

3. The issue of general education has dogged _____ educators.
   A. Technology
   B. Engineering

The answer for question three, according to the original citation, is engineering (in both blanks). During the mid to late 1900s, Eric Walker, Dean of Engineering and later President of Penn State University, argued that engineering should be considered a liberal art (Seely, 2005). Could you have also chosen technology as your answer?

4. _____ is a profoundly creative process.
   A. Technology
   B. Engineering

Question four, especially given the only answers you could utilize, would be engineering, which is exactly how the National Academy of Engineering described engineering in The Engineer of 2020: Visions of Engineering in the New Century (2004, p. 7). Could you have chosen another answer for this question? Problem solving, technological design or engineering design would work.

5. _____ _____ utilizes curriculum that educates students on biotechnology, nanotechnology, materials science, information and communication technology, and logistics?
   A. Technology education
   B. Engineering education

In the citation from the National Academy of Engineering (2004), the answer is engineering education. The National Academy of Engineering discusses biotechnology, nanotechnology, materials science, information and communication technology, and logistics in substantial length and notes that these are tremendously important areas for engineers to study. Are these curricular areas also important for a technologically literate citizenry? Could technology education be inserted for the answer to this question?

6. The available evidence shows that engaging elementary and secondary students in learning _____ ideas and practices is not only possible, but can lead to positive learning outcomes.
   A. Technological
   B. Engineering

In the National Academy of Engineering and National Research Council's (2009) Engineering in K-12 Education: Understanding the Status and Improving the Prospects, the answer to question six is engineering. Could technological be inserted instead of engineering?

7. The potential effectiveness of K-12 _____ _____ has been limited by a number of factors, such as curriculum, professional development, new content with existing curricula in other subjects, standards-based education, teacher certification requirements, and pre-service teacher preparation programs.
   A. Technology education
   B. Engineering education

According to the information found in the National Academy of Engineering and National Research Council's (2009) Engineering in K-12 Education: Understanding the Status and Improving the Prospects, the answer to question seven is engineering education. Has technology education struggled with curriculum, professional development, new content with existing curricula in other subjects, standards-based education, teacher certification requirements, and pre-service teacher preparation programs?

8. The potential for enriching and improving K-12 STEM education is real, and _____ _____ can be the catalyst.
   - A. Technology education
   - B. Engineering education

The answer, engineering education, is based on the National Academy of Engineering and National Research Council's (2009) Engineering in K-12 Education: Understanding the Status and Improving the Prospects. Could you also insert technology education as the answer?

Does it matter what we believe? Yes, it matters what we believe as a profession. We all need to believe that teaching for technological literacy involves engineering concepts and teaching engineering (the verb) involves technological concepts, both of which also rely on scientific and mathematical understanding. We need to believe that there is no single right answer.

Are we pursuing the same goals? Yes, I believe we are pursuing the same goals if we are focused on students at the P-16 levels. Whether you call it engineering education, technology education, or technology & engineering education, should not be the issue. Rather, the issue should be preparing students to live in an ever changing world where technological, engineering, mathematical, and scientific knowledge and skill will satisfy our human needs and wants.

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Articles

Future Critical Issues and Problems Facing Technology and Engineering Education in the Commonwealth of Virginia

The word *crisis* is not always presented as having a negative connotation. John F. Kennedy once said, “When written in Chinese, the word “crisis” is composed of two characters - one represents danger and the other opportunity” (John F. Kennedy Presidential Library and Museum, 1959). Some may feel that the technology and engineering profession is in a crisis, but in the midst of this crisis, opportunities exist. As Sanders suggested, “A series of circumstances has once more created an opportunity for technology educators to develop and implement new integrative approaches to STEM education” (2009, p. 20). STEM education is just one of many potential technology and engineering education opportunities; however, concerns, as well as opportunities, must be identified and prioritized in order to ensure the profession correctly progresses into the future.

Evolving from manual arts, vocational education, and industrial arts, technology and engineering education in the United States is the result of an evolutionary process that spans two centuries. Changing philosophy concerning what these programs should teach students drove much of that evolution. Among others, the philosophical points of view documented by Woodward, Dewey, Warner, Olson, Snyder & Hales, and the *Standards for Technological Literacy* (ITEA/ITEEA, 2000/2002/2007) guided curriculum development. It is widely accepted that technology and engineering education should continue to evolve in order to meet future requirements (Kelley & Kellam, 2009; Kozak, 1992; Lewis, 2005). In response to the changing face of technology, in 1992 the Virginia Council on Technology Education for the 21st Century published *The Technology Education Curriculum K-12*. This document addressed the concerns of the day. The preface stated:

> In less than 80 years, the western world has moved from an economy primarily based on agriculture through an industrial age to a contemporary society based largely on information and technology. Technology has become the dynamic, driving force in modern life and has achieved such a high level of sophistication that many people are unable to comprehend its economic, social, and cultural impact. Consequently, citizens often feel they lack control over their daily lives because they do not understand

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technological changes or the reasons for them.

> Schools today must prepare students to understand technological innovation, the productivity of technology, the impact of technology on the quality of life, and the need for critical evaluation of the social changes resulting from technological changes. Educators must ensure that graduates are prepared to live knowledgeably in a technology-based society and contribute productively to it. (Willcox & Van Dyke, 1992, p. iii)

As theoretical program changes occurred in the past, curricula also changed to meet program goals and objectives. Creating curricula that address philosophical program changes presents a challenge. McCabe and Litowitz indicated that “one of the major obstacles hindering the continued growth of technology education is the lack of a curriculum development aptitude by secondary level teachers to create and implement curricular change” (as cited in Wicklein, 1993b, p. 66).

Wicklein (1993a, 2005) and Ritz (2009) performed studies in an effort to help guide future needs of the technology education profession. Wicklein’s (1993a, 2005) studies on the critical issues and problems in technology education laid the foundation for this study. Ritz’s (2009) *A New Generation of Goals for Technology Education* study provided additional information “to develop meaningful instructional programs for technology education” (p. 50). Indeed, every profession requires periodic program assessment. Hoepfl and Lindstrom (2007) indicated that assessments are necessary to maintain viable technology and engineering programs. Day and Schwaller (2007) identified ten principles of program assessment in technology education. Principle number three stated, “Assessment works best when the program it seeks to improve has clear, explicitly stated purposes” (p. 253).

The International Technology and Engineering Educators Association (ITEEA)—formerly ITEA—provided program evaluation guidance in their *Realizing Excellence: Structuring Technology Programs* (2005) document. The document stated, “Evaluation refers to the process of collecting and processing information and data to determine how well a program and its various components meet the requirements and provide direction for improvements” (ITEA/ITEEA, 2005, p. 8).

Purpose

The purpose of this research was to determine the future critical issues and problems facing the K-12 technology and engineering education profession in the Commonwealth of Virginia. This study was based on the Wicklein nationwide studies (1993a, 2005). Even though this study did not exactly replicate the Wicklein studies—since it was limited to the Commonwealth of Virginia—the method and questions used were identical.

When introducing this study to participants, the researchers defined the terms *critical issue, critical problem,* and *future*. The following excerpt from

Wicklein's 1993 study identifies how those terms were defined and how these researchers used the term to conduct the study.

> A critical issue was defined as: Of crucial importance relating to at least two points of view that are debatable or in dispute within technology education. A critical problem was defined as: A crucial impediment to the progress or survivability of technology education…. The term "future" was defined as: A projected period of time of 3-5 years in the future. This span of time was judged as appropriate based on current strategic planning procedures used by the ITEA (5 year increments). Based upon identified critical issues and problems the leadership of the technology education profession could more accurately design a path to achieve the primary mission of advancing technological literacy. (Wicklein, 1993a, p. 56)

This study focused on two of the four research questions found in Wicklein's study.

- What are the critical issues that most probably will impact on the technology education discipline in the future (3-5 years)? (1993a, p. 56).
- What are the critical problems that most probably will impact on the technology education discipline in the future (3-5 years)? (1993a, p. 56).

During the 2009 Virginia Governor's STEM education conference, technology and engineering education stakeholders held a breakout session to discuss the future of the profession in the Commonwealth of Virginia. Whereas there was a tremendous amount of information conveyed, no definitive focus arose. The Virginia Career and Technical Education Supervisors organization sponsored a second meeting, held in Henrico County. Third and fourth meetings were held in Richmond. After the meetings, there was still no clear focus. It was the opinion of several group members that a study should be performed to determine what Commonwealth of Virginia stakeholders felt were the most pressing issues and problems facing Virginia programs. Based on study results, the group could then devise a plan to address future technology and engineering education curriculum and program needs. Wicklein (1993a) recognized that data driven decisions are essential when planning for the future.

> The need to plan for the future is critical to the overall health of any organization. However, planning is often biased by the opinions of a select group of individuals who may not possess the knowledge and/or empirical data to formulate a plan that could address the most critical current and future concerns and issues facing the agency/institution. (p. 54)

This study utilized the input of a group of informed technology and engineering education stakeholders, as suggested by Wicklein in both of his studies (1993a, 2005).

Methodology

The purpose of this research was to determine the future critical issues and problems facing the technology and engineering education profession in the Commonwealth of Virginia. Hsu and Stanford (2007) identified that "The Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise" (p. 1). Wicklein (1993a) recognized that "the primary objective of a Delphi inquiry is to obtain a consensus of opinion from a group of respondents" (p. 56). The Delphi technique was used to consult a body of experts, gather information, and formulate a group consensus, while limiting the complications and disadvantages of face-to-face group interaction (Isaac & Michael, 1981). An electronic Delphi study was used to reduce the potential for a panel member dominating the interaction or distortions arising from decisions based on panel member feedback (Clayton, 1997).

Anonymity, interaction with controlled feedback, and statistical group responses were used in the study. Through the Delphi technique, participant anonymity was secured, allowing individuals to change their opinion on the subject matter, while also preventing them from being persuaded or inhibited by other participants (Clayton, 1997). Group consensus was an essential component for the Delphi process, since it is a function of the validity and quality of the initial competency selection process through the literature review (Custer, Scarcella, & Stewart, 1999). Researchers used a modified Delphi (three round) study to ask Commonwealth of Virginia technology and engineering education stakeholders, hereafter referred to as panelists, what they felt were the future critical issues and problems concerning Virginia technology and engineering education programs.

Population

As in Wicklein's study (1993a), "the success of the Delphi Technique relies upon the use of informed opinion; random selection was not considered when selecting the Delphi participants" (p. 57). The researchers of this study emailed 56 technology and engineering education stakeholders, who had been actively involved in technology and engineering education, and asked if they would agree to participate in this study. Of the 56 stakeholders asked to participate, 30 agreed. The participating panelists consisted of six state and district level technology and engineering education administrators, 11 former Virginia Technology Education Association (VTEA) State or Regional Presidents, four current or past members of the VTEA Board of Directors, two Virginia technology and engineering education teachers of the year, five technology and engineering teachers that have been very involved the Virginia Technology Student Association, and two technology and engineering education teacher educators. Eight of the 30 panelists were female. Potential panelists were provided with an overview of the study and specific study questions that they would be asked to answer.

Procedure

Round one of this Delphi study commenced when researchers emailed panelists the background and purpose of the study. The researchers provided the definitions of the terms *critical issues* and *critical problems*. The first round asked panelists to identify as many future issues and problems as they deemed necessary. Using qualitative research coding procedures, the researchers categorized the issues and problems into key descriptors (Patton, 2002, p. 127). Round two asked panelists to rate the key descriptors using a Likert-type scale. Round three asked panelists to identify key descriptors that they felt were *essential* or *non-essential* for profession leaders to address when planning future technology and engineering program guidance.

Analysis of Findings

Delphi I

Via an online survey tool, panelists were asked to provide as many answers as possible to the following questions; those questions were:

1. What are the critical issues that most probably will impact the technology and engineering education discipline in Virginia in the future (3-5 years)?
2. What are the critical problems that most probably will impact the technology and engineering education discipline in Virginia in the future (3-5 years)?

Panelists were also provided the following definitions:

- A critical issue was defined as: Of crucial importance relating to at least two points of view that are debatable or in dispute within technology education (Wicklein, 1993a, p. 56).
- A critical problem was defined as: A crucial impediment to the progress or survivability of technology education (Wicklein, 1993a, p. 56).

Twenty-nine of the 30 panelists responded. Those 29 panelists provided 63 future issues and 75 future problems facing the future of technology and engineering education in Virginia. The researchers classified and coded these 63 issues and 75 problems into key descriptors, which resulted in 21 future issue and 20 future problem key descriptors. These key descriptors formed the basis for rounds two and three of this study.

Delphi II

Researchers asked panelists to consider the same two questions when rating the critical issues and problems in round two. The researchers asked participants to use the Likert-type scale (*strongly disagree, disagree, neutral, agree,* or *strongly agree*) when responding to the 21 future issue and 20 future problem key descriptors. Twenty-eight panelists rated the critical issue key descriptors in question one and 29 rated most of the critical problem key descriptors in question two. Table 1 identifies key descriptors and how panelists felt those descriptors represented future critical issues facing technology and engineering education in Virginia.

Table 1 (continued on next page)
Future Critical Issues Key Descriptors Ratings and Response Frequencies

	Future Critical Issues		**Number of Responses**				
Delphi II	**Key Descriptor**	***Mean***	***SD***	***D***	***N***	***A***	***SA***
1	Technology and engineering education (TEE) programs are not always defined in a correct manner	4.29	1	0	0	16	11
2	There is a TEE teacher shortage	4.11	1	0	6	9	12
3	TEE courses need to become core courses	4.11	1	0	6	9	12
4	There is a lack of funding to support TEE	4.11	0	1	6	10	11
5	TEE is not equally represented in student scheduling	4.11	0	1	7	8	12
6	TEE programs do not always receive appropriate value	4.07	1	1	2	15	9
7	There is an increasing number of secondary TEE program closures	3.93	0	2	4	16	6
8	TEE curriculum development/standardization/ to include STEM, needs to be improved	3.82	2	2	3	13	8
9	TEE teacher college prep programs must be improved	3.82	1	0	8	13	6
10	The Science profession is competing with TEE programs	3.68	0	4	6	13	5
11	TEE is viewed as for males, not females	3.61	1	3	8	10	6

12	Secondary TEE teacher professional development needs to be improved	3.61	0	4	8	11	5
13	There is no clear focus for the future of TEE programs	3.54	1	3	6	16	2
14	There is a lack of TEE dual enrollment opportunities	3.54	0	5	9	8	6
15	TEE programs/courses need standardized testing	3.50	2	2	10	8	6
16	TEE needs to have an industry credentialing plan/focus	3.48	1	0	12	13	1
17	TEE has a lack of administrative support	3.43	1	4	11	6	6
18	TEE teachers are not adequately prepared to teach engineering	3.21	1	6	9	10	2
19	TEE teachers do not know industry needs	3.18	1	6	9	11	1
20	TEE class sizes are too large	3.14	0	6	14	6	2
21	There are too many TEE courses available to students	2.61	2	13	9	2	2

Table 2 identifies key descriptors and how panelists felt those descriptors represented future critical problems facing technology and engineering education in Virginia.

Table 2 (continued on next page)
Future Critical Problems Key Descriptors Ratings and Response Frequencies

	Future Critical Problems		**Number of Responses**				
Delphi II	**Key Descriptor**	***Mean***	***SD***	***D***	***N***	***A***	***SA***
1	Technology and Engineering Education (TEE) needs to be better marketed	4.57	0	0	0	12	16
2	School counselors do not understand TEE	4.50	0	0	2	10	16
3	Some TEE courses need to have AP status	4.07	0	1	5	14	9
4	There is a lack of TEE teachers	4.07	1	0	5	13	10
5	There is a lack of TEE teacher preparation programs	4.03	0	0	8	12	9

6	There is not enough room for TEE electives in students' schedules	3.97	1	1	6	11	10
7	College TEE teacher preparation programs need to be improved	3.97	0	1	8	11	9
8	There is a lack of TEE teacher involvement in Technology Student Association	3.86	0	2	5	17	5
9	TEE should have standardized STEM curriculum	3.79	1	2	7	11	8
10	TEE teachers should receive competitive pay	3.76	0	4	6	12	7
11	There is a lack of research identifying the benefits of TEE	3.69	1	3	5	15	5
12	There are too many secondary TEE programs closing	3.69	0	1	10	15	3
13	There is a lack of effective TEE professional development	3.59	1	2	10	11	5
14	Declining secondary TEE student enrollment	3.52	0	4	9	13	3
15	TEE teachers not adapting to new curriculum needs	3.45	1	2	10	15	1
16	TEE teachers not prepared to teach engineering	3.34	1	6	8	10	4
17	TEE programs have inadequate lab space	3.21	0	6	13	8	2
18	TEE teachers' lack of understanding/use of correct terminology	3.11	2	6	9	9	2
19	TEE teachers have a lack of understanding for future industry needs	2.97	1	7	13	8	0
20	Lack of support from VTEA, VDOE, and Universities	2.90	3	9	5	12	0

Delphi III

In round two, panelists rated all key descriptors that they had identified in round one. For round three, the researchers identified key descriptors that received a 3.5 or higher rating in round two. Based on a Likert-type scale of 1 to 5, the mean of 3.5 and above implied that panelists' generally *agreed* or *strongly agreed* about those key descriptors. For each key descriptor, panelists were asked to indicate if they felt that the descriptors were *essential* or *non-essential* for technology and engineering education leaders to address. Twenty-nine panelists responded; however, not all responded to each key descriptor. Using the mean of 3.5 and above criterion for panelists to indicate that a key descriptor was *essential*, this study found that the panelists felt that there were 12 future critical issues and 13 future critical problems facing technology and engineering education in Virginia. Using the criterion of 50% of more, Table 3 lists the future critical issues that the panelists considered *essential* and the percentage of participants who felt those issues were *essential.* Table 4 provides the same information concerning future critical problems. Both Tables 3 and 4 identify similarities between this study and the results found in the Wicklein study (1993a).

Table 3 (continued on next page)
Essential Future Critical Issues Facing Technology and Engineering Education in Virginia

Delphi III	Key Descriptor	Number Considering Essential	Percentage	Wicklein 1993a Study Findings
1	Technology and Engineering Education (TEE) programs are not always defined in a correct manner	24 of 28	85.7%	Poor and/or inadequate public relations for technology ed.
2	TEE programs do not always receive appropriate value	23 of 28	82.1%	General populous ignorant regarding technology and the discipline of technology ed.
3	TEE curriculum development/ standardization/to include STEM, needs to be improved	22 of 29	75.9%	Non-unified curriculum for technology ed.; Curriculum development paradigms for technology ed.

4	There is no clear focus for the future of TEE programs	21 of 28	72.4%	Lack of consensus of curriculum content for technology ed.
5	TEE is not equally represented in student scheduling	20 of 28	71.4%	HS graduation requirements reduce opportunities for technology ed. courses
6	There is a lack of funding to support TEE	20 of 28	71.4%	Insufficient funding of technology ed. programs; Funding of technology ed.
7	There is a TEE teacher shortage	20 of 29	69.0%	Insufficient quantities of technology ed. teachers; Elimination of teacher education programs in technology ed.
8	There are an increasing number of secondary TEE program closures	17 of 27	63.0%	Elimination of technology ed. programs
9	TEE courses need to become core courses	18 of 29	62.1%	No similar issues or problems
10	TEE college prep programs must be improved	16 of 28	57.9%	Inappropriate certification procedures for technology ed.
11	TEE is viewed as for males, not females	16 of 29	55.2%	Number of females in technology ed.
12	Secondary TEE teacher professional development needs to be improved	15 of 28	53.6%	Inferior in-service training for technology ed.

Note: Not all panelists responded to every key descriptor.

Table 4 (continued on next page)
Essential Future Critical Problems Facing Technology and Engineering Education in Virginia

Delphi III	Key Descriptor	Number Considering Essential	Percentage	Wicklein 1993a Study Findings
1	School counselors do not understand technology and engineering education (TEE)	27 of 29	93.1%	Inaccurate understanding and support of technology ed. by administrators and counselors
2	Secondary TEE enrollment is declining	25 of 28	89.3%	Recruitment of students and teachers in technology ed.; Declining enrollments in technology ed. courses
3	TEE needs to be better marketed	22 of 27	81.5%	Inadequate marketing and public relations of technology ed.
4	There is a lack of TEE teacher preparation programs	22 of 28	78.6%	Insufficient quantities of technology ed. teachers; Elimination of teacher education programs in technology ed.
5	There is a lack of TEE teachers	22 of 29	75.9%	Insufficient quantities of technology ed. teachers; Elimination of teacher education programs in technology ed.
6	There is a lack of research identifying the benefits of TEE	21 of 28	75.0%	Inadequate research base for technology ed.; No clear research agenda for technology ed.; Defining measurable outcomes for technology ed. students; Research agenda for technology ed.
7	There is not enough room for TEE electives in students' schedules	19 of 28	67.9%	High school graduation requirement restrictions on technology ed.

8	There are too many secondary TEE programs closing	19 of 28	67.9%	Elimination of technology ed. programs; Program closings and eliminations in technology ed.
9	College TEE teacher preparation programs need to be improved	18 of 28	64.3%	Inappropriate certification procedures for technology ed.
10	TEE should have standardized STEM curriculum	18 of 28	64.3%	Non-unified curriculum for technology ed.
11	There is a lack of TEE teacher involvement in Technology Student Association	17 of 29	58.6%	No similar issue or problem identified
12	Some TEE courses need to have AP status	16 of 29	55.2%	No similar issue or problem identified
13	TEE teachers should receive competitive pay	15 of 28	53.6%	Insufficient funding of technology ed. programs

Note: Not all panelists responded to every key descriptor.

In order for specific problems and issues to make the final list (Tables 3 and 4), at least 50% of participants had to indicate that they felt those problems and issues were essential to take into consideration when planning the future of technology and engineering education in Virginia. This process is consistent with cut-rates reported in other educational research studies, such as Lewis, Green, Mitzel, Baum, and Patz (1996) and Mitzel, Lewis, Patz, and Green (2001). Table 5 provides a comparison of the top five indicators (above 75%) found in the three studies, including Wicklein's 1993 and 2005 studies and Katsioloudis and Moye's study from 2011. The top five indicators showed that further correlation exists between the three studies. Even though the indicators do not share the same position in the hierarchy, they suggest that the problems facing the technology and engineering education profession have remained very similar for the past two decades.

Table 5
Comparison of Top Five Issues and Problems –Wicklein (1993, 2005) and Katsioloudis and Moye (2011)

	Future Problems (Wicklein, 1993)	**Problems (Wicklein, 2005)**	**Critical Issues and Problems (Katsioloudis & Moye, 2011)**
1	Insufficient quantities of technology education teachers and elimination of teacher education programs in technology education	Insufficient quantities of qualified technology education teachers	School counselors do not understand technology and engineering education (TEE)
2	Loss of technology education identity, absorbed within other disciplines	Inadequate understanding by administrators and counselors concerning technology education	Secondary TEE enrollment is declining
3	Poor and/or inadequate public relations for technology education	Inadequate understanding by general populace concerning technology education	TEE needs to be better marketed
4	Insufficient funding of technology education programs	Lack of consensus of curriculum content for technology education	There is a lack of TEE teacher preparation programs
5	Non-unified curriculum for technology education	Inadequate financial support for technology education programs	There is a lack of TEE teachers

Discussion

The purpose of this research was to determine the future critical issues and problems facing the technology and engineering education profession in the Commonwealth of Virginia. The modified Delphi research design was used to draw consensus among technology and engineering education experts in the Commonwealth of Virginia. Seventy-five percent of the participants agreed with one another concerning the top five critical problems and issues that Virginia leaders should consider when planning future programs (see Table 4).

The participants agreed (93%) that the most pressing problem is that school counselors do not understand technology and engineering education (TEE). This finding indicates that technology and engineering educators and school counselors need to improve their relationships. Perhaps leaders from both professions should become more familiar with each other through meetings and presentations. These meetings and presentations could occur at the national, state, local, and school levels. Promoting awareness of the technology and engineering education courses and profession and its benefits could improve counselors and students' knowledge of what these programs have to offer. Discussion could eliminate misconceptions about technology and engineering education programs, as well as further identify how these programs can benefit students in their effort to become more technologically literate and more college and career ready.

Almost ninety percent (89%) of the participants identified the fact that secondary technology and engineering education enrollment is declining as a critical problem. This decline could be attributed to several issues. One of the most pressing issues is the lack of available technology and engineering education teachers (Moye, 2009; Ndahi & Ritz, 2003; Weston, 1997). If a school district cannot find a teacher to fill a position in tight budgetary times, that position may be eliminated in order to save scarce and valuable funds. It is difficult to imagine that once a program closes it will be reopened again in the future (Volk, 1997).

Participants (81.5%) felt that technology and engineering education needs to be better marketed. This ranked third of the most critical issues and problems, but could be considered one of the most critical points to consider. If the technology and engineering education profession is to gain creditability amongst other secondary education programs, leaders must devise plans to illustrate the benefits of the programs, as well as advertise program successes. If we, the profession's leaders, rest on our proverbial laurels, we will continue to experience the slow demise that Volk (1997) described. A possible solution is to provide awareness and knowledge diffusion to the general public. Educating parents and school faculty about the benefits and options that technology and engineering education has to offer will help stymie the negative "shop" perception that continues to exist.

Seventy-nine percent of the participants felt that a major issue is the lack of technology and engineering education teacher preparation programs. Again, this is not a new concern (Moye, 2009; Ndahi & Ritz, 2003; Volk, 1997; Weston, 1997). These feelings are an indication that participants felt that the lack of programs will have a negative impact on the profession in Virginia. This situation is true is all areas of the United States. Illustrating the downward trend over the past decade:

> In 2004-2005, there were 34 institutions that produced 338 technology education teachers (Schmidt & Custer, 2005). In 2005-2006, 32 institutions produced 315 technology education teachers (Schmidt & Custer, 2006). Twenty-nine institutions produced 311 technology education teachers in 2006-2007 (Schmidt & Custer, 2007). Finally, in 2007-2008, 27 institutions produced 258 technology teachers (Waugh, 2008). (Moye, 2009, p. 31)

Participants (75.9%) felt that there is a lack of technology and engineering education teachers. The reason for this shortage could be due to several of the other factors that participants felt were critical, e.g. misunderstanding of technology and engineering education, declining secondary enrollment, and the decreasing number of technology and engineering teacher preparation programs. It stands to reason that if leaders adequately address the *other issues*, the number of available teachers will increase. According to Moye (2009), Weston (1997), and Volk (1997) the shortage of technology teachers is so severe that it threatens the profession’s very existence.

Seventy-five percent of the participants felt that there is a lack of research identifying the benefits of technology and engineering education. According to Zuga (2004), in the United States, cognitive research about technology education for the general educational purpose of technological literacy has suffered from a lack of a coherent focus. Zuga (2004) also stated that the complacency that we have about doing or not doing research, the atheoretical stance of the profession, and the resulting process orientation make it difficult to create a research base. This may be the case, but Reed, Harrison, Moye, Opare, Ritz, and Skophammer (2008) reported that there is research that supports technology education. Technology and engineering teacher education programs are in a prime position to require their students to conduct research concerning the benefits and challenges the profession faces. Junior university faculty members should receive guidance from senior faculty concerning more cognitive research involvement.

Recommendations

Program assessments are necessary before leaders can determine what, if any, program improvement changes are needed (Day & Schwaller, 2007; Hoepfl & Lindstrom, 2007). This study identified what Virginia stakeholders felt were the most critical issues and problems facing the future of technology and engineering education programs in the Commonwealth of Virginia. Based on these results, the following recommendations are presented.

1. Technology and engineering education leaders should review these results to aid them in the determination of future program improvement/change foci. The benefits of this study are not limited to the Commonwealth of Virginia. Research has shown that certain issues remain the same (see Table 5) at a national level; therefore, action should be taken. The issues identified in this study can be used as a starting point in the process.
2. Future research should be conducted to identify if some of the areas identified in this study are (or are not) consistent with their findings.
3. An assessment instrument based on the key descriptors identified in this study should be created and used to assess technology and engineering education programs. The assessment could be similar to the Meade and Dugger (2004) and Dugger (2007) studies, but more directed to specific problems and issues that this study identified.
4. Future research should be conducted to identify if the same issues and problems exist at the national level.

Conclusion

Each of the critical issues and problems identified in this study bears further investigation and possible action to address the crisis (Wicklein, 2005). This research provides opinions of technology and engineering education teachers, administrators, and teacher educators, and it could be considered a starting point for future discussions. The profession is blessed with the ability to offer students an education that can transform how they think and act. Along with those blessings come responsibilities. A continuing assessment of the programs, and reassurance that students receive quality education, should be the main focus. The most obvious conclusion from this research is the lack of understanding of the technology education profession and its role in society. According to the strongest indicator (see table 4), school counselors do not understand technology and engineering education. Wicklein (1993a, 2005) also found this as one of the most critical indicators. Also found in all three studies is the insufficient number of certified technology education teachers. The general lack of knowledge about the technology and engineering education profession exacerbates the lack of interest and the limited number of secondary and post-secondary students. The problem exists from the beginning of the pipeline— lack of secondary students will cause the lack of technology and engineering teacher education candidates, which ultimately decreases the number of certified technology and engineering education teachers.

Technology and engineering education professionals at all levels across the United States must address the very basic issues and problems identified in this study. Without a serious and immediate effort to address these needs, the profession will cease to exist in the near future (Wicklein, 2005). Or said differently, our profession may very well be "Going, Going, Gone." (Volk, 1997, p. 66).

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Research Needs for Technology Education: A U.S. Perspective

The research productivity of those in the technology education profession has been well documented in the literature over the past 50 years (Dyrenfurth & Householder, 1979; Householder & Suess, 1969; Johnson & Daugherty, 2008; McCrory, 1987; Reed, 2010; Streichler, 1966; Zuga, 1994). Some have suggested that the profession lacked research data to support the need for its subject matter (technology education, design and technology, technology and engineering education, etc.), while others have suggested that the field does not actively engage in research studies of both quality and quantity. All members appear to agree that performing quality research is a healthy and enriching experience and, when properly conducted and used, can lead to making better and more informed educational decisions about the subject matter.

This study was conducted for the purpose of identifying research needs for technology education by generating a rank-ordered list of research topics that the profession's members might wish to explore individually or in collaboration with colleagues and students. The researchers' goal was to provide a concise list of topics that could be used by the profession to better position itself within the greater educational community, not to provide a call for action. The anticipated beneficiaries of this study are researchers who identify themselves as furthering the development of the technology education school subject. Professionals may use the list found in this study to further cultivate scholarly research in technology education. They may also use the list as a guide and, where appropriate, make better and more informed educational decisions through the formal, systematic application of scholarship and disciplined inquiry.

The population for the study consisted of a purposeful sample of 17 individuals who had been named recipients of the Council on Technology and Engineering Teacher Education's (CTETE) Teacher Educator of the Year award. The CTETE *Constitution and ByLaws* (2011) indicates that recipients of this award are "selected on the basis of long and valued service to the Council, to technology teacher education, and to the field of education in general" and that "past and present contributions will be considered" (p. 10). These individuals were deemed qualified to serve as panelists for this study. This homogenous group met the criterion for expertise and competency, as they were nominated and selected for this award by their peers.

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Review of Related Literature

Since our teaching field began in the late 19th Century, much of the decision making has been guided by professional collaboration and/or individual philosophical reasoning. Group and individual philosophical work has helped the profession to decide what to teach (content) and how to teach it (method). As the profession began to mature in the middle of the 20th Century, research was utilized in decision making. During the 1960s, projects (e.g., Industrial Arts Curriculum Project, American Industry Project) were funded by the U.S. Office of Education so researchers could better explore the appropriate content to deliver through instruction in their laboratories (Cochran, 1970).

Individually and in groups, professionals in the field have sought to make this school subject better and enable it to become a core teaching area required for all students. To do this, they knew that teachers, graduate students, and professors must undertake research in order to demonstrate the value of technology in the curriculum and its project-based instructional techniques (Cajas, 2000; Foster, 1992; Garmire & Pearson, 2006; Johnson, 1993; Lewis, 1999; Passmore, 1987; Pearson & Young, 2002; Petrina, 1998; Reed, 2002; Sanders, 1987). However, many in the profession have not practiced research. Instead of conducting additional research, many have chosen to teach technology in their laboratories while emphasizing student development and subject content.

The call for research is not new to this profession. Five CTETE yearbooks have reiterated the importance of research for assisting with professional decision making and building support for our school subject (Israel & Wright, 1987; Porter, 1964; Reed & LaPorte, 2010; Rowlett, 1966; Van Tassel, 1960).

The Center on Education and Training for Employment has sponsored studies reporting on the research that had been conducted in technology education, with emphasis on what needs further research. These analyses were conducted by Dyrenfurth and Householder (1979), Householder and Suess (1969), McCrory (1987), Streichler (1966), and Zuga (1994).

Others have summarized the published works of technology educators and other professionals who have published their results in journals related to the study of technology education. Johnson and Daugherty (2008) reported that there were 199 scholarly research journal articles published from 1997-2007. Williams (2011) reviewed 472 manuscripts published since 2006 and organized them into categories (e.g., design, curriculum, technological literacy). His review included both journal and major conference manuscripts.

Several MS programs require a thesis or major research paper and all PhD/EdD programs require dissertations. Reed (2010) developed the Technology Education Graduate Research Database, which has posted approximately 5,500 entries (from 1892 to 2010) of graduate research in technology education. Santos (2005) conducted an analysis of dissertation topics reported by our doctoral granting institutions in the United States between the years 2000-2005.

To move our profession into the 21st Century, Waetjan (1992) recommended that technology educators establish a research consortium to better study critical issues found within the technology education school subject. Three areas he recommended that should be studied included the following:

- Students' competence in and attitudes toward technological studies and attitudes about themselves.
- Determining how political decisions are made.
- Outcomes of technology teacher education.

There is evidence that the challenge has been taken seriously by members of this teaching community. In 2004, faculty from nine universities established the National Center for Engineering and Technology Education (NCETE), with funding from the National Science Foundation. In July 2006, researchers working with NCETE proposed a research agenda for this teaching field. Major areas that NCETE proposed for continued research included:

- Questions Involving Learning
- Questions Involving Teaching
- Questions Involving Assessment (D. Householder, personal communication, December 8, 2011)

Although these topics are related to technology and engineering education, they are the agenda of NCETE and may not be applicable to the profession in general. Will NCETE topics ultimately be formally adopted by the entire profession? What should be the focus of research in the technology and engineering education school subject?

With this background information, the researchers believed that for technology education to become a *valued subject* (ITEA/ITEEA, 1996), it must identify a list of the most important issues to guide its research activity. But, what issues should be included on the list?

Research Design

The researchers selected the Delphi method as the research design for the study, as it is widely recognized as a structured communication process. This method allows researchers to collect, review, analyze, and synthesize information from a recognized group of experts. Within the communication process, the type and amount of feedback is controlled by the researchers, as there is no planned interaction among the participants by the researchers. In this study, the names of the participants were not identified, just their qualifications to be participants. The researchers assumed that the participants did not communicate with one another. Their individual responses were not shared with the other participants, only aggregated responses were shared. Participants were deemed to have the expertise and competency to be participants.

Procedure

The Delphi method followed in this study consisted of four rounds that were preceded by a letter of invitation to participate. All communications between the researchers and participants were administered electronically. The letter of invitation provided an overview of the research problem to be addressed, the goal of the study, and a rationale for their selection to be a participant. Invitees were requested to respond to the letter of invitation in order to confirm their commitment to participate. Seventeen of 19 invitees responded in the affirmative. No incentives were provided to the participants.

Prior to commencing the study, the researchers assumed that the participants were capable of identifying and describing the most important issues that need to be researched related to (a) K-12 technology (engineering) education and (b) preparation for teaching this school subject. We assumed that the participants were capable of reaching consensus and creating a list of the most relevant issues that need to be researched by the profession's members. Furthermore, once identified, the list could be rank-ordered by applying statistics and using a structured communication process called the Delphi method. The Delphi method proved to be an acceptable research method to meet the goal of the study.

Prior to commencing the study, the researchers determined that an issue had to reach a mean score higher than a 3.50 on a 5-point scale in order to be considered a significant issue that should be researched by the profession. A mean score higher than a 3.50 is equivalent to a rating of *significant relevant issue* or *most relevant issue* on the 5-point Likert-type scale as used in this study.

Round 1

In Round 1, the researchers posed two fundamental but open-ended questions for the participants to consider:

- Research Question 1: What is the most important issue that needs to be researched related to K-12 technology (and engineering) education?
- Research Question 2: What is the most important issue that needs to be researched related to preparation for teaching this school subject?

The participants were instructed to (a) identify the most important issue related to each of the two questions and (b) provide a brief description of each issue so that other panelists would be able to properly reflect on all the issues generated in Round 2. A recommended format for receiving their response was also provided. Each participant could submit only one response to each question. Finally, the researchers provided the participants definitions of key terms to assist them in meeting the purpose of Round 1.

In order to control for researcher bias, the researchers utilized Survey Monkey^{TM} (i.e., the researchers did not know the names of each participant or their specific responses to the two questions in Round 1). In addition, an external panel of three individuals was formed to review the participants' Round 1 responses. The researchers deemed these individuals qualified to serve as panelists, as they are active participants in the profession's mission. They are not, however, past recipients of the CTETE Teacher Educator of the Year award.

The external panel met and reviewed the participants' responses to the two research questions. They created categories to group responses and, when necessary, they placed similar responses into similar categories in order to reduce or eliminate response duplication. The names of the categories were not shared with the participants as the researchers did not want to positively or negatively influence the participants in subsequent rounds. The net result was the identification of issues and descriptions of those issues. Once the external panel's recommendations were received, the researchers further edited some of the issue statements or descriptions within categories in order to place the issues and descriptions in a similar format for Round 2. The editing process by the external panel and researchers produced 17 issues with descriptions to Research Question 1 and 11 issues with descriptions to Research Question 2. A listing of the issues are provided in Table 1-A and Table 2-A.

Round 2

The purpose of Round 2 was to initiate the process of drawing consensus on the issues the participants believed were important to establish a better knowledge base for the technology education school subject. The content of the instrument in Round 2 was based on participants' responses to Round 1. There was no attrition among the participants in this round, as all participants responded to the instrument. Using a 5-point Likert-type scale (i.e., *most relevant issue* = 5 points, *significant relevant issue* = 4 points, *moderate relevant issue* = 3 points, *limited relevant issue* = 2 points, *not relevant issue* = 1 point), participants were instructed to rate the importance of each issue identified in the instrument.

Participants' ratings for each of the 17 issues from Research Question 1 and 11 issues from Research Question 2 were recorded and the mean score, median, standard deviation, and interquartile range (IQR) for each issue were computed. An IQR above 2.0 would indicate disagreement among the panelists on their rating of an item. (See Tables 1-A and 2-A for the results of Round 2 for each research question.)

Table 1-A (continued on next page)
Research Question 1

	Round 1	Round 2			
	Item	*M*	*Md*	*SD*	*IQR*
1	K-12 Technology Education and Engineering Curriculum	3.29	3	1.05	1
2	Engineering Content and Curriculum	4.12	4	0.70	1
3	Perception of Technology and Engineering Education	3.41	3	0.94	1
4	Impact on Basic Education	3.30	3	0.99	1
5	Influence on Career Selection	2.71	3	0.85	1
6	Impact on Academic Achievement	4.00	4	1.00	1.5
7	Contributions of Technology Education	3.18	3	1.24	2
8	Content that Is Valued	3.47	4	0.94	1
9	Social Confusion between Technology and Science	3.53	4	1.18	2.5
10	Value of Research	3.12	3	1.41	2.5
11	Verification of Content	4.12	4	0.93	1.5
12	Benefit of K-12 Technology and Engineering Education	4.12	4	0.86	1
13	Shortage of Critical Research Important to K-12 Learning Outcomes	3.65	4	1.06	1
14	Student Learning	3.53	4	1.18	1.5

15	Serving All Learners	2.94	3	0.99	2
16	Preparing Students for Technological (and Engineering) Literacy	2.88	3	0.99	2
17	Identify a Unique Focus for This School Subject	2.71	2	1.16	2

Round 3

The purpose of Round 3 was to draw further consensus on the issues the participants believed were important to establish a better knowledge base for our school subject. The list of issues in Round 3 was the same list and was presented in the same order as the list in Round 2. The 5-point Likert-type scale used in Round 2 was also used in Round 3. The median and standard deviation for each of the issues were provided to participants, along with their individual responses to these issues from Round 2. They were instructed to either reaffirm the original response they provided in Round 2 or change their response. A review of the data from Round 3 indicates that two participants chose not to change any of their responses and seven participants chose to change eight or more of their responses with the greatest number of changed responses being 12. The standard deviation, mean score, median, IQR, and coefficient of variation (CV) were computed for each issue (see Tables 1-B and 2-B).

There is a strong consensus when the CV is between 0.00 and 0.50. In Round 3, the strong CV substantiates the presence of a consensus among the participants for each of the issues to the two research questions. As a group of professionals, they appeared willing to compromise and reach consensus.

Table 2-A
Research Question 2

	Round 1 Item	Round 2 *M*	*Md*	*SD*	*IQR*
1	Need for Refined Content and Process Standards	3.94	4	1.03	2
2	What Is the Content for the Study of Technology	3.24	3	0.90	1
3	Strategies to Teach Engineering Design	3.71	4	0.92	1
4	Appropriate Teacher Preparation Model	3.35	3	0.87	1
5	Preparation Needed to Effectively Teach Technology (and engineering) Education	3.41	3	1.06	1.5
6	Content Pedagogy	3.29	3	0.92	1
7	Cognitive Science Connections	3.71	4	1.11	1.5
8	How Do Students and Teachers Learn Technology and Engineering	3.24	3	1.30	2.5
9	Technology and Engineering's Influences on Student Achievement	3.41	3	1.33	3
10	Determining Skill Sets that Make for the Best Secondary Technology Education Teachers	3.12	3	1.22	2
11	Effective Teaching-Learning Strategies for Technology and Engineering Education	3.41	3	1.12	1

Table 1-B
Research Question 1

	Round 1			Round 3		
	Item	*M*	*Md*	*SD*	*IQR*	*CV*
1	K-12 Technology Education and Engineering Curriculum	3.24	3	1.03	1	0.32
2	Engineering Content and Curriculum	4.18	4	0.60	1	0.15
3	Perception of Technology and Engineering Education	3.30	3	0.92	1	0.28
4	Impact on Basic Education	3.18	3	0.64	1	0.20
5	Influence on Career Selection	2.71	3	0.99	1	0.36
6	Impact on Academic Achievement	4.29	4	0.77	1	0.18
7	Contributions of Technology Education	3.06	3	1.09	2	0.36
8	Content that Is Valued	3.53	4	0.87	1	0.25
9	Social Confusion between Technology and Science	3.47	4	1.12	2	0.32
10	Value of Research	2.94	4	1.25	2	0.42
11	Verification of Content	4.06	4	0.75	.5	0.18
12	Benefit of K-12 Technology and Engineering Education	4.24	4	0.67	1	0.16
13	Shortage of Critical Research Important to K-12 Learning Outcomes	3.82	4	0.95	.5	0.25
14	Student Learning	3.65	4	1.11	1.5	0.31
15	Serving All Learners	2.94	3	1.09	1.5	0.37
16	Preparing Students for Technological (and Engineering) Literacy	2.77	3	0.97	1	0.35
17	Identify a Unique Focus for This School Subject	2.41	2	0.71	1	0.30

Table 2-B
Research Question 2

	Round 1 Item	Round 3 *M*	*Md*	*SD*	*IQR*	*CV*
1	Need for Refined Content and Process Standards	3.94	4	0.97	.5	0.25
2	What Is the Content for the Study of Technology	3.29	3	0.59	1	0.18
3	Strategies to Teach Engineering Design	3.77	4	0.83	1	0.22
4	Appropriate Teacher Preparation Model	3.18	3	1.02	1	0.32
5	Preparation Needed to Effectively Teach Technology (and engineering) Education	3.29	3	0.92	1.5	0.28
6	Content Pedagogy	3.24	3	0.90	1	0.28
7	Cognitive Science Connections	3.82	4	0.95	.5	0.25
8	How Do Students and Teachers Learn Technology and Engineering	3.06	3	1.03	2	0.34
9	Technology and Engineering's Influences on Student Achievement	3.29	3	1.11	1.5	0.34
10	Determining Skill Sets that Make for the Best Secondary Technology Education Teachers	3.00	3	1.23	2	0.41
11	Effective Teaching-Learning Strategies for Technology and Engineering Education	3.24	3	0.83	1	0.26

Round 4

As a result of input received from the participants, Round 4 was administered to determine whether the issues in the previous rounds were truly research initiatives that needed to be undertaken by the profession's members or were issues that should be undertaken by the profession to fulfill some other purpose. In other words, while the previous rounds "forced" the participants to indicate the level of relevancy of each issue, they were now being provided a final opportunity to verify whether they thought the issues were truly research initiatives.

The researchers requested that participants reflect on the Delphi process and then consider whether the issues could best be addressed in a Research Activity or Development Activity. For purposes of this study, the following two definitions were provided in the instructions to Round 4:

> **Research Activity**. Research is the formal, systematic application of scholarship and disciplined inquiry to the study of problems that have been identified by the profession's members. Individuals who conduct research are commonly referred to as researchers. Researchers identify their research question(s) and then follow a research design (e.g., quantitative and/or qualitative) or plan to answer their research question(s). Researchers formally engage in a Research Activity to address their specific research question(s). The end product is an analysis of the data collected or the results of their study that is prepared into a formal document.
>
> **Development Activity**. Sometimes what is initially thought to be a research activity is not really one at all. Instead, it is a Development Activity where individuals work together to address a specific problem in the profession. For example, a development activity may be associated with reaching consensus on (a) curricular issues, (b) marketing strategies, (c) political strategies, (d) professional development programs, or (e) recruitment strategies. As used in the context of this study, the goal of a Development Activity is to reach consensus among the participants. It may or may not result in a tangible product such as a formal document.

Data collected from Round 4 appeared to generate the greatest amount of informal discussions between the participants and the researchers and underscored the importance of whether some of the issues originally identified as research issues may best be addressed as a development activity. Other discussions centered on whether some of the issues were neither research nor developmental but actually something else. One out of the 17 original participants chose not to participate in Round 4 (see Tables 1-C and 2-C).

Table 1-C
Research Question 1

	Round 1	Round 4	
	Item	*R/D*	*%*
1	K-12 Technology Education and Engineering Curriculum	R	75
2	Engineering Content and Curriculum	R	56
3	Perception of Technology and Engineering Education	D	88
4	Impact on Basic Education	R	63
5	Influence on Career Selection	R	75
6	Impact on Academic Achievement	R	88
7	Contributions of Technology Education	D	69
8	Content that Is Valued	D	56
9	Social Confusion between Technology and Science	D	69
10	Value of Research	D	75
11	Verification of Content	R	81
12	Benefit of K-12 Technology and Engineering Education	R	75
13	Shortage of Critical Research Important to K-12 Learning Outcomes	R	75
14	Student Learning	R	94
15	Serving All Learners	D	81
16	Preparing Students for Technological (and Engineering) Literacy	R	56
17	Identify a Unique Focus for This School Subject	D	69

Table 2-C
Research Question 2

	Round 1 Item	Round 4 *R/D*	 *%*
1	Need for Refined Content and Process Standards	D	69
2	What Is the Content for the Study of Technology	R	56
3	Strategies to Teach Engineering Design	D	56
4	Appropriate Teacher Preparation Model	D	56
5	Preparation Needed to Effectively Teach Technology (and engineering) Education	R	81
6	Content Pedagogy	R	75
7	Cognitive Science Connections	R	62
8	How Do Students and Teachers Learn Technology and Engineering	D	56
9	Technology and Engineering’s Influences on Student Achievement	R	94
10	Determining Skill Sets that Make for the Best Secondary Technology Education Teachers	R	69
11	Effective Teaching-Learning Strategies for Technology and Engineering Education	R	81

Findings

Data were gathered and analyzed through the four rounds of this study. An analysis of the data derived from Rounds 3 and 4 and relating to Research Question 1 revealed there were seven issues above the mean score of 3.50 threshold level indicating they were either *significant relevant* or *most relevant* issues. (One of these seven issues, Issue No. 8, was recommended as a Development Activity, not a Research Activity, in Round 4 and was withdrawn from further consideration.) The remaining six issues are as follows:

- **Issue No. 2: Engineering Content and Curriculum** (M = 4.18, 56% selected as a Research Activity issue).
- **Issue No. 6: Impact on Academic Achievement** (M = 4.29, 88% selected as a Research Activity issue)

- **Issue No. 11: Verification of Content** (M = 4.06, 81% selected as a Research Activity issue)
- **Issue No. 12: Benefit of K-12 Technology and Engineering Education** (M = 4.24, 75% selected as a Research Activity issue)
- **Issue No. 13**: **Shortage of Critical Research** [Important to K-12 Learning Outcomes] (M = 3.82, 75% selected as a Research Activity issue)
- **Issue No. 14: Student Learning** (M = 3.65, 94% selected as a Research Activity issue)

An analysis of the data derived from Rounds 3 and 4 and relating to Research Question 2 revealed there were three issues above the mean score of 3.50 threshold level indicating it was either a *significant relevant* or *most relevant* issue. (Two of these issues, Issues No. 1 and 3, were recommended as a Development Activity, not a Research Activity, in Round 4 and were withdrawn from further consideration.) The remaining issue, Issue No. 7 is as follows:

- **Issue No. 7: Cognitive Science Connection** (M = 3.82, 62% selected as Research Activity issue)

All other issues for Research Question 2 that were originally identified by the participants in Round 1 and responded to in Rounds 2 and 3 did not meet the minimum threshold of having a mean score greater than 3.50.

Discussion and Conclusions

Buzz words or substance? What do we learn when we seek expert opinions? Researchers always fear their work may result in a ho-hum response from the profession. Do the results of this study reinforce the status quo or do they extend the profession into new arenas? The researchers believe the issues identified in this study are important and timely for technology education. If the profession's members decide to address these issues, they will have capitalized on an opportunity to advance the profession well into the next decade, while advancing the position of technology education as a school subject.

As data were further reviewed, analyzed, and synthesized, the researchers reached several conclusions. First, there was relative stability between Rounds 2 and 3 on the issues the participants rated for Research Question 1 that met the criterion of a mean score greater than 3.50. For example, in Round 2, Issues No. 2, 6, 9, 11, 12, 13, and 14 met the criterion (see Table 1-A). In addition, all seven issues reported a median of 4. These same issues, except for Issue No. 9, had an IQR less than 2.0. In Round 3 (see Table 1-B), only Issue No. 9 had a mean score less than 3.51. In addition, Issue No. 8 reported a mean score of 3.53 in Round 3. These seven issues (2, 6, 8, 11, 12, 13, & 14) had a median of 4, an IQR less than 2.0, and a CV less than 0.50. At the end of Round 3, these seven issues for Research Question 1 were deemed significant by the researchers.

Second, Round 4 instructed the participants to reflect on all the statistical data provided in Rounds 2 and 3 and then recommend whether each of the 17 issues for Research Question 1 was a Research Activity or a Development Activity. The researchers arbitrarily decided that for an activity to be considered a Research Activity or a Development Activity, 51% of the participants had to recommend it in their responses. The data indicated that participants believe Issues No. 1, 2, 4, 5, 6, 11, 12, 13, 14, and 16 are Research Activity issues (see Table 1-C).

Third, when data for the issues in Rounds 2, 3, and 4 were further analyzed, it was readily apparent that only Issues No. 2, 6, 11, 12, 13, and 14 had met the minimum criteria for a mean score greater than 3.50, an IQR of 2.0 or less, and a CV of 0.50 or less. Each issue also had a median of 4. These six issues had been identified by the participants as Research Activity issues. The researchers recommend the following rank-ordered list of Research Activity issues that should be addressed by the profession:

- Rank #1: Issue No. 6 – Impact on Academic Achievement; M = 4.29
- Rank #2: Issue No. 12 – Benefit of K-12 Technology and Engineering Education; M = 4.24
- Rank #3: Issue No. 2 – Engineering Content and Curriculum; M = 4.18
- Rank #4: Issue No. 11 – Verification of Content for Technology and Engineering Education; M = 4.06
- Rank #5: Issue No. 13 – Shortage of Critical Research [Important to K-12 Learning Outcomes]; M = 3.82
- Rank #6: Issue No. 14 – Student Learning; M = 3.65

The researchers followed the same procedure used in analyzing data for Research Question 1 when analyzing data for Research Question 2. For example, in Round 2, issues No. 1, 3, and 7 had mean scores greater than 3.50 and an IQR of 2.0 or less. They also had a median of 4 (see Tables 2-A through 2-C). In Round 3, these same issues were the only issues with mean scores greater than 3.50, an IQR of 2.0 or less, a CV less than 0.50, and a median of 4. Just as with the procedure used in Research Question 1, Round 4 directed participants to reflect on all the statistical data provided them in previous rounds and then recommend whether each of the 11 issues was a Research Activity or a Development Activity. As before, the researchers arbitrarily decided that for an activity to be considered as either a Research Activity or a Development Activity, 51% of the participants had to recommend it in their responses. The data indicated that the participants believe that issues No. 2, 5, 6, 7, 9, 10, and 11 are Research Activity issues. When data for the issues in Rounds 2, 3, and 4 were further analyzed, it was apparent that only Issue No. 7 had met the minimum criteria for a mean score (greater than 3.50), an IQR of 2.0 or less, and CV of 0.50 or less with a median of 4. Therefore, only one issue is being recommended as a significant issue that should be researched to meet Research Question 2.

- Rank #1: Issue No. 7 – Cognitive Science Connections; M = 3.82

When provided an opportunity in Round 4 to reconsider their original recommendations for issues to address the two research questions, several issues that had been previously recommended as research activities were changed by the participants to development activities. In fact, seven (41%) of the original 17 issues identified in Research Question 1 became development activity issues and four (36%) of the original 11 issues for Research Question 2 became development activity issues.

Finally, the researchers of this study take the prerogative to identify what might first appear to be glaring omissions in the recommendations of the participants. First, as the number of educators in technology education continues to dwindle, our research attention needs to be directed to best practices in recruitment, specifically, identifying and implementing strategies to recruit new members into the teaching profession and retain those that are already serving as teachers. Second, attention also needs to be directed to attracting and serving the needs of females and minorities. The changing demographics in the United States require that we focus more of our time and energies on these populations. Third, the role that student organizations may serve to reinvigorate our profession needs to be researched. Student organizations are one vehicle to attract new students into our subject matter courses and our profession. Fourth, there is a growing void in the number of people who seek to serve in leadership roles. Research that focuses on successful strategies to lead others towards common goals needs to be undertaken. Finally, there is an important role for our professional organizations. The Council on Technology and Engineering Teacher Education and/or the International Technology and Engineering Educators Association should consider hosting a forum to further discuss the profession's research activity priorities and development activity priorities.

Recommendations for Further Research

The population for this study was a purposeful sample of past recipients of the CTETE Teacher Educator of the Year award. Future researchers may wish to include other panelists who may have different academic and professional credentials. It is clear that when the panelists participated in Round 4 and were given time to reflect on the previous three rounds, some issues they had originally identified in Round 1 were rated as Development Activities, not Research Activities. For example, future researchers may wish to review and consider moving Round 4 to the position of Round 2, and then following Round 4 with the processes followed in Rounds 2 and 3 as described in this study. Future researchers may also wish to take the findings from this study and develop a new and improved set of data. Finally, a considerable amount of work remains to be completed by the profession and it is the desire of the authors that future researchers will take from this study what they find of value and leave the rest behind.

In the spirit of openness and a supporting nature for a positive future of the profession, the authors are making available to the profession data collected in this study. Data may be retrieved from the following URL: http://www.ctete.org/#!resources. This posting also provides a description for each research issue identified through this study.

Summary

The authors selected the Delphi method to develop a rank-ordered list of topics that would be of substance and which researchers might wish to further explore individually or in collaboration with their colleagues and students. The participants who served as panelists are recognized as leading professionals within the technology education school subject area (technology education, technology and engineering education, etc.). Specifically, these professionals are all past recipients of the CTETE Teacher Educator of the Year award. The authors posed two questions to the panelists and charged each of them with (a) identifying the most important issue related to each question and (b) providing brief descriptions of each issue. In the end, six issues were identified and rank-ordered for Research Question 1 and one issue for Research Question 2. Obviously, it is unknown whether a different set of panelists would have generated a different list of issues. The final rank-ordered list, however, does provide a foundation of information to build upon for future researchers and advisors of aspiring graduate research students who have as one of their goals to establish a better knowledge base for the technology education school subject.

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Standards for Technological Literacy and STEM Education Delivery Through Career and Technical Education Programs

The domestic and international marketplaces are changing, developing new technology and processes to improve productivity in every sector, requiring people to have different skills and attitudes about work. Arguably, technology and the new literacies associated with it have transformed the workplace more quickly and more deeply than any of our other institutions (Mikulecky & Kirkley, 1998). With these improvements, some segments within the workforce have experienced technical obsolescence. Today's knowledge-based society that thrives on technological transformation has little room for those who cannot read, write, and compute proficiently; find and use resources; frame and solve problems; and continually learn new technologies and skills, as well as work in technical occupations (National Commission on Teaching and America's Future, 1996). According to the U.S. Department of Labor, technical occupations require knowledge of scientific, engineering, and mathematical theories, principles, and techniques that enable individuals to understand how and why a specific device or system operates (United States Department of Labor, n.d). Democratic governance in knowledge-based societies like the United States relies on the ability of the general populace to make informed choices about the options made available to them by responsible scientific and technological progress (Busquin, 2002). In such societies, it is commonplace to say that relationships between science, technology, engineering, and mathematics disciplines are becoming increasingly stronger, permeating the workplace and creating new literacy demands for solving daily work-related problems.

Career and Technical Education (CTE) has traditionally been viewed as the cornerstone of workforce preparation. CTE programs address aspects of science, mathematics, and most certainly technology, addressing STEM-related careers in auto technology, medical technicians, registered nurses, process control processors, machinists, financial managers, and many other kind of technical-related careers (Stone, 2011). The Association of Career and Technical Education (2009) stated that career and technical education (CTE) programs offer an important instructional approach that strengthens students understanding of STEM content and helps attract more individuals into STEM career pathways. In a culture that is increasingly embracing STEM concepts in the workplace, literacy in these disciplines and how they relate to each other is imperative. STEM requires cognitive comprehension, which enables the general

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populace to grasp how natural and designed worlds work, to think critically and independently, to recognize and weigh alternative explanations of events and design trade-offs, and to sensibly deal with problems that involve evidence, numbers, patterns, logical arguments, and uncertainties (American Association for the Advancement of Science [AAAS], 1993). Therefore, as the need for those with knowledge of technical work and critical thinking skills in the 21st century workplace continues to grow, policy makers, researchers, and educators alike believe that integration of STEM disciplines into CTE curriculum is a viable solution to meet some of these demands (Terrell, 2007; The President's Council of Advisors on Science and Technology, 2010).

Nevertheless, STEM integration into CTE curriculum faces unprecedented challenges. A search for CTE and STEM education curricula in academic databases will yield an insurmountable amount of documents and curricula. A more recent study by the Academic Competitiveness Council found 105 STEM education programs that experienced frequent programmatic changes with differing definitions of what constitutes STEM curricula and programs, in addition to multiple program goals (United States Department of Education, 2007). The National Science Board (2007) stated that the nation faces two central challenges to constructing a strong coordinated STEM education system: (a) ensuring coherence in STEM learning and (b) ensuring an adequate supply of well-prepared and highly effective STEM teachers. Further, the board stated that educators should strive to facilitate a strategy to define national STEM content and guidelines that would outline the essential knowledge and skills needed at each grade level, developing metrics to assess student performance that are aligned with national content guidelines, ensuring that assessments under No Child Left Behind promote STEM learning, improving the linkage between high school and higher education, and preparing individuals for the world of work (National Science Board, 2007).

To this end, some researchers have questioned the significance of STEM infusion into CTE without a clear curriculum, standards, or assessment procedures. Williams (2011) asserts that Sanders (2009) raised a lot of skepticism with regard to STEM education, specifically upon an examination of projects that have been developed for teachers and are available online to support teachers wishing to implement STEM activities into their school (e.g., projects found at http://www.stemtransitions.org). According to Williams (2011), these projects generally do not integrate science, technology, engineering, and mathematics but do offer bits and pieces of a couple of these disciplines. Pitt (2009) argued that such an approach as an education concept is problematic because there is little consensus as to what STEM education comprises and how it can be taught in schools—whether it needs to be taught as a discrete subject or whether it should be an approach to teaching the components.

The wide variation in STEM curricula and lack of coherence are two of the many factors that birthed the common standards initiative to examine what is taught, when it is taught, and how to test student performance. Bybee (2000) stated that standards influence the entire educational system because they are inputs, but they also define outputs. Similarly, Wulf (2000) noted that standards provide a much needed reference point for developers of curriculum and instructional materials. The question then arises: Which content standards should guide what students need to know with regard to comprehending principles that may lead to the goal of STEM literacy?

This paper seeks to address the first challenge identified by the National Science Board, “ensuring coherence in STEM learning” (2007, p. 1). Some thoughts about designing a set of content standards and a possible process that could contribute to the realization of this goal are presented. It should be noted that providing a clear set of standards is beyond the capabilities of this author. Nonetheless, clear standards for STEM literacy are very important to CTE profession because they provide direction for teachers to structure instruction methods to ensure students achieve a set of expected competencies. This essay contributes to ongoing discussions about STEM content standards that can guide instruction in order to realize the goal of STEM literacy. As a starting point, educators should comprehend literacy from a science, technology, engineering, and mathematics perspective and examine the categories for content standards from these disciplines for common themes that may guide STEM instruction and integration into the CTE curriculum. This essay presents a description of what science, technological, engineering, and math literacy entails and a process of identifying STEM literacy standards.

Math, Science, and Technological Literacy to STEM Literacy

Given the pressing needs for a high quality STEM workforce in 21st century economies, proposals for science, technology, engineering, and mathematics are being developed to meet and create pathways to a wide range of interesting and exciting career opportunities. The goal of this amalgation is to seek knowledge in science, technology, mathematics, and engineering in order to achieve STEM literacy. An examination of the content standards related to math, science, technology, and engineering disciplines describes the knowledge, skills, and proficiency students should acquire in each area of study. Content Standards guide the creation of goals and expected outcomes that are measurable by some form of assessment procedures that seek to examine the growth in students learning experiences (National Academy of Education [NAEd], 2009).

According to Kintgen, Kroll, and Rose (1988), the term *literacy* is usually interpreted as the ability to read and write. However, extensions of this term, to computer literacy, cultural literacy, political literacy, and of course STEM literacy, suggest that the semantic aspects of this term are very important. Although educators generally use literacy in its descriptive sense, it is the evaluative sense of the term—the mastery of a body of knowledge—that provides an understanding of the intended meaning. With advocacy to integrate STEM disciplines into CTE curriculum, it is imperative that we examine each discipline and what kind of literacy each advocates.

Science is a process of producing knowledge; the process depends on making careful observations of phenomena in the natural world and inventing theories for making sense out of those observations and therefore develop in students a set of predetermined beliefs about their natural environment (AAAS, 1989). Further, a scientifically literate individual is one that is able to sensibly deal with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty, not only with respect to decisions involving their own lives, but also with respect to issues that affect societies in general. Such a person has the ability to describe, explain, and predict natural phenomena as well as comprehend articles about science in the popular press and engage in social conversation about the validity of the conclusions (AAAS, 1989). In light of this view, Dani (2009) posited that scientific literacy is the knowledge and understanding of scientific concepts and processes required for: personal decision making, identification of scientific issues underlying economic productivity at the national and local level, as well as express positions that are scientifically and technologically informed. In other words, an individual can ask, find, or determine answers to questions derived from curiosity about everyday experiences.

Technology seeks to develop new knowledge by extending our abilities to change the world and cut, shape, or put together materials to satisfy our needs. In contemporary society, technological processes constitute a complex social enterprise that not only includes research, design, and crafts, but also includes finance manufacturing, management, labor, marketing, and maintenance (AAAS, 1989). Gagel (1997) suggested that technological literacy implied the ability to use, manage, understand, and access technology leading to four generalized competencies: (a) accommodate and cope with rapid and continuous technological change, (b) generate creative and innovative solutions for technological problems, (c) act through technological knowledge both effectively and efficiently, and (d) assess technology and its involvement with human life judiciously. The International Technology Education Association (ITEA/ITEEA) defined technological literacy as "the ability to use, manage, assess, and understand technology" (2000/2002/2007, p. 242). Garmire and Pearson (2006) provide a three dimensional view that includes (a) knowledge, (b) capability, and (c) critical thinking and decision-making. "First, a technologically literate person must have a certain amount of basic knowledge about technology…. Second, a technologically literate person should have some basic technical capabilities, such as being able to work with a computer and to identify and fix simple problems in the technological devices used at home and in the office. More generally, he or she should be able to employ an approach to solving problems that rely on aspects of a design process…. And third, a technologically literate person should be able to think critically about technological issues and act accordingly" (Garmire & Pearson, 2006, p. 21).

Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practices are applied to develop ways to economically utilize the materials and forces of nature for the benefit of humanity (Jones, 2000). The knowledge needed to solve an engineering problem is pre-defined by the context. This context determines relevant knowledge that requires the integration of mathematical principles and scientific knowledge for the purpose of solving or meeting societal needs. Engineering integrates the principles of science and the fundamentals of mathematics for the purpose of meeting societal needs. Heywood (1993) stated that engineering literary requires that we understand how individuals, organizations, and society interact at a variety of levels of technology in an engineered world, and how in this process we can exercise purposive control over the changes that technology creates in our lives. For example, a course that includes basic engineering will help students unravel some of the mysteries of technology necessary to succeed in the workforce of a technological society. The idea of engineering literacy is synonymous with technological literary, since it is difficult to differentiate between the two, though engineers may argue differently. However, engineering serves as the connection between scientific and mathematical theory and the technology we use in our everyday lives. For example, a certified nursing assistant in laboratory health care systems uses technology to gather information, compute gathered data, and make critical decisions based on this information from various products that have been engineered. Therefore, it’s a profession devoted to designing, constructing, and operating structures, machines, and other industry devices. This is characteristic of 21st century work environments, which are a mosaic or collage of solutions to engineering problems.

Mathematics is the study of any patterns or relationships (AAAS, 1993). Mathematics explores the possible relationships among abstractions, which can be anything from a string of numbers to geometric figures to a set of equations. Because of its abstractness, mathematics is universal in a sense that other fields of human thought are not. It finds useful applications in business, industry, music, history, politics, sports, medicine, engineering, and social and natural sciences. According to the Organization for Economic Co-operation and Development (2003), mathematical literacy is an individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments, and to engage in mathematics in ways that meet the needs of that individual’s current and future life as a constructive, concerned, and reflective citizen. Therefore, mathematics plays a central role in modern culture, and some basic understanding of the nature of mathematics is requisite for a better understanding of the world.

Although each of these disciplines has a character and history of its own, they are interdependent and reinforce each other. New insights from science often catalyze the emergence of new technologies and their applications, which are developed using engineering principles. In turn, new technologies create opportunities for new scientific investigations (National Research Council, 2011). It is the union of science, mathematics, and technology that forms the scientific endeavor, which is further reinforced by engineering principles that reflect our modern designed world and the quest for STEM literacy (AAAS, 1989).

So, what is STEM literacy, and how can it be attained*?* Leon Lederman, a renowned physicist, posited that STEM literacy implied that an individual operating in a knowledge–based economy has the ability to adapt to and accept changes driven by the new technology, work with others across borders, anticipate the multilevel impacts of their actions, communicate complex ideas effectively to a variety of audiences, and find measured yet creative solutions to problems that are today unimaginable (National Governors Association, 2007). On the contrary, Williams (2011), Sanders (2009), and Pitt (2009) have argued that there seems to be little clear discussion about the similarities, differences, and relationship between science, technology, engineering, and mathematics as school subjects; the idea of STEM literacy is a vague idea that is laudable but problematic with regard to educational outcomes, scientific literacy, and technological literacy—although reasonably well researched and defined, an amalgam of the three has not been developed nor tallied.

Standards and the School System

Subramanyam (1981) described standards as "fundamental to many aspects of modern life including science, technology, industry, commerce, health, and education. Standards and specifications are documents that stipulate or recommend: (1) minimum levels of performance and quality of goods and services, and (2) optimal conditions and procedures for operations in science, industry, and commerce" (as cited by Erdmann, 2010). According to NAEd (2009), a standards-based vision was enacted in federal law under the Clinton administration with the 1994 reauthorization of the Elementary and Secondary Education Act (ESEA) and carried forward under the Bush administration with the No Child Left Behind Act (NCLB) of 2001. In recent years, conversations about the importance of standards in our school systems have intensified. In 2008 the National Research Council of the National Academies produced a summary report titled *Common Standards for K-12 Education? Considering the Evidence.* By 2009, the National Governors Association, the National Association of Secondary School Principals, the Council of Great City Schools, and the American Federation of Teachers all publicly supported national standards. Further, in a recent survey of policy makers, standards were acknowledged as the central framework guiding state education policy (Massell, 2008). Today, discussions around education reform are focused on developing common core standards. The mission statement of the standards directly relates to CTE: “relevant to real word, reflecting the knowledge and skills that our young people need for success in college and careers” (Bray, 2011, p. 6). Although these statements seem to support taking action and designing standards for integrating STEM disciplines into CTE curriculum, most are sparse on the details of what to do and how to do it.

Could Technological Literacy Standards Be a Common Approach to STEM Literacy Standards?

The study of technological process provides students with opportunities to learn about the processes of design, fundamental concepts of technology and engineering, and the limits and possibilities of technology in society. *Standards for Technological Literacy: Content for the Study of Technology*, national standards released by the International Technology Education Association (ITEA/ITEEA) in 2000, identifies and defines 20 standards that every student should know and be able to do to be technologically literate. Widespread acceptance of technological literacy as a desirable outcome for both academic and vocational education has led to the development and implementation of a variety of curriculum innovations in the field of career and technical education (Prime, 1998).

In 2009, ITEEA proclaimed that the delivery of STEM education content is closely aligned with the same core content as the *Standards for Technological Literacy* (STL). The organization stated that the content contained within the STL standards was the foundation for students to develop 21st Century STEM literacy—the very core of abilities needed for students to become advanced problem solvers, innovators, technologists, engineers, and knowledgeable citizens. ITEEA believes that all true STEM programs must include STL as a ladder to help students achieve STEM literacy (ITEEA board of directors, 2009). Gorham, Newberry, and Bickart (2003) offered a starting point for such a discussion by illustrating the connection between the *Standards for Technological Literacy* and *Engineering Criteria 2000,* criterion 3. They further stated that STL provided a focused guide for improving technological literacy and the standard will provide a much needed reference point for developers of curriculum and instructional materials in addition to laying a foundation for building a technologically literate society (Gorham, Newberry, & Bickart, 2003).

Most often educators have developed integrated STEM programs around shared themes based on existing national standards, such as the National Council of Teachers of Mathematics’ *Principles and Standards for School Mathematics* (2000), the National Research Council’s *National Science Education Standards* (1996), the *Standards for Technological Literacy (*2000), the Accreditation Board for Engineering and Technology’s *Engineering Criteria 2000* (1997), and most recently the *Common Core State Standards Initiative for Mathematics* (2011). Utilizing the work of Gorham, Newberry, and Bickart (2003) as a basis toward the development of STEM literacy is a viable strategy that will provide coherence and a robust foundation toward development of the standards. This will enable instructional practices that will enable all students to achieve both academic and technological abilities in all career pathways and future leadership in technical occupations. Table 1 details the correlation of ideas and concepts in both standard and outcome between the twenty *Standards for Technological Literacy* (STL) and the eleven Accreditation Board for Engineering and Technology (ABET) *Engineering Criteria* outcomes.

Table 1
Comparison of Standards for Technological Literacy with ABET Engineering Criteria

ABET	A	B	C	D	E	F	G	H	I	J	K
STL 1	●	●	●	●	■	●	✓	■	●	✓	■
STL 2	●	●	■	■	■	●	✓	■	●	✓	■
STL 3	■	■	●	●	✓	■	■	■	●	✓	✓
STL 4	■	●	●	●	✓	■	✓	■	●	✓	✓
STL 5	●	●	●	●	✓	■	✓	■	●	■	✓
STL 6	●	●	●	●	■	■	✓	■	●	■	✓
STL 7	■	●	●	●	✓	■	✓	■	●	■	✓
STL 8	✓	■	■	●	■	●	■	■	●	✓	■
STL 9	✓	■	■	●	■	●	■	■	●	✓	■
STL 10	✓	■	■	●	■	■	■	■	●	✓	■
STL 11	✓	■	■	■	■	●	■	■	●	✓	■
STL 12	✓	✓	■	■	✓	●	■	■	●	✓	■
STL 13	✓	■	■	■	✓	■	■	■	●	✓	■
STL 14	✓	■	■	✓	■	●	■	■	●	✓	■
STL 15	✓	■	■	✓	■	●	■	■	●	✓	■
STL 16	✓	■	■	✓	■	●	■	■	●	✓	■
STL 17	✓	■	■	✓	■	■	■	■	●	✓	■
STL 18	✓	■	■	✓	■	●	■	■	●	✓	■
STL 19	✓	■	■	✓	■	●	■	■	●	✓	■
STL 20	✓	■	■	✓	■	●	■	■	●	✓	■

Table Key:
■ = denotes a correlation in ideas and concepts in both standard and outcome
✓ = denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both standard and outcome
● = denotes an implied idea or concept that may be used in both standard and outcome

Source: Accreditation Board for Engineering and Technology's *Engineering Criteria 2000* (ABET) and International Technology Education Association's *Standards for Technological Literacy* (STL); a modification of table from Gorham, Newberry, and Bickart (2003).

Table 2 details the correlation of ideas and concepts in both standard and outcome between the twenty *Standards for Technological Literacy* (STL) and the eight *National Science Education Standards*.

Table 2
Comparison of Standards for Technological Literacy with the National Science Education Standards

NSES	A	B	C	D	E	F	G	H
STL 1	✓	✓	✓	✓	✓	●	●	✓
STL 2	✓	✓	✓	✓	✓	●	●	✓
STL 3	●	●	✓	✓	✓	●	●	✓
STL 4	✓	✓	✓	✓	✓	●	●	✓
STL 5	✓	●	✓	✓	●	●	●	✓
STL 6	✓	●	✓	✓	✓	●	●	✓
STL 7	✓	●	✓	✓	●	●	●	✓
STL 8	✓	●	■	✓	●	●	✓	✓
STL 9	✓	●	■	✓	✓	●	✓	✓
STL 10	✓	●	✓	●	✓	✓	✓	✓
STL 11	✓	●	■	●	✓	●	✓	✓
STL 12	✓	●	✓	●	✓	●	✓	✓
STL 13	✓	●	■	●	✓	✓	●	✓
STL 14	✓	●	✓	●	✓	✓	●	✓
STL 15	✓	●	■	●	✓	●	●	✓
STL 16	✓	●	●	✓	●	●	●	✓
STL 17	✓	●	✓	✓	✓	●	✓	✓
STL 18	✓	●	●	✓	✓	●	✓	✓
STL 19	✓	●	●	✓	✓	●	✓	✓
STL 20	✓	●	●	✓	✓	●	✓	✓

Table Key:
■ = denotes a correlation in ideas and concepts in both standard and outcome
✓ = denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both standard and outcome
● = denotes an implied idea or concept that may be used in both standard and outcome

Source: International Technology Education Association's *Standards for Technological Literacy* (STL) and National Research Council's *National Science Education Standards* (NSES); a modification of table from Gorham, Newberry, and Bickart (2003).

Table 3 details the correlation of ideas and concepts in both standard and outcome between the twenty *Standards for Technological Literacy* (STL) and the eight *Common Core State Standards Initiative for Mathematics*.

Table 3
Comparison of Standards for Technological Literacy with the Common Core State Standards Initiative for Mathematics

CCSSI	1	2	3	4	5	6	7	8
STL 1	✓	✓	✓	✓	●	■	✓	✓
STL 2	✓	✓	✓	✓	●	■	✓	✓
STL 3	●	✓	✓	✓	●	■	✓	✓
STL 4	●	✓	✓	✓	■	✓	✓	✓
STL 5	✓	✓	✓	✓	■	✓	✓	✓
STL 6	✓	✓	✓	✓	■	✓	✓	✓
STL 7	●	✓	✓	✓	✓	■	✓	✓
STL 8	✓	✓	●	●	●	●	■	✓
STL 9	✓	✓	●	●	●	●	■	✓
STL 10	✓	■	■	●	●	●	■	■
STL 11	✓	✓	●	●	●	●	■	■
STL 12	✓	✓	✓	●	●	●	■	■
STL 13	✓	■	■	●	●	✓	■	■
STL 14	✓	✓	✓	●	●	✓	■	✓
STL 15	✓	✓	✓	●	●	✓	■	✓
STL 16	✓	✓	✓	●	●	✓	■	✓
STL 17	✓	✓	✓	●	●	●	■	✓
STL 18	✓	✓	✓	●	●	✓	■	✓
STL 19	✓	✓	✓	●	●	✓	■	✓
STL 20	✓	✓	✓	●	●	✓	■	✓

Table Key:
■ = denotes a correlation in ideas and concepts in both standard and outcome
✓ = denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both standard and outcome
● = denotes an implied idea or concept that may be used in both standard and outcome

Source: International Technology Education Association's *Standards for Technological Literacy* (STL) and National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM); a modification of table from Gorham, Newberry, and Bickart (2003).

Key Concepts and Principles That May Support STEM Literacy in Career and Technical Education

As educators, school districts, and stakeholders continue to advocate for integration of STEM disciplines into the curriculum, it should be noted that, ideally, students learn better in a standards-based environment because everybody is working towards the same goal (U.S. Department of Defense, Domestic Dependent Elementary & Secondary Schools, 2008). This author hopes that by using STL standards as a basis for interacting with STEM disciplines anticipated learning outcomes, as depicted in tables 1-3, students will be able to develop lifelong learning skills that will help to impart in them STEM competencies required for 21st century workplace. Building further on Gorham, Newberry, and Bickart's (2003) work, Table 4 (next two pages) depicts some of the major concepts and principles covered in CTE courses, specifically technology education. According to the Association of Career and Technical Education (2009), a thoughtful integration of STEM concepts into CTE curriculum can help students become more STEM literate and increase the chances that these students consider STEM-related careers. It then can be argued that if students understand more about the concepts and principles of technology incorporating science, engineering, and mathematics standards, then their overall level of STEM literacy will be enhanced. An increase in STEM literacy will very likely result in a workforce that is capable of assuming technical occupations in a knowledge-based society.

Table 4 (continued on next page)
Depiction of Some of the Major Concepts and Principles Covered in Technology Education Courses Across Science, Technology, Engineering, and Mathematics Standards

Concepts and Principles	NSES	STL	ABET	CCSSI
Understand and use mathematics, science, and technology	✓	3, 4, & 7	A	1 through 8
Understand technological knowledge	F	1 & 2	✓	1, 2, & 5
Understand the history of technology	✓	7	✓	✓
Understand the historical significance of previous advances in technology and engineering	H	3 & 7	✓	✓
Understand about engineering and technology in society	J & H	4, 5, 6, & 7	F, H, & J	1 through 8
Understand systemic principles	A & C	11, 12, & 13	C & H	1 through 8
Understand ecological principles	E & D	5	J	✓
Use and recognize inquiry skills, apply knowledge in retrieving information, and recognize and analyze major limitations in the usefulness of information	B	3, 10, 13, & 17	B, F, & G	1, 2, 3, 5, 6, & 7
Understand and use abilities of engineering design • Define a problem • Brainstorm, research, and generate ideas • Identify criteria and specify constraints • Develop and propose designs and chose between alternative solutions • Implement a proposed solution • Make a model or prototype • Evaluate a solution and its consequences • Refine the design • Create or make the design • Communicate the processes and results	A, B, & F	8, 9, 10, & 11	B, C, E, G, & K	1 through 8

Table Key:
A checkmark ✓ refers to the topic being mentioned or covered in some manner, but it may not be directly stated.

Table 4 (continued from previous page)
Depiction of Some of the Major Concepts and Principles Covered in Technology Education Courses Across Science, Technology, Engineering, and Mathematics Standards

Concepts and Principles	NSES	STL	ABET	CCSSI
Identify, formulate, and solve engineering problems	B & F	8, 9, 10, & 11	E	1 through 8
Employ tools and equipment and use appropriate tools and techniques	B	1, 11, & 12	K	5 & 6
Understand properties of objects and materials	C	2, 15, 18, 19, & 20	✓	✓
Understand about risks and benefits of design solutions	G	2, 5, & 13	✓	1 through 6
Understand resources: • Understand properties of earth materials, such as building materials & sources of fuel • Understand resources and human use	E, C, & H	2, 14, 15, 16, 17, 18, 19, & 20	✓	✓
Work as a team or individually to solve problems	✓	2, 11, 12, & 13	D	3, 4, & 6
Assess impact and consequences of products and systems and assess impact and consequences of actions	A & G	13	✓	✓
Communicate solutions in portfolios, design sketches and drawings, journals, logs, multi- media presentations, and audio-visual presentations	A & F	12 & 17	G	3, 4, 5, & 6
Recognize the need for, and ability to engage in life-long learning	H	✓	I	✓

Source: Accreditation Board for Engineering and Technology's *Engineering Criteria 2000* (ABET), International Technology Education Association's *Standards for Technological Literacy* (STL) , National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM), and National Research Council's *National Science Education Standards* (NSES); a modification of table from Gorham, Newberry, and Bickart (2003).

Conclusion

At a minimum, employers rely on career and technical education (CTE) and workforce training systems to supply workers able to perform in their jobs (Rojewski 2002). In CTE classes that seek to integrate STEM concepts, it falls to the instructors to design and sequence the learning experiences that will promote such a deliberate practice. Instructors must also arrange learning experiences that help students learn to identify the knowledge and skills needed for expert practice, as well as to develop that knowledge and skill set. This paper provided a standards-based framework based on the STL to lay a foundation for

STEM instruction supporting the goal of STEM literacy. It is the intent of this paper to contribute to ongoing discussions among educators, employers, parents, and all those concerned, to seek coherence in STEM instruction through a common standards-based approach. This will serve as the benchmark for accomplished teaching of STEM disciplines in CTE programs preparing individuals for the jobs of the 21st century, consequently requiring that CTE teacher education programs be organized around STEM literacy standards.

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A Comparative Analysis of Preferred Learning and Teaching Styles for Engineering, Industrial, and Technology Education Students and Faculty

Learning styles are personal qualities that influence the way students interact with their learning environment, peers, and teachers (Alkhasawe, Mrayyan, Docherty, Alashram, & Yousef, 2008). According to Felder and Silverman (1988), mismatches exist between common and traditional learning styles of engineering students and traditional teaching styles of engineering professors. Felder (1996) indicates that the Felder-Silverman model classifies students as fitting into one of the following four learning style dimensions:

- *Sensing learners* (concrete, practical, oriented towards facts and procedures) or *intuitive learners* (conceptual, innovative, oriented towards theories and meanings);
- *Visual learners* (prefer visual representations of presented material—pictures, diagrams, flow charts) or *verbal learners* (prefer written and spoken explanations);
- *Active Learners* (learn by trying thins out, working with others) or *reflective learners* (learn by thinking things through, working alone);
- *Sequential learners* (linear, orderly, learn in small incremental steps) or *global learners* (holistic, systems thinkers, learn in large leaps) (Felder, 1996, p. 19).

According to the model, “engineering instructors who adapt their teaching style to include both poles of each of the given dimensions should come close to providing an optimal learning environment for most (if not all) students in a class” (Felder & Silverman, 1988, p. 675). One common discrepancy is that most people, college age and older, are visual learners (Barber & Milone, 1981), while most college teaching is verbal. Also, according to Felder and Silverman (1988), a second learning/teaching style mismatch exists, this one between the preferred input modality of most students and the preferred presentation mode of most professors. Ernst and Clark (2008) state that, in the discipline of engineering/technical graphics, many researchers have studied the use of learning styles of students in both lecture and laboratory situations, but few have attempted to link their research to instructor bias in the classroom. In an ideal setting, these two factors would be aligned since matching teaching strategies to a students' preferred learning style not only promotes understanding, but information is more likely to be retained, leading to a higher level of understanding (Wittmann-Price & Godshall, 2009). However, most professors will teach the way they were taught, even to the detriment of student learning

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(Sadowski, Birchman, & Harris, 2005). According to Bastable (2008), information that is delivered in a style that matches the students' learning style promotes understanding that leads to the retention of new information at a conceptual level, versus surface learning that only requires memorization (Wittmann-Price & Godshall, 2009). On the other side, discounting learning styles can lead to bored, unresponsive class participants, which in turn effect grades and attendance rates, therefore, leading to a loss in satisfaction (Alkhasaweh et al., 2008). Learners make the most out of information when they can select information and organize it into representations that make sense to them (Jonassen, 1999; Mayer & Moreno, 1998; Mayer, 1996; Mayer, 1999b; Wittrock, 1990). To address this identified need, a study was conducted to examine the alignment of students' preferred learning styles with instructor's teaching style in a materials process course.

Instrumentation: The VARK Questionnaire

The VARK Questionnaire was used in this study to assess the preferred learning styles of university students enrolled in a materials process course. The questionnaire is employed to determine to what extent, what percentage of, the students' preferred style is visual, aural, read/write, or kinesthetic. In 1987, Neil Fleming of Lincoln University, New Zealand developed the VARK Questionnaire. It diverges from the majority of learning styles instruments in that its principal intent is to be consultative rather than pointing and prognostic. The major additive component that separates the VARK Questionnaire from other preferred learning style advisories is the fourth category, read-write (Fleming, 2006).

Methodology

In the spring semester of 2010, a materials process course was selected as a means to perform a preferred learning style research study. This course was selected because it contained three groups of students: technology education, engineering technology, and industrial technology. The researchers believed that the differences in the students' background and program emphasis would lead to interesting results. The study's goal was to identify students' preferred learning style according to major and then compare it with the teaching style of the faculty members that have taught the course in the last five years.

All three groups of students were enrolled in a materials process course. This course introduced the students to basic content and skills needed to process common materials and produce functional products using woods, metals, plastics, and composite materials. This course also included laboratory safety, use of hand tools, and operation of machinery. Course content was reiterated to students through laboratory discovery experiences in materials testing and construction of multi-material projects. Pedagogy and learning outcomes were based on the creation and demonstration of physical products.

The two research questions that guided this study were:

1. Is there a difference in the preferred learning style of students in a materials process course according to their academic major?
2. Does the faculty use instructional methods that align with the students' preferred learning styles in a materials process course?

The VARK Questionnaire was distributed to the student groups about midway through the spring semester of 2010. The willing student participants (n = 37) completed the VARK Questionnaire, and instructors collected and returned the questionnaires to the researchers. The faculty members who were currently teaching the course, or who have previously taught the course (n = 8), were given descriptions of each type of learning style: visual, aural, read/write, and kinesthetic. The faculty members were then asked to reflect back on their methods of teaching the course and estimate what percentage of instructional class time was spent teaching within each style. For example, an instructor may report 70% of the instructional time was spent on kinesthetic tasks, 10% on visual, 10% on aural, and the remaining 10% on read/write.

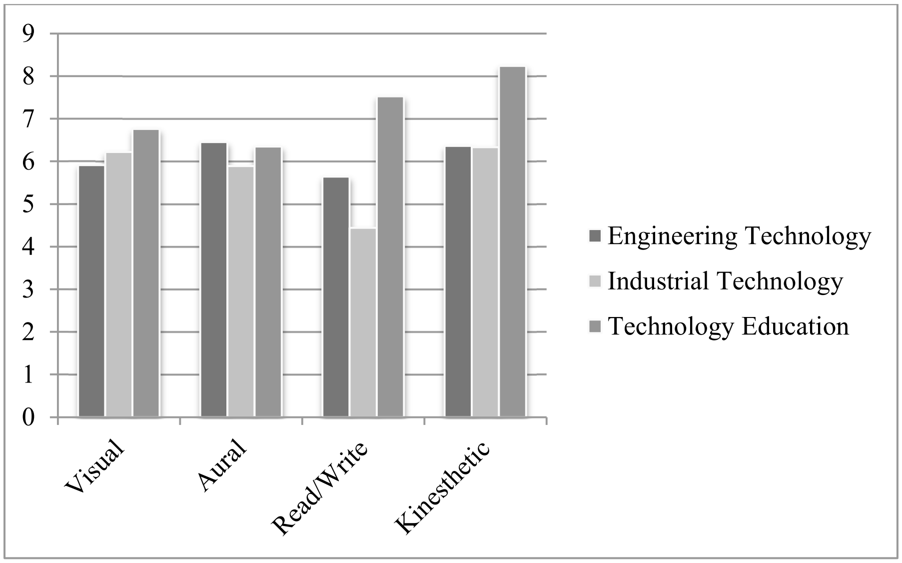
Data Analysis

Analysis of the data began with generating summary statistics of the mean score within each learning style for the student sample. As shown in Table 1, the mean scores for each learning style were segregated by major. The predominant learning style is the largest number compared to the other learning styles and is shown in bold in Table 1. The same data is visually represented and grouped based on learning style in Figure 1. The percentage of each learning style's contribution to the sum total of all the learning styles is also shown in Table 1.

Table 1
Mean VARK Score as a Function of Declared Major

Major	*N*	*Visual*	*Aural*	*Read/Write*	*Kinesthetic*
Engineering Technology	11	5.91	**6.45**	5.64	6.36
Industrial Technology	9	6.22	5.89	4.44	**6.33**
Technology Education	17	6.76	6.35	7.53	**8.24**
Average		6.30	6.23	5.87	**6.98**
Percentage of Total		24.8%	24.5%	23.2%	**27.5%**

Figure 1
Mean VARK Score as a Function of Declared Major



Research Question 1

Due to the non-normality of the data set, non-parametric statistics were used to explore for any significant differences between the groups and their preferred learning styles. A Kruskal-Wallis test was used to develop a mean rank score for each learning style based on academic major. The mean rank score results are shown in Table 2. The mean rank scores were then used in the Kruskal-Wallis test to explore for statistically significant differences between majors for each learning style. The results of this test are shown in Table 3.

Table 2
Mean Rank VARK Score as a Function of Declared Major

Major	*N*	*Visual*	*Aural*	*Read/Write*	*Kinesthetic*
Engineering Technology	11	17.55	20.05	17	15.95
Industrial Technology	9	18.72	17.67	12.83	15.67
Technology Education	17	20.09	19.03	23.56	22.74
Average		18.79	18.92	17.80	18.12

Table 3
Kruskal-Wallis Test of VARK Difference as a Function of Declared Major

	Mean Rank	*Chi-Square*	*df*	*Sig.*
Visual		0.383	2	0.826
Engineering Technology	17.55			
Industrial Technology	18.72			
Technology Education	20.09			
Aural		0.243	2	0.885
Engineering Technology	20.05			
Industrial Technology	17.67			
Technology Education	19.03			
Read/Write		6.379	2	0.041*
Engineering Technology	17.00			
Industrial Technology	12.83			
Technology Education	23.56			
Kinesthetic		3.810	2	0.149
Engineering Technology	15.95			
Industrial Technology	15.67			
Technology Education	22.74			

* Denotes Statistical Significance

Statistical differences that resulted from the Kruskal-Wallis test are designated with an asterisk next to the significance value. A pre-determined significant level, α, of 0.05 was used as a significance threshold. The only learning style that achieved statistical significance was the Read/Write learning style with a mean rank of 23.56 for Technology Education students and a mean rank of 12.83 for the Industrial Technology students.

Overall, there is not much variation between any of the groups within each learning style. In response to Research Question 1, *is there a difference in the preferred learning style of students in a materials process course according to their academic major*, we conclude that the only difference is between the technology education students and the industrial technology students within the read/write learning style.

Research Question 2

All faculty who have taught the materials process course in the last five years agreed to participate in this study (n = 8). Via an online survey instrument, faculty members were given descriptions of each type of learning style and asked what percentage of their instructional time was spent on each style. The results of the faculty survey are shown in Table 4.

Table 4
Use of VARK Methods by Faculty

		Percentage of Time Spent Teaching in Each Style			
	N	*Visual*	*Aural*	*Read/Write*	*Kinesthetic*
Faculty	8	15	28.75	21.25	37.5

The faculty report an emphasis on the kinesthetic learning style with nearly 40% of their instruction time spend on a kinesthetic type of pedagogy. On the other end, the visual learning style is the least represented pedagogy in the faculty's presentation of material. To compare the composite class learning style with the pedagogical methods used by instructors, a percentage of the average preferred learning style of the students was calculated, as shown in Table 1. A comparison of the methods used by faculty and the preferred learning style of students is shown in Table 5. In addition, the difference in percentages between the faculty and students preferred learning styles are also shown in Table 5. A negative difference indicates that faculty are short in the allocation of the amount of time needed for that learning preference to target the courses' learning style needs. A positive difference indicates an excess of time spent with that learning style based on the courses preferred learning style make-up.

Table 5
VARK Methods by Faculty and Preferred Methods by Students

	Percentage of Time in Each Style			
	Visual	*Aural*	*Read/Write*	*Kinesthetic*
Faculty	15%	28.75%	21.25%	37.5%
Students	24.8%	24.5%	23.2%	27.5%
Difference (Faculty-Students)	-9.8%	4.25%	-1.95%	10%

While the instructional methods of the faculty are dominant in the kinesthetic style, and the students' dominant preferred learning style is also kinesthetic, the faculty spend about 10% more time within the style than the overall student learning style suggests. Addressing Research Question 2, *does the faculty use instructional methods that align with the students' preferred* *learning styles in a materials process course,* the researchers conclude that, while the faculty's percentage of time is close to aligning with the students' preferred learning style make-up, less emphasis on the kinesthetic style and more emphasis on the visual style would lead to an optimal match.

Conclusions and Recommendations

This study showed that while there was some variation within majors, the overall dominant learning style in the materials process course was the kinesthetic style. While this was a result the researchers expected, the technology education students were unexpected outliers from the rest of the group. From the Kruskal and Wallis test, the researchers observed a statistical significance (0.041*) between the three groups for the read/write learning style with the technology education students rating it the most preferred learning style. This does raise additional questions for researchers. Based on how the curriculum is often developed and delivered, technology education is typically a very hands-on, kinesthetic discipline. In fact, the content is more kinesthetically based than industrial technology and engineering technology programs, yet students from these other disciplines rated kinesthetic learning as more important than the technology education students. Further research is needed to determine if technology education as a discipline should shift a little more toward the read/write delivery method, sacrificing some of the kinesthetic teaching in the process. These results could also be due to the grass being greener on the other side of the fence. As engineering technology and industrial technology students do not have as much kinesthetic-based learning in their programs, they may see it as a better, more preferred, option of getting content. The same may be true of technology education students believing more read/write-based curriculum would be beneficial.

The researchers suggest that the current data-base of student preferred learning styles be continued as additional sections of the course are taught. The number of industrial technology students (n = 9) and engineering technology students (n = 11) in the data-base were low compared to that of technology education (n = 17). The researchers also plan to review additional courses that contain all three academic majors to determine if this course is representative of the programs in general.

In addition, the researchers are interested in further exploring the preferred teaching style of faculty. According to the study, the dominant preferred teaching style of the faculty members who taught the materials process course (n = 8) was the kinesthetic style. The researchers suggest that this is due to the learning style and comfort zone of the faculty. In essence, faculty members are teaching the way they were taught. Further research is needed to determine how willing faculty members are to teach outside their comfort level to match the students' preferred learning styles.

While conducting the literature reviews to better focus this research, it was determined that there was a lack of research undertaken on cognitive technical learning. The researchers would like to thank our colleagues who have worked on studying the design process, problem solving in technology, and technical thinking. More needs to be done in these areas so that the added value of technical learning is determined and used to better promote our school subject. By understanding the learning style make-up of the students enrolled in their courses, faculty should be able to adjust their modes of content delivery to match student preferences and maximize student learning.

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Book Review

You Are Not a Gadget: A Manifesto

Bertrand Schneider

Lanier, J. (2011). *You are not a gadget: A manifesto*. Random House Digital, Inc. $15.00 (paperback), 240 pp. (ISBN: 978-0-307-38997-8).

Nowadays, most people strongly believe that the internet, and more broadly technology, has transformed our lives for the better. A single click can perform a search on billions of web pages, reach every single human being connected to the net, access an aggregation of individual knowledge (e.g., *Wikipedia*), get a virtual or physical copy of almost every single book humanity has written, or get a snapshot of each other's lives by sharing multimedia content through a social network. Surely, this technological revolution is having a tremendous impact on our cognitive skills and our way to organize and develop knowledge; however, as Jaron Lanier argues in *You Are Not a Gadget: A Manifesto*, most people are so blinded by the potential benefits that they forget to consider how it may threaten our intellectual growth. This is precisely the purpose of his book: to open a philosophical discussion on how technological progress is shaping and constraining the human mind.

As a simple example, Lanier discusses the notion of files. At the birth of computers, plenty of computer scientists believed the concept of files was not such a great idea. Alternatives were proposed, without success. Soon files became the standard, and every computer uses this metaphor to symbolize information. So why does that matter? Or as Lanier frames it, "what do files mean to the future of human expression?" (p. 13). The same question could be asked about human languages—how do words and cultures shape the way we think? Ultimately files or languages are a means by which to express ourselves. But limiting our array of expression means that we constrain the richness of our cognition. In other words, by limiting ourselves to one information format, we have prevented other possible futures where another concept for data structure would have existed (and potentially led to more efficient way to organize data and knowledge).

The kind of design decision that happened for computer files is called a *locked-in* situation—one idea becomes so big that it can't be changed anymore. Plenty of examples can be found in Lanier's book (e.g. web anonymity would be the result of '60s paranoia). As Lanier phrases it, "Lock-in makes us forget the

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lost freedoms we had in the digital past. That can make it harder to see the freedoms we have in the digital present" (p. 14).

An even bigger subject of concern for Lanier is the growth of the Internet *cloud*. He argues that current designs are based on the faith that "internet as a whole is coming alive and turning into a superhuman creature" (p. 14). One manifestation of such an entity is Wikipedia: the way it suppresses human authorship, giving the text superhuman validity. According to Lanier, "traditional holy books work in precisely the same way and present many of the same problems," such as a blind adoration of those entities (p. 32). As a consequence, people "degrade themselves in order to make machines seem smart all the time," because they believe in this supernatural *hive mind* (p. 32). Furthermore, they are more likely to blame themselves when technology doesn't work, instead of recognizing its limitations and defects. According to Lanier, "the 'wisdom of crowds' should be thought of as tool," nothing more (p. 59).

Another side effect of cloud computing is the dehumanization of the data because the growth of the digital hive is done at the expense of individuality. Services such as Wikipedia completely erase points of view, while Facebook organizes people into "multiple-choice identities" (p. 48). Furthermore, "What computerized analysis of all the country's school tests has done to education is exactly what Facebook has done to friendships"—life is degraded and turned into a database (p. 69). Can we adequately judge a child's intelligence based on standardized test scores? Can we say we know anything about someone just by looking at his or her Facebook page?

With the development of more and more sophisticated algorithms, Lanier believes that creativity will become the most valuable resource among human beings, since all other tasks can be performed more quickly and accurately by technology. Unfortunately, creativity is not left unscathed in Lanier's view. He takes music as an example and declares that "pop culture has entered into a nostalgic malaise," because "online culture is dominated by trivial mashups of the culture that existed before the onset of mashups, and by fandom responding to the dwindling outposts of centralized mass media" (p. 20). For Lanier, music hasn't produced anything original since the late '90s; everything is retro or a remix of existing style. In his own words, Generation X is "exceptionally bland" and inert because of its dependence to the cloud, which provides all kind of material for free.

Finally, Lanier mentions a plethora of other cases where technology, and more specifically Web 2.0, may harm us (e.g. the case of money: how advertisement has become central and sacrosanct in the web and how it is corrupting us; which alternatives to Wikis existed; what kind of alternative economic models exist for music; how the "Lords of the Clouds" are more evil than they pretend to be).

Even if this manifesto generally stays on a philosophical level, it has the merit of opening up questions about, and giving an alternative framing on, how technology influences human cognition. Lanier does not provide any empirical evidence or proof to support his claims; he merely asks us to imagine what would have been different if the internet had been created in a different time and place.

In conclusion, it should be noted that this book has several interesting implications for education in general. It asks us to consider how technology may constrain our cognitive abilities (e.g. how many children—and adults—are taking Wikipedia as their only source of information?), and to what extent teaching is in a locked-in situation because of previous educational decisions.

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