Perceptions of *Technological Literacy* among Science, Technology, Engineering, and Mathematics Leaders

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The use of the term *literacy* has a deep history within the United States as it relates to improving people's abilities to listen, read, and write using the English language. Literacy movements have employed formal and informal educational strategies with the express intent to help individuals build the core knowledge and skills of communication which help them achieve the full rights and benefits of citizenship. Over time, the term has been appropriated by numerous communities to describe a broader range of human qualities related to socio-cultural phenomena (e.g., cultural literacy), technological innovations (e.g., media, computer, and digital literacy), workplace skills, competency domains (e.g., Microsoft-literate), and curricular goals.

As early as the 1950s, the term *scientific literacy* was used in discussions of science in general education when Paul DeHart Hurd drew connections between society and scientific and technological innovation (Bybee, 1997). The term *technological literacy* was employed by C. Dale Lemons at the 1972 Mississippi Valley Industrial Teacher Education Conference (Bouhdili, in Cajas, 2001) and by James A. Hale (1972) as a fundamental focus of his dissertation research. In both instances, *technological literacy* embodied the knowledge and skills needed to function in a society dominated by technological innovation and its impact upon society. The use of this term heralded philosophical and curriculum debates (for an overview, see Zuga, 1989) where factions struggled over the mission, goals, and content of an educational program which eventually emerged as technology education.

Since the early 1990s, U.S. national leaders within technology education—William Dugger and Kendall Starkweather—have long fought to position *technological literacy* as the fundamental goal of technology education. Under the auspices of the *Technology for All Americans Project (TfAAP), technological literacy* became the embodiment of a vision for the study of technology as a general education goal for all students. The TfAAP was an 11-year, $4.2 million project (W. E. Dugger, Jr.,personal communication,

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February 20, 2006) administered by the International Technology Education Association (ITEA) and funded by the National Science Foundation and National Aeronautics and Space Administration (NASA). In its premier document, the TfAAP presented a rationale for the study of technology to a national audience (ITEA, 1996). Then, after several years of consensus-building strategies, the TfAAP released the *Standards for technological literacy: Content for the study of technology (STL; ITEA, 2000)*. These content standards were meant "to build the case for *technological literacy* by setting forth precisely what the outcomes of the study of technology should be" (p. 3). Within this document, *technological literacy* is defined as "the ability to use, manage, assess and understand technology" (p. 7).

The T*fAAP* has been one of the most far-reaching curriculum reform projects to occur within technology education. Its national impact can be attributed, in part, to the multi-disciplinary representation of its advisory board, consensus-building methods used for decision-making, and the efficacy of its approach to curriculum change. After more than a decade of advocacy for the goal of *technological literacy*, there is evidence to suggest that this vision has diffused throughout certain sectors of the technology education profession. For instance, Daughtery's (2005) study of technology teacher educators indicates widespread support for 18 of the 20 content standards.

However, the extent to which other educational communities share common values and definitions for *technological literacy* has not been established. Lewis and Gagel (1992) point out, "advocacy for the goal of technological literacy originates from philosophically diverse quarters (e.g., the scientific community, business and industry, politicians) and it cannot, therefore, be assumed that the concept has a stable, unambiguous meaning" (p. 117).

In addition, there have been urgent political voices and significant financial investments—$2.8 billion in fiscal year 2004 for 207 education programs (Government Accounting Office, 2005)—to improve opportunities for all students to attain high standards of achievement in science, technology, engineering, and mathematics (STEM). These efforts are driven by a desire to maintain the technological competitiveness of the U.S. into the future and address a need for teachers to build deep understandings of mutually relevant STEM concepts and processes. Therefore, it could be argued that achieving common ground among key stakeholders embedded within STEM education—teachers, teacher educators, curriculum developers, and professional organizations—is a precondition to envisioning and implementing curricular programs that could positively impact the *technological literacy* of their students and possibly the competitive strength of the U.S. workforce.

Purpose and Research Questions

The purpose of this research study was to gauge the extent to which a vision of *technological literacy* might be shared among leaders of the STEM communities. Three research questions originally posed by the leadership of the

Mississippi Valley Technology Education Conference guided the study, including:

- What are the perspectives of *technological literacy* in each of the four STEM education areas?
- To what extent is *technological literacy* an important goal in each of the STEM education areas?
- To what extent can technology education lead STEM education in delivering on the goal of general *technological literacy*?

Methods

This descriptive study was a re-telling of perspectives and experiences garnered through semi-structured telephone interviews with 13 leaders of national educational organizations during the fall of 2006.

Participants.

Four organizations were selected as exemplars of professional organizations that support educators within the STEM disciplines because of the size of their membership, their charge to support undergraduate teacher education, their leadership in developing national educational standards, or their involvement in STEM programs. These include the National Science Teachers Association (NSTA, $n = 2$), National Science Education Leadership Association (NCELA, $n = 3$), the National Council of Teachers of Mathematics (NCTM, $n = 3$), and the American Society for Engineering Education (ASEE, $n = 5$). The technology education community was purposefully excluded from this sampling frame because both the researcher and the target audience were professionally embedded within the technology professional community.

After receiving human subjects research approval, potential informants were purposefully selected from each organization because of the leadership position individuals held within the organization. Specifically, members of the board of directors, and committee chairs, especially those officers related to *technological literacy*, standards, teacher education, or K-12 education, were invited to participate in the study through a personal telephone invitation.

Interview Protocol

After an explanation of the purpose of the study and assurances of confidentiality, these key informants engaged in telephone interviews lasting from 25 to 75 minutes. A set of 20 questions (14 open-ended) guided each interview; additional probes were extended to better explore unique propositions and unexpected issues.

Initially, open-ended questions elicited individual "points of view" on several topics, including characterizations of technology and *technological literacy*, examples of how STEM curricula addresses technology and technological literacy, familiarity with the STL, and receptiveness to interdisciplinary partnerships. In addition, several closed-ended questions helped clarify informants' judgments about established definitions or principles held by the technology education community. For example, modeled after an item on the 2004 ITEA/Gallup poll (Rose, Gallup, Dugger, & Starkweather, 2004), participants were asked: "Using a broad definition of technology as 'modifying our natural world to meet human needs', does __[insert STEM]__ education address the study of technology? If so, how …"

Data Analysis

To minimize interpretive bias, the researcher recorded verbatim the conversations with informants and reviewed single transcripts in their entirety before segmenting the data by STEM area and research questions. As noted in the Findings and Interpretation section, inductive (themes emerging from the data) and deductive (themes pre-established) analytical methods were employed for coding and interpreting the narratives. Key documents referenced by these informants were also reviewed in order to enhance the consistency of information and explicate the interview data.

Findings and Interpretation

Clearly the limited number of informants, the methods of data gathering, and the analytical lens of the researcher limits the transferability of these results. Any judgments about the usefulness of these findings must be made by the reader. These findings are presented below as they relate to the guiding questions.

What are the perspectives of technological literacy in each of the four STEM education areas?

Several questions specifically elicited informants' understandings of technology and *technological literacy*. In Table 1, key phrases have been extracted from the responses of the informants when asked: In the context of _[insert STEM]_ education, what does 'technology' mean?" This table represents a simplified facet of the results of an inductive process used for coding the data by emergent themes and then collapsing themes into a manageable set. When considered together these themes represent the range of perspectives offered by the informants. When examining specific phrases, it should be noted that this tabular representation indicates overlaps across themes. These themes included: knowledge of technology, technology as the object of assessment, technology and society, technological processes (design and problem solving), technology for teaching and learning, and technology as artifacts or outcomes.

In Table 2, key phrases represent informant's responses when asked: "In the context of _[insert STEM]_ education, what does 'technological literacy' mean?" Using a deductive analytical method, this data was categorized into the common themes extracted from the *STL* in order to more easily compare these perspectives to those of the technology education community. In addition, two categories have been added to represent other comments offered by the informants, including educational technology.

Table 1
Perspectives on the meaning of technology from STEM informants.

	Science	**Engineering**	**Mathematics**
Knowledge about Technology		Understanding, handling, & properly using anything that humans synthesize	
Technology as Object of Assessment	Actual physical stuff, how to use it, & evaluate it Evaluating & selecting tools & materials		
Technology, Individual, & Society	If a human need is to know & understand & explore, then technology certainly meets that human need. It would be defined by human need		
Technological Processes: Engineering Design, Trouble-shooting, R&D, Problem Solving	Retrofitting modern concepts into structures A way of problem solving. A way of logically thinking through a problem to find a solution Design engineering	Habits of mind, processes, tools, materials, & ways we approach the human-built world ….design under constraint & optimization	
Technology for Teaching or Learning	Use of tools as it applies to science teaching Technologies enhance instruction Enable students to do experiments, manipulate variables & find information Technology enables long distance learning Instructional technology		Tool for the study of math Visual tools that open doors to mathematics at higher levels Application of technology to teaching Appropriate use of technology for doing math

Table 1 (continued)
Perspectives on the meaning of technology from STEM informants.

	Science	Engineering	Mathematics
Technology as Artifact or Outcome	Technology is a tool The software & hardware of technology That which grows out of science Monitoring environmental conditions	Systems that are engineered, designed, or created to achieve a purpose Outcomes of the engineering process Computational technology, software for computers, graphic calculators The human built environment Products of the engineering profession	Any kind of device that aids you in doing something: a calculator. Handheld technologies

A multiple-answer question was also posed to informants; this item encouraged informants to select any combination of established definitions which spoke to their understanding of *technological literacy*. Column 1 of Table 3 represents the distribution of selections by STEM discipline.

Science

The science informants offered the most multifaceted and complex definitions for *technology* and *technological literacy*. The initial definition offered by the majority of informants was "technology as tool/tool use", especially as it related to teaching, learning, or doing inquiry. For example, one informant offered this example:

> We use technology for monitoring environmental conditions. Without the instrumentation, we could not track environmental conditions in an effective manner.

In addition to defining technology as a tool/tool use, science informants described technology in terms of connections to the individual and society, design and problem solving processes, and as an object of assessment. These connections were evidenced in thoughts about *human need, retrofitting, problem solving, engineering design, and evaluation and wise selection.* An informant's reference to the *Science for All Americans* (AAAS, 1989) document further elaborated this theme. Essential propositions in the Nature of Technology section note that technologies have side effects and risks, and they

Table 2
Perspectives on the meaning of technology literacy among STEM informants.

Technology	Science	Engineering	Mathematics
STL #1-3 • Characteristics • Core concepts • Relationships	Meeting the ITEA standards Understanding the manmade [sic] world from the natural world	Understand the important underlying principles that engineers use to create technology	Minimal level of knowledge about tools & systems Read, write, & comprehend text
STL #4-7 • Effects • Environment • Role of society • Influence on history	The safety piece, the technology that we need to ensure the safety of students & the students in the broad society Science, technology, & society		
STL #8-10 • Attributes of design • Engineering design • Role of troubleshooting, R&D…. problem solving	Applying that knowledge [conceptual science] to address a problem whether it is a medical, physical, or environmental problem Important in using technology & as consumers telling the difference between hype & what it is actually doing Using technology to solve everyday problems Experiencing low-tech & high-tech tools	Know key principles that engineers use, including both design principles & engineering science Every individual needs to have habits of mind, knowledge & the ability to solve problems Ability to effectively use technology either in the workplace or for personal benefit Being comfortable with technology, understanding, handling, & properly using anything that humans synthesize	
STL #11-13 • Apply design process • Use & maintain • Assess			The ability to solve [problems] & do one's work Understand & use basic technology

Table 2 (continued)
Perspectives on the meaning of technology literacy among STEM informants.

Technology	Science	Engineering	Mathematics
Other	A teacher would understand the use of a wide variety of tools, when & how to apply Teachers know how to integrate technology & enhance their teaching Students are technologically literate Meeting the ISTE standards	I don't know	I don't know. We don't talk about it

Table 3
Results of STEM informants' selection of definitions for technological literacy.

Respondents	I'm going to read four definitions. Which of these describes your understanding of a "technologically literate" person? (multiple answer)
SEEE	a. A person who is able to read and interpret literature about technology.
SSSEEE	b. A person who is able to design, build, install, and troubleshoot products and systems.
SSSEEEEEM	c. A person who critically examines technological innovation in order to make informed decisions.
SSSSSEEEEM	d. A person who understands linkages among the individual, technology, environment, and society.
M	e. Other (Using technology to solve everyday problems)

Key: S=Science (n=5), E=Engineering (n=5), M=Mathematics (n=3)

can fail, therefore decisions about the use of technology are complex at both the societal and personal levels (p. 44). Furthermore, this perspective places the analytical (e.g., risk analysis) and decision-making acts prior to the introduction of the innovation or instantiation of the design. Assessment that precedes technological adoption can inform adoption and diffusion decisions. This chronological placement may also differentiate the science definition of technology from that portrayed within the technology education literature where the emphasis is upon assessment of an innovation after its implementation (see STL #13).

Among the definitions offered by science informants, there were strong parallels between definitions of *technology* and *technological literacy*. As indicated in Table 2, the range of responses addressed:

- understandings of the manmade [sic] world;
- connections among science, society, the environment, and technology;
- abilities to use technology, especially in learning and teaching science and conducting inquiry;
- abilities to evaluate and make informed decisions; and
- standards for technological literacy, including both those produced by the ITEA (2000) and the International Society for Technology in Education (ISTE, 1998).

Science informants offered examples of how science and technology seem to be interdependent. An informant explained that biotechnology (as a course of study) is being adopted by many larger districts in her state. However, within the biotechnology field, the boundaries between science and technology are blurred. The technology enables scientists to research gene splicing and stem cell research, but the tools and processes required to do this research often have to be developed for this research to continue.

Agreement was also unanimous among the science informants that a technologically literate person was one who understands linkages among the individual, technology, environment, and society (Table 3). However, the majority of respondents also insisted that a single statement could not encapsulate the full range of knowledge and abilities that they associated with the term. One informant proposed that it takes both the *STL* and the *National Educational Technology Standards for Students* (ISTE, 1998) to elaborate what it means to be technologically literate in grades K-12. Certainly, it must be concluded that the science informants hold a broad perspective of *technological literacy* which emphasizes a knowledge base, assessment, decision-making, problem solving, and its interconnected nature to society.

Engineering

As shown in Table 1, engineering informants defined technology along several facets: technology as artifact or outcome, knowledge about technology, and processes. The strongest sentiment was that technology was an outcome, artifact, or creation of an engineering process, rather than as a tool to accomplish engineering design or as the process of engineering. Explanations offered by two informants may help clarify this perspective:

> Tool use makes me think of technology and not engineering. It's engineering if there is a direct linkage from the knowledge base to the solution of a problem. I've heard people from technology education speak about a technological design process or a technological problem solving process. This is never

> mentioned in engineering. Engineers would reject the notion that you do technology.

In addition, the reaction of two informants to a definition of technology—"modifying our natural world to meet human needs"—offered to elicit responses to research question #2 was also informative. One rejected this definition of technology because of its engineering orientation; he explained that this "definition seems to be the creation of technology" not a definition of its meaning. Another informant spoke to the inadequacy of the definition: "this definition is lacking because it doesn't focus upon constraints and optimization." At the very least, this line of evidence suggests that the language employed by the technology and engineering education communities may present obstacles to developing mutual understandings about *technological literacy*.

Perspectives of *technological literacy* among the engineering informants were fairly consistent with clear connections to the framework of "knowledge, capabilities, and ways of thinking and acting" that the Committee on Technological Literacy presented in *Technically Speaking* (NAE & NRC, 2002). In addition, all engineering informants agreed that a technologically literate person may be described as one who has the ability to critically examine technological innovation in order to make informed decisions. This emphasis upon critical thinking and decision-making is mirrored in the National Academies recent effort to examine approaches to assess *technological literacy*. In *Tech Tally* (NAE & NRC, 2006), the Committee on Assessing Technological Literacy renamed the "ways of thinking and acting" dimension to "critical thinking and decision making" to better represent one's approach to technological issues (p. 2).

These informants were also quick to indicate that "engineers are far more technologically literate than the average citizen. However, their *technological literacy* is not equally balanced across all the aspects." One informant explained:

> There is a difference between a professional [engineer] and a technologically literate citizen; the professional has more advanced skills. But it's also important that a citizen has similar literacy especially as it applies to medical technologies and communication systems. Just because you are an engineer does not mean that you could lay claim to a domain outside your specialized area. I wouldn't expect an electrical engineer to be more literate than an average citizen in regards to cloning.

Mathematics

As suggested by Table 1, all mathematics informants restricted their definition of technology to tools, especially those used to teach, learn, and do mathematics. When offered a broad definition of technology—"modifying our natural world to meet human needs"—one mathematics informant explained:

> We don't use those phrases. We talk about the appropriate use and application of technology [as it applies to mathematics], not the technology itself…. Mathematics is used as a tool to modify the natural world. Technology is a tool

> within that tool set…. We have three principles which are outlined in our standards.

A review of the *Principles and Standards for School Mathematics* (PSSM; NCTM, 2000) confirmed this perspective. In this national standards document, one of these principles stated:

> Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. (Principles for School Mathematics section)

Additionally, informants indicated that technology is also woven into mathematics through the communication, representation, and connections threads of the PSSM content standards. Although a review indicated that explicit references to technology were scarce within these threads, one infers that technology is valued as a tool for developing, sharing, visualizing, and demonstrating mathematical understandings. For example, one respondent explained that technology "represents ideas using different forms, such as physical forms, graphs, data, and symbolic forms."

In contrast to their narrow definition of technology, mathematics informants' perspectives on *technological literacy* were broader and more encompassing. As evidenced by Table 2 and 3, it appeared that the literacy connection spoke to the development of "minimal skills" that enabled people to make informed decisions about both the problems encountered in everyday life, as well as future "opportunities and challenges" encountered by society. An informant elaborated this point:

> For us, the ability to simulate future scenarios, see *Illuminations* on our Web site, allows students to explore and control future pandemics, population, the possibility of catching a disease, and the number of days a person is contagious and quarantined…. I contend this is technology.

Given these perspectives, we may conclude that *technological literacy* refers to a minimal set of understandings and skills used to explore, predict, and make more informed decisions about personal and societal problems.

To what extent is technological literacy an important goal in each of the STEM education areas?

In addition to more general discussions, informants were asked: "Technological literacy is sometimes defined as 'one's ability to use, manage, assess and understand technology.' In light of this definition, is developing technological literacy among students an important element in _[insert STEM]_ education?" As indicated in Figure 1, informants responded using a 4-position scale, ranging from Very Important to No Importance. However, these responses cannot be interpreted on an equal interval scale because there were qualitative differences in their definitions of *technological literacy* and the examples respondents offered to describe the position of technological literacy within their educational area. Further discussion will be offered for each STEM area below.

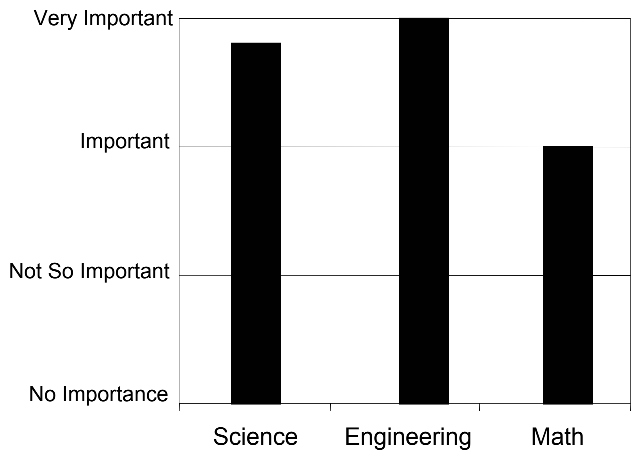

Figure 1. Reported importance of *technological literacy* to STEM informants.

Science

Most evidence from this inquiry supports the conclusion that the science informants link *technological literacy* to science literacy. Informants' numerous references to *Science for All Americans* (AAAS, 1989) and the *National Science Education Standards* (NSES; NRC, 1996) further clarified these connections. There is a clear and redundant message within these documents that building both science literacy and *technological literacy* among all people is an urgent national concern for the health and well-being of citizens, the environment, and the economy. A review of the NSES revealed explicit standards and explanations related to these connections; for instance, Content Standard E states:

> As a result of activities in grade 9-12, all students should develop:
> - Abilities of technological design
> - Understandings about science and technology (p. 190).

Therefore, a reasonable conclusion is that the goal of *technological literacy* is an essential element to the study of science. As one informant emphatically stated:

> Technological literacy is critical…The whole notion of learning science conceptually is to apply that knowledge to a model that will address a problem whether it is a medical, physical, or environmental problem.

Engineering

Although all engineering informants indicated that *technological literacy* was very important to engineering education (see Figure 1), three of five informants cautioned that their views were probably not representative of all engineering educators. One informant conceded "engineering students need to develop *technological literacy*. But they are not necessarily getting it from the engineering curriculum." For instance, when asked where an undergraduate engineering curriculum might provide experiences for students to make connections between engineering and societal concerns, a second informant positioned within a prominent engineering institution indicated that these connections were limited to two experiences within the undergraduate curriculum. These connections were made within a seminar and a senior design project where ethical considerations of the project must be taken into consideration.

However, engineering informants enthusiastically reported that there were significant efforts within the ASEE to raise the consciousness of its members toward *technological literacy*, including the technological literacy strands of the 2005 and 2006 ASEE National Conferences and the formation of a Technological Literacy Constituency Committee. One informant explained:

> The Technological Literacy Constituency Committee has been in existence for less than 2 years. One of our goals is to define technological literacy relative to engineering education. Our goal is to become a full Professional Interest Council within the ASEE. To do that, our committee needs active members. We invite involvement from technology educators and the ITEA.

There was a common sentiment that other populations of learners should also engage in engineering design activities throughout their educational career. Informants spoke enthusiastically about current efforts to infuse engineering into the K-12 environment (e.g., Massachusetts Department of Education, 2001) especially through access to resources provided by the ASEE K12 Engineering Center (see http://www.engineeringk12.org/). In addition, one informant explained that there was a small, but dedicated group of engineering faculty across the U.S. who delivered undergraduate courses which aimed to build technological literacy among non-engineering college students (see Krupczak & Ollis, 2005, for examples).

Mathematics

All mathematics informants indicated that *technological literacy* is important within mathematics education. As already discussed, the mathematics informants' narrow definitions for *technological literacy*—skills and abilities related to teaching, learning, and doing mathematics to solve problems—tempers the weight we should place on their contention that *technological literacy* is an important goal within their area. An informant's reaction to definitions of *technological literacy* clarifies this point:

> I don't see this as math education. I don't believe that building technology literacy, the way you have defined it, is a part of mathematics education.

Therefore, we must conclude that building *technological literacy* is not as high a priority within mathematics education as Figure 1 suggests.

To what extent can technology education lead STEM education in delivering on the goal of general technological literacy?

To approach this highly-speculative, politically-charged question, several assumptions had to be made. First, it was assumed that familiarity with technology education as a school subject, the STL, and professional organizations for technology educators (e.g., the ITEA) would be a necessary precondition for members of the other STEM areas to accept leadership from the technology education field. Second, it was also assumed that confidence in a potential leader could be inferred from recommendations informants make about how public schools should build *technological literacy* among students and about what entities should lead a national effort.

Familiarity

To assess familiarity, a specific question was raised concerning informants' level of familiarity with the STL. Informants responded using a 4-position scale, ranging from Very Familiar to Not Familiar At All. As indicated by Figure 2, all communities had awareness-level familiarity of the STL; in other words, informants knew this document existed but could not discuss its general themes or attributes. In addition to this direct question, a phrase count of the occurrences of technology education or any technology professional

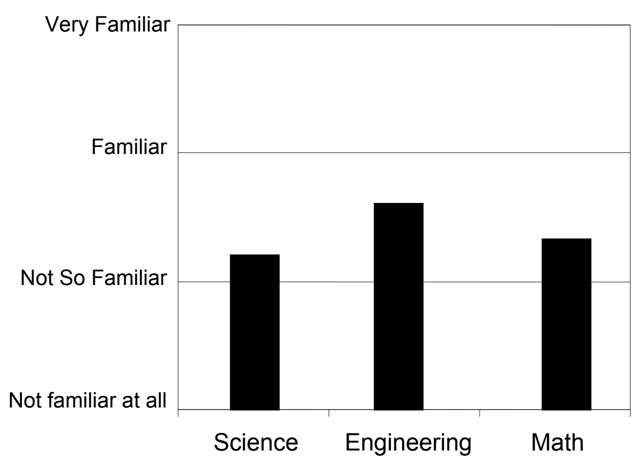

Figure 2. STEM informants' familiarity with *Standards for Technological Literacy* (ITEA, 2000)

organization within the informant's responses was conducted. The results indicated that references to technology education as an area of study were negligible, with only one reference made by science, and five made by engineering informants. References to a technology education professional organization, only the ITEA, occurred more frequently with two from science and six references from engineering informants.

Confidence in School Curriculum

To assess levels of confidence that STEM informants might have in technology education as a curricular program, informants were asked to make recommendations about how public schools could best build *technological literacy*. Six of thirteen informants recommended that public schools make it a responsibility of all subject areas within a school. Not one informant suggested that the appropriate placement of *technological literacy* goals should be embedded within technology education or a technical subject area. Two engineering informants provide some insight into this reasoning:

> I would like to say that all students would take an interdisciplinary course in technological literacy. But, that's not going to happen. Schools should integrate the study of technology into science and math because all students must take science and math. Then in high school, students can take specific explorations of technology and engineering in their electives. The focus of my high school experience was a college prep orientation. This program [technology education] sounds more like a vocational orientation. I do think that some courses that are directly oriented toward understanding or using technologies can be a useful thing. But I suspect that there isn't that much linkage between the more traditional math and science courses. Engineering is a linkage between the two.

Confidence in Leaders

Finally, informants were asked to make recommendations as to who should best lead a national effort to deliver on the goal of *technological literacy*. Twenty-one recommendations were offered; the most frequently mentioned organizations are mentioned below with first letter codes representing each community, (e.g., S=Science):

SSSSE	National Science Teachers Association
EEEE	American Association of Engineering Education
EEE	International Technology Education Association
SE	National Academy of Engineering

Leadership Conclusion

Given the science and mathematics informants' (1) low level of awareness of the STL and the technology profession, (2) lack of confidence in technology education's power to build technological literacy in public schools, and (3) recommendations for desirable national leaders, one might predict that any entity or professional organization embedded within the technology community will have a significant struggle in positioning itself as a national leader within science and mathematics. However, there appears to be an opportunity for mutual cooperation between technology education and the engineering community.

Conclusion

This descriptive research study characterized and compared the perceptions of *technological literacy* among 13 leaders of professional organizations representing science, engineering and mathematics communities. The evidence suggests that these STEM leaders conceptualize it in subtly different ways and place priority upon different dimensions. The science informants tend to value the knowledge and abilities that enable them to conduct inquiry, solve problems, evaluate, and make wise decisions about technology within a larger social context. The engineering informants value the knowledge and abilities that enable them to apply engineering design in a human-synthesized world. The mathematics informants value technological knowledge and skill that enables them to understand and use technology to do and teach mathematics, as well as to make more informed decisions about personal and societal problems.

The importance of *technological literacy* as a goal of STEM education varied among the STEM informants. The interdependencies among the knowledge, abilities, and habits of mind expressed within science literacy and *technological literacy*, as well as the multiple, explicit connections made within the *Benchmarks for Science Literacy* (AAAS, 1993) and content standards (NSES) indicate that the science community places high priority upon *technological literacy*. The engineering informants also value *technological literacy*, especially as it relates to the knowledge and abilities which enable them to engage in their fundamental professional act of engineering design. However, their interest in making *technological literacy* a goal is still emerging and appears to parallel a movement to infuse engineering into K-12 education. The mathematics informants place high priority upon a subset of *technological literacy*, i.e., the abilities and knowledge required to teach, learn, and do mathematics to solve problems. This evidence is in clear agreement with Lewis and Gagel's (1992) conclusion that "technological literacy as a general educational goal cannot be claimed by any one sector or discipline within the curriculum. The sum of the conceptions of technological literacy we see results in an amalgam which suggests a whole-school approach to the problem" (p.135).

These STEM leaders did not readily associate the "T" in STEM with a curricular program known as technology education. Among those who were aware of technology curricular programs, there was a lack of confidence in its power to positively build *technological literacy* among students. There was a prevailing sense that technology education was not considered to be an equal partner in efforts to build interdisciplinary knowledge and skills at the public school level in order to increase numbers of students pursuing undergraduate studies in STEM disciplines. Therefore, this evidence suggests that science, engineering, and mathematics communities may not look toward the technology education profession for leadership.

Although there have been significant political, economic, and educational efforts to promote a common understanding of *technological literacy* among STEM educators, the goal still remains illusive and the costs of achieving common ground may be great. It may be time to call into question the assumption that the technology education field is the banner waver of *technological literacy*. Fundamentally, technology proponents may be wise to embrace diverse representations of *technological literacy,* applaud the significant efforts of others, welcome collaboration with others, and focus attention on the unique contributions they make in building *technological literacy* within general education.

References

AAAS (American Association for the Advancement of Sciences). (1989). *Science for all Americans: A Project 2061 report on literacy goals in science, mathematics and technology*. Washington DC: Author.

AAAS (American Association for the Advancement of Sciences). (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

Bybee, R. W. (1997). *Achieving scientific literacy: From purposes to practices.* Portsmouth, NH: Heinemann.

Cajas, F. (2001). The science/technology interaction: Implications for science literacy. *Journal of Research in Science Teaching*, *38*(7), 715-729.

Daugherty, M. K. (2005). A changing role for technology teacher education. *Journal of Industrial Teacher Education*, *42*(1), 41-53.

Government Accounting Office, U.S. (2005). *Federal science, technology, engineering, and mathematics programs and related trends* (No. GAO-06-114).

Hale, J. A. (1972). *Essential determinants of technological literacy for high school graduates.* Unpublished doctoral dissertation, West Virginia University, Morgantown.

ISTE (International Society for Technology in Education). (1998). *National educational technology standards for students.* Eugene, OR: Author.

ITEA (International Technology Education Association, Technology for All Americans Project). (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

ITEA (International Technology Education Association, Technology for All Americans Project). (1996). *Technology for all Americans: A rationale and structure for the study of technology.* Reston, VA: Author.

Krupczak, Jr., J., & Ollis, D. F. (2005, April). *Improving the technological literacy of undergraduates: Identifying the research issues.* Workshop sponsored by The National Science Foundation. National Academy of Engineering, Washington, DC.

Lewis, T., & Gagel, C. (1992). Technological literacy: A critical analysis. *Journal of Curriculum Studies*, 24(2), 117-138.

Massachusetts Department of Education. (2001). *Science and technology/engineering curriculum framework.* Retrieved July 10, 2007, from http://www.doe.mass.edu/frameworks/scitech/2001/standards/strand4.html

NAE & NRC (National Academy of Engineering & National Research Council). (2006). *Tech Tally: Approaches to assessing technological literacy.* Washington, DC: National Academies Press.

NAE & NRC (National Academy of Engineering & National Research Council). (2002). *Technically speaking: Why all Americans need to know more about technology.* Washington, DC: National Academy Press.

NCTM (National Council of Teachers of Mathematics). (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

NRC (National Research Council). (1996). *National science education standards.* Washington, DC: National Academy Press.

Rose, L.C., Gallup, A.M., Dugger, W.E., & Starkweather, K.N. (2004). The second installment of the ITEA/Gallup poll and what it reveals as to how Americans think about technology: A report of the second survey conducted by the Gallup organization for the International Technology Education Association. *The Technology Teacher*, *64*(1), (Insert).

Zuga, K. F. (1989). Relating technology education goals to curriculum planning. *Journal of Technology Education*, *1*(1), 34-58.