Changes and Progress in Elementary Technology Education

For the past 20 years the field of technology education, in the United States, has made significant strides at the middle and high school levels. Standards are available in most states for grades K-12 and many states and private agencies have developed curricular frameworks for technology education at the secondary level. At the elementary school, there has not been the plethora of curriculum, resource availability, and especially research about elementary technology education experience. This paper will trace some of the historical trends in elementary technology education by examining four separate aspects of it. Part one will briefly discuss characteristics of successful programs in elementary school technology education (ESTE). Part two will show a compilation of data from state standards projects specific to grades K-5 in technology education and how they align to the *Standards for Technological Literacy* (ITEA, 2000). The third section will examine approaches that teacher preparation institutions have made to deliver elementary technology education. Finally, the fourth section will provide an overview of major-funded research studies related to elementary technology education.

Part I: Characteristics of Successful Elementary Technology Education

For an ESTE program to be successful, it must begin with the teacher. A variety of models have been presented in the literature over the past 20 years to implement successful ESTE. Each of these models require well-trained, energetic, and creative classroom teachers who desire to learn and deliver a new curriculum and processes and an administration that is willing to take some risks (Kirkwood, 2000).

In 1997 Foster reported the results of a study that identified three predominant classifications of philosophies toward ESTE. These three included content, process, and method. Content is defined as students gaining and understanding of the knowledge about technology. Foster indicted that "To these writers, technology (or alternatively, technology education) is a discipline" (p. 22). Content based teachers would tend to focus on the study of the seven facets of the designed world as identified in the *Standards for Technological Literacy* (ITEA, 2000). Teachers who prefer to deliver ESTE through a process fall into one of two arenas: design as a process or a problem solving process. Finally, proponents of ESTE delivery as a method indicate that there is already too much material to be covered in the classroom and that technology can not be a separate subject and should be seamlessly integrated into the regular curriculum.

Many elementary teachers currently use some type of "hands-on" activities within their classroom, although this type of activity does not necessarily qualify as an ESTE activity. Kieft (1997) indicated that "One survey of exemplary elementary school programs indicated that just about every elementary school teacher at every grade level implemented some type of hands-on activity each day (p. 254). This does indicate that students desire to and learn better in a setting where active learning is present (see also Foster, 1997). It is important to note that technology education, at any level, is more than just "hands-on" activities, but involves the development of technological literacy: The ability to use, manage, understand, and assess technology (ITEA, 2000).

Part II: Standards in Elementary Technology Education

There continues to be confusion between technology education and educational technology standards. In 1998 The International Standards on Technology in Education (ISTE) developed standards entitled National Educational Technology Standards for Students (NETS*S). These standards were designed to produce technology capable students, specifically in communication and information technologies. As of May 2004, “At the state level, 49 of the 51 states have adopted, adapted, aligned with, or otherwise referenced at least one set of standards in their state technology plans, certification, licensure, curriculum plans, assessment plans, or other official state documents” (Use of NETS by States, 2002). The NETS*S standards focus on the development of computer technology skills in six areas including:

1. Technology Communication Tools
2. Technology Problem Solving and Decision-Making Tools
3. Technology Productivity Tools
4. Technology Research Tools
5. Social, Ethical, and Human Issues
6. Basic Operations and Concepts (Thomas & Knezek, 2002, p. 4)

The authors of this manuscript conducted a general survey to determine the extent to which states have published standards for ESTE. To conduct the survey, each state department of education website was searched and reviewed to determine if such standards existed for ESTE. Throughout the process it was important to differentiate between standards for computer literacy (NEST*S) and those that are more closely aligned with the *Standards for Technological Literacy* (ITEA, 2000). It should also be noted that many states have a technology education curriculum framework that may include ESTE concepts. Curricular frameworks usually provide a philosophic background and suggested learning outcomes, course outlines/descriptions, and suggested activities, but unlike standards they are usually neither legislatively enacted nor required for implementation. There are many states that are currently working on developing state standards for ESTE, although they were not considered unless they appeared in published form. For example, the state of Maryland does not have specified content standards for ESTE, but does have a suggested technology education framework. Furthermore, technology education teachers in Maryland are certified in grades 7-12 and thereby would not be certified for elementary school levels as a specialty area. Of the 50 states, 12 have published standards in technology education for elementary school. The breakdown can be found in Table 1.

	Connecticut	Maine	Michigan	Nevada	New Jersey	New York	Ohio	Pennsylvania	Vermont	Wisconsin
Materials, Tools, and Processes	X		X	X	X	X	X	X	X	X
Technological Impacts and Consequences	X	X	X	X	X	X	X	X		X
Career Awareness	X		X	X						X
Problem Solving	X	X	X	X	X	X	X	X	X	X
Technological/Engineering Design	X		X		X	X	X	X	X	X
Information Systems	X	X	X		X	X	X	X		
Production Systems	X				X	X		X		
Transportation Systems	X				X					
Biotechnology Systems							X	X		
Technological Systems				X		X	X	X	X	
History of Technology	X	X	X		X	X	X			X
Human Ingenuity & Endeavors		X						X	X	X

Table 1: ESTE State Standards

From the data provided in the Table 1, it reveals that the use of materials, tools, and processes, technological impacts and consequences, problem solving, history of technology, and technological/engineering design are most consistently listed as standards for ESTE. It also shows that for ESTE to begin to take hold, more states need to adopt standards for technology education at the elementary level.

Part III: Teacher Preparation in Elementary Technology Education

"There is no complete record of the number of elementary teachers in the U.S. certified to teach technology education or incorporate technology education concepts and principles into their curriculum throughout the school year" (Newberry, 2001, p. 11). Changing the way ESTE is delivered in the class has been a monumental problem. With a shortage of certified technology education teachers for middle and high school program, it is somewhat unrealistic to think that full-time elementary technology education teachers would be available. For ESTE to take make an impact on the technological literacy development there must be a consistent effort to train teachers to deliver contemporary standards-based technology programs. This training may take the form of university courses, in-service training, or special workshops.

Linnell (2000) reported only 15 technology education teacher preparation schools in the United States offered a course in ESTE. Of those 15, "it appears that only five universities in the United States offer technology concepts courses for elementary education and technology education majors throughout the academic year" (p. 96). The remaining 10 universities indicated that the course was not offered on a consistent basis or only during the summer. One year later Newberry reported that a survey conducted of the status of technology education in each state revealed that only 14 teacher education programs in the United States prepare teacher to deliver ESTE (2001).

In 2002, Flowers and Kirkwood reported that Ball State University piloted an online ESTE course entitled *Practicum for Technology Education for the Elementary Grades*. The course focused on the importance of integrating technology education into the classroom with “strategies related to classroom organization, physical planning, and tool and material acquisition” (p. 9). In a recent phone conversation with Dr. Jim Flowers, the Online Technology Education Coordinator for Ball State, online course has been offered three during three summers. Since the course is not a requirement of degree seeking graduate students, he indicated that only a handful of students have enrolled in the course each offering.

To determine the extent to which an ESTE course for elementary students was effective, Kirkwood reported the results of a study of 492 teachers who took a two-credit-hour course entitled “Technology Education for Elementary Grades” (2000). The course was delivered in 1995 and 1996 for elementary education majors and taught by a technology education faculty member. The results of the study showed that 82 (48%) of the respondents indicated an understanding of ESTE and were using it in their classroom. The study goes on to show that “only 35% of all respondents … benefited significantly from, or even remembered, a class that was required of all or nearly all of them” (p. 14). The author indicated that this result was disappointing and indicated that a two-credit-hour course was not enough time to adequately prepare elementary teachers to teach ESTE.

Part IV: Research Findings in Elementary Technology Education

The final section of this paper will summarize five projects and publications that received funding for or are nationally recognized in the development and implementation of ESTE. Each project has a national scope and was begun after 1985. Of the projects listed, four were funded by the National Science Foundation. Dr. Gerhard Salinger, current program officer at NSF indicated in 2002 that NSF has “been funding projects that provide guidance for achieving technological literacy and demonstration of particular implementation strategies” (¶ 2). This effort was thought to also make more students aware of the career choices in the field of engineering and possibly improve the number of students going into that field.

In 1996 the International Technology Education Association released its first issue of *Technology and Children*. The journal was started to “provide a point of communications between children and their teachers in elementary classrooms across the country” (Botrill, 1996, p. 1). The emphasis of the journal has always been the integration of technology education into the elementary classroom by providing relevant articles, design briefs, school showcases and relevant information. This journal is published four times each year and is available for a subscription cost of $25.00 per year for ITEA members. Each issue of *T&C* is “packed with practical, innovative, and creative articles and activities for the elementary teacher. Interdisciplinary learning program successes and other current issues are addressed.” (Technology and Children, 1996, p. 21) This is the only journal that specifically focuses on ESTE, although other publications including *T.I.E.S.*, *Tech Directions, Journal of Industrial Teacher Education,* and *Journal of Technology Education* also include ESTE related articles.

A World in Motion (AWIM)

Funding Agencies: Society of Automotive Engineers Foundation (Challenges 1 & 4) & National Science Foundation (Challenge 2 & 3)
Dates: 1990 – current
Director: Kathleen O'Connor
Institution: Society of Automotive Engineers
Contact Information: http://www.sae.org/foundation/awim/

In 1990 the Society of Automotive Engineers developed a curriculum for students in grades 4-6 entitled *A World in Motion*. This curriculum offered students an opportunity to experience authentic engineering design challenges, increase their interest in mathematics and science, develop a more competitive workforce, and eventually reverse the decline of students entering the field of engineering. Each challenge is designed to take approximately 3 weeks. Challenge I contains three different activities (Skimmer, JetToy, and Steel Can Rover) and is written specifically for grades 4 through 6. These three activities cover topics such as friction, forces, design, creativity, and basic engineering principles. With support from the National Science Foundation, in 1996 and 1998 *AWIM* released Challenge 2 and Challenge 3 for grades 7 and 8 respectively (AWIM 2004).

AWIM provides the initial curriculum and supplies for a class of 27 to 32 students at no cost. Teachers are expected to partner with a local engineer to deliver the curriculum. Since the inception of the program almost 15 years ago, *AWIM* estimates that over 20,000 schools and 2 million students in grades 4-10 have experienced the curriculum. The curriculum continues to grow and has recently added a fourth challenge entitled *Electricity and Electronics*. This challenge is CD-ROM based and geared for students in grades 4-10.

Children Designing and Engineering (CD&E)

Funding Agency: National Science Foundation
Dates: 1998 – current
Director: Pat Hutchinson
Institutions: The College of New Jersey and New Jersey Chamber of Commerce
Contact Information: http://www.childrendesigning.org/

The Children Designing and Engineering (CD&E) project developed 12 thematic units that are given in Table 2. Each unit "draws on research from a wide range of current educational orientations… [including] contextual learning and problem-based learning" Hutchinson, 2003, p. 2). All 12 units are intended to be four to six weeks in length and begin with a design brief that engages the students in the learning situation. The design problem is presented in either a video format, a game, a book, or in interactive story. This introduction of a problem, through the design brief, is meant to stimulate the student's thinking early on in learning process. As students begin to solve the presented challenge they follow a design loop that helps students better plan and make their solution.

Grades K-2	**Grades 3-5**	**Partner Company**
Opening Day at the Safari Park	Camp Koala	Six Flags Wild Safari

Bright Ideas Playhouse	Say It with Light, Inc.	Lucent Technologies
Earth-Friendly Greetings	Paper Products: You Be the Judge	Marcal Paper
Waterworks for Watertown	--	Elizabethtown Water Company
--	Solar-powered Energy Savers	Public Service Electric & Gas Company
Cranberry Harvest Festival	Juice Caboose	Ocean Spray Cranberry Products
Germbusters & Co.	Suds Shop	Johnson & Johnson

Table 2: CD&E Thematic Units

Preliminary results from the study show that students had a high degree of understanding, especially of science concepts and that research and presentation skills, collaboration, self-confidence and problem-solving abilities improved. In addition, teachers indicated that they generally enthusiastic about the units and that although the units may take more time the learning is more lasting. (Hutchinson, 2002, p. 20).

Integrating Mathematics, Science, and Technology in the Elementary Schools (MSTe)

Funding Agency: National Science Foundation
Dates: 1997 - 2002
Directors: Michael Hacker, David Burghardt, & Thomas Liao
Institution: Hofstra University & Stony Brook University
Contact Information: http://www.hofstra.edu/mste

The mission of the MSTe Project is "to provide expertise, inspiration, support and means to all elementary teachers in the participating schools so that they might better construct and sustain learner-centered environments where curriculum, instruction and assessment are guided by contemporary pedagogical practices and matched to MST learning standards" (Hacker, 2002, p. 1). Six goals were developed to carry out this mission and are given below from the MSTe website.

GOAL 1. To equip a group of leadership teachers in three-person MSTe teams with enhanced pedagogical, content, and leadership skills in order that they might reflect upon and improve their own practice, conduct exemplary inservice programs for other teachers, and become regional MST leaders.
GOAL 2. To provide 1,320 NYS elementary school teachers with the ability to use inquiry and design as mechanisms to connect MST in their classrooms; to enhance their MST skills; and to encourage them to engage in reflective practice.
GOAL 3. To develop a substantial and significant infrastructure of MST capability within the MSTe Project schools.
GOAL 4. To enhance the mathematical, scientific, and technological capabilities of elementary school students through instruction that interconnects MST.
GOAL 5. To support systemic change by enhancing the scale-up efforts of the NYSSI and NYCUSI and bring the lessons learned to MSTe Project participants.
GOAL 6. To develop an Implementation and Resource Guide as a planning and decision-making tool for MSTe teams. (MSTe, n.d., p. 1).

Overall the project exceeded its intended outcomes by training 126 state team leaders and 1282 trained participants for a total of 1408, exceeding the target of 1200 teachers by over 200 individuals. The major findings of this project include:

1. Teachers are quite receptive to integrating design and technology into classroom activities in mathematics and science.
2. There is a need for continual professional development for a project of this magnitude to be sustained.
3. State mandated standardized tests constrain the possibilities of an inquiry and design based teaching process.
4. Mentoring teachers is important for change to occur.
5. Strong support from administration is critical to allow teachers to take risks in their teaching.
6. Priority and care needs to be given to reform activities since schools can handle only so many reform projects at a time.

Invention, Innovation, and Inquiry: Units for Technological Literacy, Grades 5 & 6

Funding Agency: National Science Foundation
Dates: 2001 – current
Directors: Daniel E. Engstrom, Kendall Starkweather
Institution: International Technology Education Association
Contact Information: http://www.iteawww.org/i3

Invention, Innovation, and Inquiry (I^3) is so named because invention and innovation are the hallmarks of technological thinking and action as inquiry is for science. Project activities include designing 8-10 day units that develop technological literacy in students, grades 5-6; developing teaching and learning resources based on selected technological and science literacy standards; and disseminating the units to teachers. Each unit has standards-based content, suggested teaching approaches, and detailed learning activities including brainstorming, visualizing, testing, refining, and assessing technological designs. Specific attention will be given to how inventions, innovations, and systems are created and how technology becomes part of people's lives. The engineering design process is at the heart of each unit along with the integration of mathematics and science concepts.

All units are developed through a rigorous process of writing, expert reviewing, and pilot and field-testing. Each unit is developed using the Understanding By Design approach (Wiggins and McTighe, 1999). All the units were pilot tested by technology education teachers in 5th and 6th grade classrooms. In the final phase units are field tested by general education 5th and 6th grade teachers. After each review, extensive revisions are made resulting in teacher-friendly units that focus on student learning of technological capabilities and understandings.

Both pilot teachers and field test teachers have given very positive reviews of the units and the student learning they engender. Through focus groups, site visits, and written reviews these teachers have reported that students expanded their understanding of technology, used the engineering design process to solve problems, developed basic design skills, and related mathematics and science to real-world situations. One teacher noted that because of the I^3 units her students “can claim a much broader understanding of technological literacy, innovation, inspiration, and invention.”

The ten units being developed include:

1. Invention: The Invention Crusade
2. Innovation: Inches, Feet, & Hands
3. Communication: Communicating School Spirit
4. Manufacturing: The Fudgeville Crisis
5. Transportation: Across the United States
6. Construction: Beaming Support
7. Power and Energy: The Whispers of Willing Wind
8. Design: Toying with Technology
9. Inquiry: The Ultimate School Bag
10. Technological Systems: Creating Mechanical Toys

Mission 21

Funding Agency: National Aeronautics & Space Administration (NASA)
Dates: 1987 - 1992
Directors –
Institution – Virginia Tech
Contact Information: http://teched.vt.edu/TE/html/ResM21.html

Mission 21 is designed to launch science and technology across the elementary curriculum. The project sought to help “elementary school teachers introduce the concept of technology education into the classroom through meaningful activities that are suitable for integration into the curriculum” (Brusic, Dunlap, Dugger, & LaPorte, 1988, pp. 23-24). The core value of the Mission 21 project is “the application of the problem-solving process to a variety of technological problems, thereby increasing students' technological literacy” (p. 23). The cooperative effort created the teacher resource guides which show teachers how to integrate technological concepts into their existing programs. The materials of the program are divided into three levels. Level one is for grades one and two, level two is for grades three and four and level three is for grades five and six. *Mission 21* is an ongoing project and funding support shows future technology education research efforts.

Stuff that Works!

Funding Agency: National Science Foundation
Dates: 1997 – current
Directors: Gary Benenson and James Neujahr
Institution: City College of New York
Contact Information: http://citytechnology.ccny.cuny.edu

The primary goal of *Stuff that Works* is to research and develop a professional development model that supports the wide-scale integration of technology education into the elementary grades. The project developed a series of five guides that are given in Table 3. Each guide provides five sections that allow teachers to deliver the concepts presented in the guide including:

Appetizers are short activities that the teacher can do to become familiar with the topics.
Concepts provide an overview of the main concepts of the guide and how it relates to mathematics, science, technology, and other subjects.
Activities include a variety of classroom projects and units that students can complete that are related to the topic.
Stories provide documented commentaries from teachers who have field tested the guides. These help to further understand the concepts by providing photos, samples of students work, and children dialog.
Resources is a framework to support implementation including a bibliography and discussion about assessment.
About Standards relates that content to national standards.

Title	Overview
Designed Environments	Uses an engaging approach to teaching how the process of design makes environments work.
Mapping Ideas	Uses an engaging approach to teaching how space is organized and use and how maps express meaning about space.
Mechanisms and Other Systems	Uses an engaging approach to teaching how and why basic technologies work – those devices, systems procedures, and environments that improve people's lives.
Packaging Ideas	Uses an engaging approach to teaching how and why bags, boxes, cartons, and bottles work to contain, protect, and dispense and display products.
Signs Symbols & Codes	Uses an engaging approach to teaching different methods for representing information.

Table 3: Stuff that Works Publication Series

In all five guides, the authors reported some summary field test results. These results indicated that these materials helped students to:

- ✓ Observe and describe phenomena in detail;
- ✓ Explore real objects and situations by creating models and other representations;
- ✓ Identify salient aspect of problems;
- ✓ Use evidence-based reasoning;
- ✓ Apply the scientific method;
- ✓ Ask thoughtful questions (beyond the yes or no variety)
- ✓ Communicate in oral, written and graphic form;
- ✓ Collaborate effectively with others. (Benenson & Neujahr, 2002, p. 2)

Conclusions

This article sought to elaborate on some trends in ESTE in the United States by examining standards and national projects in ESTE. It is clear from the information that there still is a significant lack of understanding of how children learn about technology and design skills. Many of the projects showed that children do learn more when content is integrated with technological concepts, but failed to show how that learning takes place. It is the hopes of the authors that research in this area will continued to be funded by organizations such as NSF and NASA.

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