Graduate Research in Technology and Engineering Education: 2000-2009

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Introduction

In the 1990s, significant attention was given to the status of research in the Technology and Engineering Education (TEE) field and the direction for future research (Foster, 1992, 1996, 1999; Wicklein, 1993; Zuga, 1994, 1999, 2001; and Lewis, 1999). This research and dialogue resulted in numerous recommendations for future research and practice. Although each effort was unique, it is possible to assert that there existed general agreement that research was important to the field's future and was one of the primary means by which the field would continue to develop and mature. It was also clear, that collectively this body of literature supported the notion that more research was needed that focused on key questions that provide a theoretical foundation for the field. A brief summary of this literature follows.

Relevant Literature

With funding from the Council on Technology Teacher Education, Foster (1992) completed an analysis of 503 doctoral dissertations and masters theses completed from 1985 to 1990. Using content analysis techniques, he reviewed the title pages and abstracts of these studies (and when necessary, the full manuscript). The analysis revealed an average of 84 dissertations/theses annually (72% at the doctoral level). The majority of the studies employed self-reporting techniques (i.e., the survey method) and were focused on program/project evaluation (19.3%) and instructional methods (10%). Foster noted that one would be justified in concluding that the graduate research reviewed constituted a group of "stand-alone" studies focused on a wide-range of questions. He concluded by calling for a greater focus on "seminal issues facing our fields" and the use of more powerful research designs.

This research led to a study whereby Foster (1996) attempted to identify an agenda for Technology Education researchers. This project was partially sponsored by the Technical Foundation of America (TFA) and was presented at TFA's 1996 Issues Symposium. Before the symposium, Foster surveyed 40 researchers/leaders in the field to rank order 21 topics as to their level of importance for future research. In addition, he presented seven statements that were described as a "set of theories deduced from the literature." He asked the respondents to rate each statement as to whether the statement was, in their opinion, (a) a foundational theory, (b) adequately research, and (c) should be a major concern for future research. Table 1 is a summary of those topics with emphasis on the top ten. Six of the seven "theoretical" statements, included in

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Table 2 were ranked above a 4.0 on a five point scale. The numbers in parentheses following each of the statements in Table 2 represent the mean and standard deviation for two of the three questions: (a) should this statement be considered a foundational theory for the field, and (b) should this statement be a major focus of future research.

Table 1. *Foster's (1996) Top Research Topics for the Technology Education Field in Rank Order.*

		Adequately Researched		Major Topic for T.E.	
		X	S.D.	X	S.D.
1.	Integration of educational disciplines (e.g., M/S/T)	2.15	0.87	4.39	0.61
2.	The role of technology education as general education for all students	2.42	1.20	4.27	0.88
3.	Rationale for technology education	2.76	1.35	4.24	1.03
4.	The capability (i.e., effectiveness) of technology education programs to deliver technological literacy	1.91	0.91	4.24	0.83
5.	Nature of technological literacy	2.42	1.20	4.18	1.04
6.	Need for technological literacy	2.73	1.33	4.09	1.07
7.	The nature & effectiveness of applied instructional techniques (i.e., learning by doing)	2.55	1.06	4.03	0.95
8.	Impacts of technology on people and society	2.52	1.09	4.06	0.83
9.	Effectiveness of various instructional techniques	2.82	1.18	4.00	0.94

Others: Definitions (3.36, 1.17; 3.73, 1.31); The relationship between T.E. & other programs (2.39, 1.03; 3.64, 1.03); The nature of learning (2.79; 1.36; 3.52, 1.30); Organizational models for K-16 education (2.52, 1.00; 3.45,1.25); Historical topics (2.85, 0.97; 3.42, 1.00); Change in educational institutions (2.61, 1.17; 3.33, 1.22); Impacts of technology on industry (3.06, 0.97; 3.36, 1.06); Dev. & application of educational technology (2.97, 1.10; 3.36, 1.14); The impact of federal funding on education, in general, and technology education, in particular (2.76, 0.83; 3.27, 1.13); General education issues (3.00, 1.00; 3.12, 1.24); Employment trends and projections (3.33, 0.92; 3.03, 1.05); Technical research (3.06, 1.14; 3.00, 1.30).

Table 2. *Mean and Standard Deviation on the Value of Seven Statements as Elements of Theory for Technology Education*

1. Upon the completion of high school every student should have a "citizens" level of understanding of and ability with technology (i.e., technological literacy as commonly defined). In other words, a basic awareness of and ability with technology is essential for survival and productive citizenship now and in the future (4.58, 0.50; 4.15, 0.91).
2. Technology education is a primary means by which "technological literacy" can be delivered to all students (4.24, 0.97; 4.09, 1.04).
3. Learning by doing in a "real-world" context is the primary means by which most people learn most effectively (4.15,0.91; 3.94, 1.12).
4. Human endeavor provides the best organizer for the content of K-12 technology education. In addition, human endeavor falls into three categories: producing things, communicating information and ideas, and transporting people and things (3.52, 1.20; 3.55, 1.03).
5. Technology is systematic and should be studied as such. To adequately understand technology, students should be exposed to the components and processes of a wide variety of technological systems (4.15, 0.91; 3.73, 1.01).
6. Technological activity produces positive and negative impacts. An understanding of these impacts is a major component of "technological literacy." To properly understand technology, students must be exposed to these impacts and explore solutions for negative impacts of various technologies (4.42, 0.50; 4.15, 0.80).
7. Successful human beings in a post-industrial society must be able to think clearly, creatively, and critically. They must be able to identify and solve problems, and make good decisions. Technology education is a primary means by which students can be taught to think (4.24, 1.12; 4.15, 0.97).

During the symposium, Foster presented the survey data, but used the majority of the time to conduct a "strategic planning" session to address the following questions: What would be ideal for research in the field? What roadblocks were preventing the realization of the ideal? Interestingly, there was general consensus that the major roadblocks were the low status of research (i.e., limited resources, and rewards; and that it was boring and of low perceived value), the nature of the questions being asked, and the lack of central coordination and synthesis.

During this time, Zuga (1994) completed an analysis of 220 doctoral studies in technology education. She too noted the reliance on survey research methods and a focus on curriculum and instruction issues. She recommended focusing our research efforts on (a) the inherent value of technology education, (b) cognition and conceptual attainment with respect to technology education, (c) the ideology and inherent biases that limit access for all students, (d) public attitudes and receptivity to technology and technology education, and (e) curriculum materials in order to implement technology education for all students.

The American Association for the Advancement of Science (AAAS) hosted a conference on technology education research in 1999. During this conference, Foster (1999) and Zuga (1999) revisited these and related issues. The organizers of this conference forwarded the notion that there was a strong argument in favor of technology education, but that the subject "has largely failed to materialize as a school subject in the U.S." (i.e., as a required aspect of general education). In response, Foster (1999) noted that a solid agenda and high-quality research were not adequate to address the issue of technology education as a required subject for all students. Throughout the conference, there was general agreement regarding the importance of research for the future of technology education and that more researchers were needed (Zuga, 1999).

Lewis (1999) synthesizing the discussion to date, proposed eight questions that could provide a "basis for inquiry" for the field. These included questions relating to (a) technological literacy, (b) conceptions and misconceptions of technological phenomena, (c) perceptions of technology, (d) technology and creativity, (e) gender in technology classrooms, (f) curriculum change, (g) integration of technology and other schools subjects, and (h) the work of technology teachers. He cautions his readers that we should not intentionally or accidentally "box in" researchers and challenges researchers in the field to "find their own questions."

National Center for Engineering and Technology Education

A major development in Technology and Engineering Education research has been the infusion of National Science Foundation (NSF) funding to the National Center for Engineering and Technology Education (NCETE) project housed at Utah State University. NCETE is a partnership between nine universities, two professional associations, and a private educational research organization. NCETE's mission is "to build capacity in technology education and to improve the understanding of the learning and teaching of high school students and teachers as they apply engineering design processes to technological problems" (http://ncete.org/flash/index.php). NCETE sponsored its first cohort of doctoral candidates at the universities in April 2005, and have generated several dissertations to date.

Regarding research, NCETE's goals are to

- "define the current status of engineering design experiences in engineering and technology education in grades 9 – 12;
- "define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education;" and
- "identify guidelines for the development, implementation, and evaluation of engineering design in technology education" (www.ncete.org).

In an internal report (National Science Foundation, 2004), the staff of Centers for Learning and Teaching Program, in writing about the National Center for Engineering and Technology Education, noted that technology education was “an important, and much neglected area of K-12 formal school education” (p. 7). They went on to note that the “research base for the Center is not as well-established than the areas of mathematics and science education, particularly relative to cognitive learning” (p. 7).

Problem, Purpose, and Limitations

It is evident from this brief literature review, that there has been significant amount of effort to expand the research base supporting technology and engineering education. However, it is unclear the extent to which recent graduate TEE research has addressed these and related issues. Further, the direction and findings of recent graduate TEE research is unknown. While graduate research is not the only body of research being conducted my researchers in the field, it does represent a major body of research that warrants independent analysis.

The purpose of this study was to amass as comprehensive a collection of dissertations and theses in technology and engineering education as possible, and to conduct a modified meta-analysis of this body of research. It was guided by the following research questions:

1. What graduate research has been completed during the period of 2000 – 2009 and at which institutions?
2. What methods were used, and what keywords and other descriptors were used to describe the research?
3. What were the major topics and themes of this research?

The current study was limited to dissertations and theses completed between 2000 and 2009 that were identified using the ProQuest search engine. Additional studies were identified from the NCETE web site. Two studies were identified because they were known to the author. The possibility exists that there are others that have been inadvertently omitted. The sample is limited to studies that were clearly within industrial technology education, technology education, and technology and engineering education.

Methods

This study was a modified meta-analysis as the diversity of the studies did not allow for the creation of a set of common variables. The primary method was content analysis of dissertation and thesis abstracts. The list of research method categories comes from a synthesis of lists provided by Borg and Gall (1989) and Cohen and Manion (1984). The methods employed in this study were those used in Foster’s 1992 study. A major difference between this study and the 1992 study was that in the previous study, the author made numerous efforts to collect unpublished manuscripts from multiple sources (e.g., contacting graduate coordinators and even traveling to university libraries). As stated above, this study was limited to those studies located primarily through “on-line” searches.

The dissertations and theses were identified using the ProQuest search engine and multiple searches using such key terms as technology education, engineering education, engineering and technology education, technology and engineering education, and industrial technology education. Approximately 200 studies were identified. After careful review to ensure that the study pertained to the technology and engineering education field, a total of 74 studies were included in the final pool. The abstracts, and in some cases the full report, were reviewed to determine the university offering the degree, date completed, the research method employed, the keywords and subject descriptors, and the topic/focus of each study.

Results

The results of this study will be reported in sections based on the three research questions used to guide the study.

1. *What graduate research has been completed during the period of 2000 – 2009 and at which institutions?*

Table 3. *Degrees earned by year and the focus of the study by educational level.*

2000	9	K-12 Education	44 (59%)
2001	2	Post-Secondary Education	17 (23%)
2002	5	Neither/Both	13 (18%)
2003	9		
2004	8		
2005	5		
2006	6		
2007	6		
2008	13		
2009	11	N = 74	

As stated above, a total of 74 dissertations/theses were included in this analysis. Table 3 provides a summary of the degrees earned by year and the educational-level focus of each study. On average, there are 7.4 studies per year with the majority (59%) focused on the K-12 educational level. As noted above, there is good reason to believe that additional studies were completed during this time period and were inadvertently omitted from analysis. While it is too soon to declare a trend, it is noteworthy that there was a marked increase in studies in 2008 and 2009.

Table 4. *Universities Offering the Degree*

North Carolina State University	11
The Ohio State University	9
University of Minnesota	5
Utah State University	4
Old Dominion University	3
Virginia Polytechnic Institute and State University	3
Nova Southeastern University	2
Purdue University	2
University of Central Missouri	2
University of Georgia	2
University of Illinois - Urbana/Champaign	2

Others with one each: Alabama State University; Andrews University; Central Michigan University; Clemson University; Colorado State University; Duquesne University (PA); Immaculata College; Indiana University; Indiana University of Pennsylvania; Jyvaskylan Yliopisto (Finland); Kent State University; McGill University (Canada); Royal Roads University (Canada); Southern Illinois University at Carbondale; Texas Tech University; The University of Nebraska – Lincoln; The University of Wisconsin – Madison; University of California - Los Angeles; University of Maryland, College Park; University of Massachusetts – Amherst; University of Missouri – Columbia; University of Pittsburgh; University of South Carolina; University of South Dakota; University of South Florida; University of Tennessee; University of Toronto (Canada); University of Wyoming

The institutions granting the degrees included in this study are listed in Table 4. Eleven institutions contributed multiple dissertations/theses for a total of 45 (61%) studies. Interestingly, two institutions (North Carolina State University and The Ohio State University) accounted for 20 (27%) of the total. It is also interesting to note that three of the studies come from Canadian universities and one from a Finnish university.

2. *What methods were used, and what keywords and other descriptors were used to describe the research?*

Table 5. *Research methods employed*

	f	%
Survey (1)	23	31.1
Delphi (1.1)	5	6.8
Observation (2)	0	0.0
Causal-Comparative (3)	4	5.4
Correlational (4)	5	6.8
Experimental (5)	3	4.1
Quasi-Experimental (6)	11	14.9
Test Development (7)	0	0.0
Observational - Participant (8)	1	1.4
Observational - Non-part. (9)	1	1.4
Case Study (10)	15	20.3
Evaluation (11)	0	0.0
Research & Development (12)	0	0.0
Historical (13)	1	1.4
Philosophical (14)	1	1.4
Combination (15)	4	5.4
Total	74	100.0

Table 5 provides a summary of the methods used to complete each study. When combined, the survey and Delphi methods comprise the method used in 37.9% of the studies. The case study method was employed 20.3% of the time. A total of 19% used experimental or quasi-experimental methods. Qualitative methods were employed 25.5% of the time.

Table 6. *Keywords used by author to categorize the study*

Technology education	26
Technology & technological literacy	10
Teacher education; technology teacher education	9
Industrial arts	6
Problem solving; finding; efficiency	6
Science; science and technology education	6
Learning; learning style; learning system	5
Curriculum & curriculum consonance	4
Elementary school	4
Self-efficacy	4
Standards for Technological Literacy	4
Cognition, cognitive apprenticeship, profiles	3
Engineering and technology education	3
High school	3
Industrial technology; education	3
Professional development	3

Table 6 contains an abbreviated list of keywords used by the author to describe the study and to provide one of the means of locating the study when using an electronic search engine. The reader should be aware that it is likely that the database software (in this case, ProQuest) also generates keywords by breaking down the title into key concepts. Consequently, it seems that the current Subject category in ProQuest is closer to the Keyword category in the former Dissertation Abstracts International. Readers should also note that authors are allowed to provide multiple Keyword descriptors per study.

What were the major topics and themes of this research?

The topic/theme of each study was determined using two methods. The first was simply listing and summarizing the Subject descriptor provided by the author. The second method was a subjective analysis of the content of the study by this researcher. Table 7 contains an abbreviated list of Subject descriptors.

Table 7. *Subject descriptors used by author to categorize the study*

Vocational education	26
Educational software	24
Curricula & curriculum development	17
Secondary education	16
Teacher education	14
Teaching	12
Educational technology	10
In-service training	9
Educational psychology	7
Industrial arts education	6
Elementary education	5
Higher education	5
School administration	5
Educational evaluation	4
Science education	4
Mathematics education	3

The Subject descriptor used most frequently is vocational education (26 times) followed by educational software (24 times), curriculum and curriculum development (17 times), and secondary education 16 times). Readers should note that authors are allowed to provide multiple Subject descriptors per study.

Table 8. *Topic/focus of the studies*

Effectiveness of instructional activities	15
Acceptance/perception of TE or TEE	10
Professional/political issues	8
Diversity/inclusion	7
Cognition/problem solving	6
Program/project evaluation	6
Teacher preparation	6
Values of TE/TEE as general education	6
Inclusion of engineering in TE	5
Instructional technology	5
Nature/testing of technological literacy	5
Teacher in-service/professional development	5
Acceptance/use of Standards for Tech. Literacy	3
Recruiting to STEM degrees/careers	3
TE/TEE curriculum development	2

Table 8 contains the results of a subjective analysis of each study (note: studies may fit more than one category). A significant number of the studies focused on testing specific instructional activities to determine their effectiveness. The second most common focus was assessing the acceptance/perception of technology education, and technology and engineering education, followed by professional and political issues.

Discussion

The purpose of this study was to conduct a modified meta-analysis of dissertations and theses completed from 2000 to 2009. The total number of studies found that were clearly in the field (i.e., industrial technology education, technology education, and technology and engineering education) was 74. The titles and abstracts, and in some cases the full report, were reviewed to determine the university offering the degree, date completed, the research method employed, the keywords and subject descriptors, and the topic/focus of each study. This study was basically a replication of Foster's (1992) early study.

It was noted in the 1992 study that one of the goals for the study was that it would serve as a benchmark for future studies and to a limited extent it does so for this study. However, it should be noted that the 1992 study included dissertations and theses from six fields of education and not just technology and engineering education. Of the 503 studies analyzed in the previous study, only 88 were categorized as Industrial Arts/Technology Education studies; a separate analysis of those studies was not completed in the 1992 study.

The data clearly indicated that the majority of the studies completed in technology and engineering education from 2000 to 2009 were focused on K-12 education (59%). The greatest percentage of those studies was completed using the survey methods (31.1%). A total of 28% of the studies could be categorized as status studies. The studies were completed at 39 different doctoral granting universities with 11 universities accounting for 45 (61%) of the studies. In forty-five cases, the studies were described using the following keywords: technology education (26), technology and technological literacy (10), and teacher education/technology teacher education (9). A subjective analysis of the topics revealed significant diversity; the topics occurring most often were (1) effectiveness of instructional activities, (2) acceptance/perception of technology education or technology and engineering education, (3) profession/political issues, and (4) diversity/inclusion issues.

On one hand, it is possible to make the case that very little has changed since 1992. The group of dissertations and theses analyzed in the current study also tend to represent a set of stand-alone studies that do not build on recognized theory, with a significant percentage of them using descriptive analyses. However, this analysis does not give us a complete picture. First, there was a marked decline in the percentage of survey studies (48.7% to 31.1%) and a sharp increase in the use of the case study method (2.8% to 20.3%). Second, there was a definite shift in the questions being asked. It can be argued that additional movement is needed, but it is clear that more work was done relative to diversity, cognition and problem solving, and the nature of technological literacy. Third, as was noted in the first point, there was a sharp increase in the number of qualitative designs.

A study of doctoral granting programs was completed in 1981 (Koble, 1981). The purpose of the study was to determine the characteristics of the programs and to rank the programs. The author reviewed programs at 27 institutions. Foster (2008) noted that the majority of those programs listed in Koble's study were no longer in existence. As noted above, the 74 dissertations and theses were awarded by 39 institutions. Only nine of those institutions were listed in Koble's study. The data indicate new "players in the game" and some growth in programs that have been around for many decades. However, it is clear that the number of researchers in the field has remained small and that there is still a need for more (Foster, 1992; Zuga, 1999).

This analysis is encouraging. It is clear that the increase attention to research in the field has resulted in positive developments. Progress is being made. It is also encouraging to note a significant increase in funding for research in the field as evidenced by the NCETE project. Additional efforts of this magnitude are needed. However, we cannot ignore the fact that more work is needed, especially in the development of a sound research base for the field. It is imperative if we are to continue to marshal and expand support for our efforts. Technology and engineering education is important to our country and research is important to the continued development of technology and engineering education.

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