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Comparative Analysis of Research Priorities for Technology Education

Gene Martin & John Ritz

Abstract

This study compares and contrasts the most relevant research priorities identified through two Delphi studies by the authors. The panels of experts used in these studies, an international and a U.S. study group, were asked to identify important topics to guide future research studies for the school subject of technology education. Both panels sought to determine the most relevant issues that need to be researched related to K-12 technology education and preparation for teaching this school subject. This study reports the similarities of research priorities identified by both expert panels, then contrasts the major differences that the groups identified for further research.

Keywords: Research needs, research priorities, technology and engineering education, comparative analysis of research needs, research on teaching, international and US technology education

Introduction

To advance humankind, scholars and practioners undertake research and development activities to determine how best to move societies forward. In education, researchers undertake studies to determine the knowledge students should learn and to determine the best practices to assist students in learning this knowledge. This study was designed to compare and contrast the findings of two earlier studies (Martin & Ritz, 2012; Ritz & Martin, 2012) that used panels of experts to identify major issues that need to be researched for K-12 technology education (design and technology, technological and engineering literacy) and also the issues that need to be researched regarding the teaching of this school subject. Subsequently, the following two research objectives were established.

RO_1: Compare the most relevant research issues needed to be studied for the betterment of K-12 technology education including the preparation for teaching this school subject as identified by international and US panels of experts.

RO_2: Contrast the most relevant research issues needed to be studied for the betterment of K-12 technology education including the preparation for teaching this school subject as identified by international and US panels of experts.

Literature Review

Many education professions have established research agendas to guide the development of the knowledge for their school subjects/specialty areas. A cursory review of data bases showed studies of this nature have been undertaken for art and design education (Hickman, 2008), school, family, and community connections (Jordan, Orozco, & Averett, 2001), school-to-work education (Rusch,1986), distance education (Rockwell, Furgason, & Marx, 2000), technical education (MacLennan, 2008), and education in general (Pew Charitable Trust, 2013), to mention a few.

Martin and Ritz (2012) and Ritz and Martin (2012) undertook two such studies to determine issues that needed to be researched in technology education. Others have undertaken studies to classify what had been researched by individuals working within this school subject. Some examples are de Vries (2005), Johnson and Daugherty (2008), Lewis (1999), Middleton (2008), Petrina (1998), Williams (2011), and Zuga (1994). Their analyses used document review methodologies to categorize research issues presented through publications and conference papers within our profession. They identified frameworks for categorizing past research efforts by individuals who study technology education. Zuga reviewed research studies from 1987-1993 and reported these by categories. Most research was focused on curriculum concerns. Shortcomings cited in the study for this period of time included a lack of studies on the value of this school subject, problem-solving, cognition, instructional methods and strategies, and technological literacy.

Williams (2011) reviewed research papers developed between 2006-2011 that were found in journals and technology education research conference proceedings. His intent was to determine what had been researched. Forty-two papers were developed that focused on design in technology education. Other significant topics researched during this five-year period included curriculum (34), technological literacy (34), and thinking (32). There were many other topics identified that were studied through technology education research.

With the publication of the Technology Education Series by Sense Publishing, five recent volumes have reported on current research completed by the technology education community. de Vries and Mottier (2006) had authors report on research in their countries during a 20-year period. This included reports from countries on all continents. Middleton (2008) wrote in and edited a volume in the Technology Education Series, and it included the use of various research methods and techniques that could be employed when studying technology education. Ginestie (2008) had authors report 20 years of research and development efforts in France on how knowledge for technology education is taught and learned. Jones and de Vries (2009) edited *International Handbook of Research and Development in Technology Education* which again had authors from many different cultures. Most recently, Skogh and de Vries (2013) guided current and new PhD's to report on their research on school-based technology education practices including philosophy, technology education research, engineering education, and teachers' perspectives.

Martin and Ritz (2012), through their international and US studies on research needs for technology education, used inductive techniques to ask panels of experts what needed to be further researched to improve this school subject. This paper discusses the findings of these studies.

Procedures

Four-round Delphi methodologies were used to gather initial items for future research needs for technology education, and subsequent study rounds were used to draw panel consensus on the issues needing researched. The international panel of 32 experts, representing 20 countries (a heterogeneous group from all continents, except North and South America; the US was excluded because there was a parallel study involving this population), identified 10 research needs for technology education and eight research needs related to the preparation for teaching this subject. The US panel of 17 experts consisted of individuals designated as Technology and Engineering Teacher Educators of the Year by the Council on Technology and Engineering Teacher Educators (CTETE) who represented different states/universities and had proven research expertise as part of their selection criteria. They identified six research needs for technology education and one related to the preparation for teaching this school subject. Each issue was assessed by panel members and reported through a mean score (5=most important to 1=not relevant).

This study will further explore the findings of these two Delphi studies by drawing conclusions on the similarities and differences in the groups' research priorities for technology education. The Delphi studies provided the researchers with extensive narrative descriptions of the issues used as the basis of these comparisons. The researchers used this knowledge to compare and contrast the most relevant research needs for the school subject of technology education and identify whether philosophy/practices of the leaders from countries/regions may have caused some relevant research priorities to exist.

To begin the analysis, the researchers reviewed and sorted the two panels' issues, using details noted in their author's descriptions, and placed these into categories. Between Round 1 and Round 2 of the Delphi studies, an outside panel was used to combine similar items and to begin the process of creating research issue categories. The studies produced 32 significant research needs (mean scores above 3.51), with 22 issues identified by the international panel and seven issues identified by the US panel. The researchers categorized these issues into seven distinct research categories: technological and engineering literacy knowledge, student learning related to the study of technology, pedagogical content knowledge for teaching technology education, designing, nature of technology, and sustainability for global citizenship. The following comparative analyses will report items by category. The items identified related to K-12 technology education are listed in rank-order in Table 1, while the items related to the teaching technology education are reported in rank-order in Table 2.

Comparative Analysis

Technological and engineering literacy knowledge

The category of technological and engineering literacy knowledge drew a significant amount of attention from the international and US participants in this study when they were charged with identifying the most important issue that needs to be researched related to K-12 technology and engineering education. The international participants appear to be most interested (M=4.07) in conducting research into technological conceptual knowledge. They give great attention to the need for selecting and aligning appropriate exemplars of conceptual knowledge in the school subject for learners on their specific level (e.g., levels 7-8 vs. levels 9-10 and 11-12). They seek to conduct research that determines the most appropriate content knowledge to teach by grade level for learner development. The international participants are also interested in conducting research that results in determining the value (M=3.52) of technology education. In other words, they seek answers to questions that focus on identifying the short- and long-term values of students taking subjects and they seek to identify whether the value of these subjects can be quantified. The US participants also seek answers to the value of the school subject. Within this context, they refer to value as "benefit". They seek to conduct high quality research (valid and reliable studies) into the benefits of K-12 technology and engineering education. They believe this need is so great (M=4.24) that they want an "abundance" of studies that address benefit. Furthermore, they want both qualitative and quantitative research studies conducted that will provide evidence of the advantages of technology and engineering education at various learner developmental levels. It is unclear whether these learner developmental levels refer to grade levels, cognitive levels, psychomotor levels, etc.

When challenged to identify the most important issue that needs to be researched related to preparation for teaching technology and engineering education, the international participants identified three issues in the category of technological and engineering literacy knowledge. Interestingly, the US participants' responses did not provide evidence of a need to conduct further research within this category. The international participants seek further knowledge related to the epistemic beliefs of teachers (M=4.14), teachers' beliefs about program delivery (M=3.82), and the meaning of technology education for practicing teachers (M=3.52). The US participants' attention to these three areas is noticeably absent in their responses. Arguably, the lack of attention by the US participants to this issue may be related to the group's composition – they have been previously recognized by CTETE as recipients of the Teacher Educator of the Year award. There is a common bond among members of this group as they have certain attainments (e.g., research expertise) in their profession that allow them to be recognized as an award participant. The international participants seek answers to key issues such as the need to explore the tacit understandings that support or work against the goal of providing opportunities for students to increase the critical nature of their developing technological literacy. They see a need for further research that will lead to a better understanding of the ways teachers' beliefs affect program delivery and student learning in technology. Finally, the international participants appear to be unclear about the meaning of technology or have not reached consensus on the meaning of technology. This is understandable as the participants are a very heterogeneous group of 32 individuals representing 20 different countries. It may not be possible for this group to ever reach consensus or to even want to reach consensus simply by the nature of the populations they represent. They want to ensure that their technology teachers are well-grounded in philosophical understanding, regardless of whether these teachers receive their formal training in technology preparation through traditionally prepared methods and processes or by alternative means. The participants see that fulfilling this need is fundamental for all teachers of technology and engineering education.

Table 1: Rank-Ordered Significant Research Needs for K-12 Technology Education

International Research Needs		US Research Needs	
Item	Mean	Item	Mean
Abilities students develop through T.E.	4.28	Impact on academic achievement	4.29
Learning that takes place through T.E.	4.17	Benefits of K-12 T.E.	4.24
Sustainability and global citizenship	4.10	Engineering content and curriculum	4.18
Technological conceptual knowledge	4.07	Content for Tech. and Engr. Ed.	4.06
How do student learn in T. E.	4.07	Shortage of critical research	3.82
Pedagogical content knowledge for T.E.	4.03	Student learning	3.65
How students learn technology	3.97		
Assessment of technological performance	3.97		
Value of student learning through T.E.	3.93		
Nature of technology	3.90		
Measuring higher order thinking skills	3.83		
Nature of designing	3.68		
Knowledge and abilities learned in T.E.	3.66		
Designing for secondary students	3.62		
Pupil's motivation towards technology	3.62		
Shortage of research on the evaluation	3.60		
Value of technology education	3.52		

Table 2: Ranked-Ordered Statistically Significant Research Needs for Teaching Technology Education

International Research Needs		US Research Needs		
Item	**Mean**	**Item**	**Mea**	**Mean**
Epistemic beliefs of teachers	4.14	Cognitive science connections	333.82	3.82
Assessment of practical work	3.96			
How should design activities be taught	3.90			
Understanding PCK	3.88			
Program delivery	3.82			
Teachers conceptions of designing	3.76			
Meaning of T.E. by practicing teachers	3.52			
Collaborative learning in T.E.	3.52			

Mean is derived from a 5-point Likert-Scale

What might we learn from a comparative analysis of the participants' responses to research in the category of technological and engineering literacy knowledge in this study? The international participants are interested in research in technological conceptual knowledge, appropriate content knowledge for learner development, and values. The US participants want to conduct studies that focus on the benefits of technology and engineering education and which are also deemed to be valid and reliable research studies. They use the term "abundance" which may underscore the need to conduct several, if not many, studies focusing on technology and engineering education and they want their studies to include research designs that are quantitative and qualitative in scope. Finally, the international participants appear to have identified more need for research in the preparation for teaching technology and engineering education. It is unclear whether their identification of this area of research is indicative of a lack of research in their respective countries or whether they have the foundation of research and they simply want to take their research to a higher and more sophisticated level. Similarly, the US participants' lack of attention to research in this area is somewhat puzzling. Do the US participants believe their technology educators have researched this area to its fullest or might they believe there are other more urgent research needs in technology and engineering education?

Student learning related to the study of technology

The category of *student learning related to the study of technology* received the greatest attention from all the participants in this study, but their attention to specific types and foci of research is almost evenly divided among the two research questions posed in the study. The international participants express a great need in areas that address student learning related to the study of technology. For example, when students engage in a study of technology, what abilities are they developing? They seek answers to this and other similar questions. They believe more emphasis (M=4.28) should be placed on identifying and describing the ways students' ideas progress as students begin to enhance their technological literacy. If such research studies are conducted, the international participants believe the data collected from these studies will provide greater support for how student thinking in technology progresses and will provide even more support for identifying and developing teaching practices that support student learning. Participants also want to know what students learn (M=4.17), other than content and practice, in technology classes. They believe that learning in technology education is under-theorized, and its links to contemporary learning theory are weak. Finally, they believe that given the unique aspects of technology as part of the school curriculum, research needs to be conducted on the way(s) students learn (M=3.97) in this context, specifically how learning takes place mentally in the learner. Once again, the diversity of issues identified by the international panel may be attributed to the heterogeneous makeup of the panel (32 individuals from 20 different countries). While the US participants are concerned about the lack of research on student learning, they appear to be more interested in the ways students come to learn transferable concepts and habits of mind (M=3.65). This, ultimately, will enable students to make sense of technology. They also see a great need for research into the different ways that technology and engineering education impacts students' academic achievement (M=4.29) in science, technology, engineering, and mathematics. Similarly, the US participants see a need (M=3.82) for more research studies that document that technology education can generate important and desirable K-12 learning outcomes. They substantiate their desire for more research in this area by stating that there is a critical shortage of research on STEM cognitive and affective learning outcomes. Finally, the US participants want to see research studies conducted that verify (M=4.06) whether the content that is being taught and how it is being taught in a technology and engineering education program really make a difference (e.g., gain vital life skills and useful knowledge) in the lives of young learners. Research studies, for example, might explore whether problem-solving activities help students learn to be better problem solvers and whether STEM-style units of instruction promote mathematics, engineering, and science skills as well as technology skills.

The international participants identify assessment, measurement, and evaluation as some of their greatest research needs. However, they recognize that there may be many differences in technology curricula among their countries. Arguably, these differences appear to be a common thread running throughout the data collected for this study and in some cases influence our analysis of the data. They seek research studies (M=3.93) that document the links between content, contextualization, and technology learning goals and assessment of student learning in different national contexts. They recognize that thinking skills, of which they provide examples as being reflection, reasoning, and relating, are often depicted as important learning results of technology education. The international participants seek more and better ways to determine how best to measure these outcomes (M=3.83), because they believe every teacher needs to know and be able to apply good measuring skills. The international participants also believe there is a shortage of research on the topic of evaluation (M=3.60) of technology learner outcomes. If such research is conducted, they believe, it would provide answers to questions that focus on the true learning outcomes that come about from students participating in technology education.

Both panels give little attention to identifying issues that need to be researched related to preparation for teaching technology and engineering education. In fact, each group identifies only one issue in the category of student learning related to the study of technology. The US participants, for example, express an interest in research studies that would identify the most effective ways for teachers to make connections to the cognitive sciences (M=3.82). The international participants want additional research on the ways individual learning can be achieved within a collaborative project activity environment (M=3.52). The US participants' justification is that for teachers to better understand and use design-based approaches and to make learning more meaningful and conceptually powerful for their students, connections need to be made to the cognitive sciences. The international participants believe that technological practice is predominantly collaborative and students need to be taught to engage in projects that are collaborative in nature. The US participants are concerned that too much attention is being given to completing the project when this attention should be focused on the processes and criteria that are used and the impacts that the project might have on users and society.

Pedagogical content knowledge for teaching technology education

The next category examined in this comparative analysis is *pedagogical content knowledge for teaching technology education*. The international participants identified four important issues that need to be researched related to this category. The US participants identified none. The international participants believe there are two critical areas within pedagogical content knowledge that need to be researched. First, they believe that more research needs to be conducted on what teachers need to know about learners. For example, they seek research-based answers (M=4.03) to the question of how pedagogical content knowledge relates to active learning, teaching, and assessment approaches that are appropriate for a wide range of designing, manufacturing, and engineering for twenty-first century issues. They are also concerned about pupil motivation in technology (M=3.62). They see a need for research that identifies the kind of program content that learners find important and they give some specific examples of what these might be (e.g., project making, ethical topics, the design experience, contextual problem solving). The international participants also identified two research issues within the category of pedagogical content knowledge related to the preparation for teaching technology and engineering education. First, they want to further explore through research the topic of how conceptual knowledge can be gained using design activities (M=3.90). Furthermore, they believe that teachers must build certain elements into their instructional units that trigger students to use concepts and thus learn new concepts. It is unclear from this study what these certain elements might be. Second, they believe an important issue (M=3.88) is to conduct research that answers the question: What is the unique nature of technological knowledge and content that can be combined to produce an effective technology education teacher? In other words, they want more research that leads to a better understanding of pedagogical content knowledge. If such research is conducted, then they believe that what is currently unknown about how to train for pedagogical content knowledge and what is unknown about what makes for effective training programs will be discovered.

Why would the US participants not have seen the need for further research related to pedagogical content knowledge for teaching technology and engineering education since so much of the pre-service preparation of teachers is spent developing pedagogical content knowledge? In addition, the national accrediting body for technology education in the United States underscores the importance of developing pedagogical content knowledge in novice teachers and even in experienced teachers through pre-service and in-service training (NCATE, 2008; ITEA/CTTE, 2003. Did the US participants purposely omit pedagogical content knowledge as a research need because they thought it had been well covered by the teacher training institutions? Did the US participants believe the topic had been assumed within other issues that they identified for the study? Or, did they just omit pedagogical content knowledge by accident? The researchers will never know the answers to these questions other than to say that the omission of this topic as a research need by the US participants is puzzling. It is abundantly clear that the international participants view pedagogical content knowledge as an important research need for their countries.

While assessment and its importance in technology and engineering education has been previously covered in this paper, the researchers purposely separated a discussion of assessment of technological literacy from all previous discussions to underscore the importance of the topic. The international participants noted that assessment is gaining attention worldwide and through assessment, educational policy is driven internationally. They seek research (M=3.97) to develop better instruments that properly reflect the qualities of performance developed through technology education programs. Ironically, the US participants do not seek research studies in assessment of technological literacy as a critical research need at all. The international participants recognize that assessment in school subjects tends to drive teaching and in many countries assessment at local and national levels has affected teaching methods, sometimes negatively. They seek research (M=3.96) that will result in determining better ways to evaluate practical work (making). Why would the US participants not see assessment of technological literacy as an important need? Could it be that every student who matriculates a teacher preparation program completes at least one formal course in assessment? Has the United States, through the work of the Standards for Technological Literacy initiative, collected sufficient data to meet the research needs of technology and engineering educators? It remains unclear why assessment of technological literacy might not have been included in the research needs of US participants.

Designing, nature of technology, and sustainability for global citizenship

The remaining three categories of this study were *designing, nature of technology*, and *sustainability for global citizenship*. All were identified as important research need categories by the international participants but were not viewed with the same importance by the US participants. In fact, the US participants did not identify these three categories as important areas needing further research. Not surprising to the researchers, the international participants identified three areas within the category of designing that need further research. These three areas may reflect the influence and impact that the design and technology movement in education has had on technology education globally (McCormick, 2004; Stables, 1997). The international participants believe there is a need to have further research studies that will help them clarify the nature of designing in the K-12 curriculum (M=3.86). They also seek research that answers the questions (M=3.62): What should be the criteria for establishing design problems in the secondary curriculum? and What knowledge and abilities should learners develop as a result of these design problems? The third topic within the category of designing relates to research needed for teaching the school subject. The international participants are concerned about teacher trainees' conceptions of designing (M=3.76). They seek additional research about how one's beliefs influence how one teaches design.

The second category identified by the international participants is the "nature of technology" or, more specifically, understanding the nature of technology. They seek further research that will help them understand how the knowledge of technology education contributes to developing an understanding of the role of artifacts in society (M=3.90).

The final research needs category of this study is "sustainability and global citizenship". The international participants view designing for sustainability and global citizenship as a critical research need area. They seek research that provides answers to what helps and hinders technology education teachers from tackling challenging, controversial issues and values through design, engineering, and technology. It is also strange that the US participants did not reference this issue, since many are experimenting with including engineering concepts and STEM integrative approaches. These approaches often employ global societal issues to establish contexts for the application of these knowledge and principles.

Summary

Researchers are challenged to undertake studies that will contribute to the knowledge bases of their professions. Martin and Ritz (2012) undertook two Delphi studies to identify research needs for technology education. One study sought answers from an international panel (Ritz & Martin, 2012). The second study sought answers from a US panel (Martin & Ritz, 2012). This study compared the findings from these panels. Both study groups identified research interests related to technological and engineering literacy knowledge (7 issues) and student learning related to the study of technology (14 issues). The international study group identified additional research needs related to designing (3 issues), pedagogical content knowledge for teaching (4 issues), assessment of technological literacy (2 issues), nature of technology (1 issue), and sustainability and global citizenship (1 issue). The diversity of issues identified and compared in this study may be attributable to the composition of the two populations. The international participants, while having an expressed interest in technology and engineering education, may be approaching the topic from perspectives that are unique to each of 20 individual countries. The US participants appear to be a more homogenous group and by the homogeneity, view technology and engineering education through a different set of lens than those of the international participants. However, any differences that may exist today in the research needs between the international and US populations used in this study may gradually become nonexistent over time. The growing influence of recently published international literature and the growing popularity of participation in international conferences on technology and engineering education (e.g., Technology Education Research Conference [TERC], Pupil's Attitudes Toward Technology [PATT], International Technology and Engineering Educators Association [ITEEA]) are having a strong positive influence on identifying research needs common to all technology and engineering educators. In the future, the identification of specific research needs may have no geographical boundaries.

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