Examining the Demographics and Preparation Experiences of Foundations of Technology Teachers

By Tyler S. Love

ABSTRACT

When the Standards for Technological Literacy were released in 2000, Technology and Engineering (T&E) educators were expected to integrate concepts from other content areas within the context of engineering design and problem solving (ITEA/ITEEA, 2000/2002/2007). Fourteen years later, the Next Generation Science Standards called for science educators to teach engineering content and practices within their curricula (NGSS Lead States, 2014). These integrative standards have increased the demands placed on pre- and in-service teacher preparation efforts to ensure science and T&E educators are properly prepared to teach cross-disciplinary concepts. However, requisite for suggesting changes to adequately prepare educators for teaching such concepts, the demographics and preparation experiences of those teaching within these content areas must be thoroughly examined. This is especially important in T&E education, where there are fewer highly qualified T&E educators than openings in the United States (Moye, 2009). Given this shortage it begs to question, "What are the demographic and preparation experiences of those tasked with teaching T&E courses?"

This study examined the demographic and background characteristics of 55 individuals who were teaching Foundations of Technology (FoT), the International Technology and Engineering Educators Association's (ITEEA) flagship course. Furthermore, this research investigated the types and amount of formal and informal preparation experiences that participating FoT teachers completed within science and T&E education. The findings revealed substantial variations among the preparation experiences of those participants in this study. From these findings, recommendations to better prepare FoT teachers for integrating science concepts were suggested.

Keywords: technology and engineering education, STEM education, teacher demographics survey, teacher preparation, pedagogical content knowledge

INTRODUCTION

Today's Technology and Engineering (T&E) educators are expected to explicitly teach naturally intersecting STEM concepts to help students solve authentic design problems. This is not a new idea however, given that fifteen years ago the Standards for Technological Literacy (STLs) charged T&E educators to, "reinforce and compliment what students learn in other classes" as "a way to apply and integrate knowledge from many other subject areas" (ITEA/ITEEA, 2000/2002/2007, p. 6). More recently the Next Generation Science Standards (NGSS Lead States, 2014) called for the teaching of crosscutting concepts between science and engineering, expecting science educators to also capitalize on teaching integrative concepts. Although these standards aim to develop a more STEM-literate citizenry, they have consequently changed the landscape of T&E education and what is expected of T&E educators. This change inherently places new demands on the pedagogical and content knowledge (Shulman, 1987) preparation needed to adequately teach embedded STEM concepts. With this increased focus on teaching STEM concepts in an integrative fashion, it begs to question, "What are the preparation experiences of those expected to teach these crosscutting concepts, specifically within T&E education classrooms?"

LITERATURE REVIEW

Numerous studies (Moye, 2009; Moye, Jones, & Dugger, 2015; Soboloski, 2003; Volk, 1993) have shown a steady decline in T&E education graduates over the past 45 years. Despite an increasing demand for T&E educators, the supply of these teachers in the United States dropped from 37,968 in 1995 to 28,310 in 2009 (Moye, 2009). In addition, the number of T&E education teacher preparation programs in the U.S. has dwindled from 72 in 2007 (Warner, Erli, Johnson, & Greiner, 2007) to 43 in 2015 (ITEEA, 2015b). This decrease creates a challenge for school systems seeking highly qualified T&E educators to fill vacancies, which is important in certain states with a T&E education graduation requirement. Seven states currently require students to complete a T&E education course in order to graduate high school (Moye, Jones, & Dugger, 2015). As a result, schools have been left to fill these vacancies with teachers from other content areas (e.g., business education, art education). This problem, along with the call for teaching integrative concepts (ITEA/ITEEA, 2000/2002/2007; NGSS Lead States, 2014), has caused a drastic shift in the landscape of those now tasked with teaching T&E education courses such as FoT. Consequently, the pre- and in-service preparation experiences needed to prepare T&E teachers to adequately integrate STEM concepts has also shifted.

Recent research by Litowitz (2013, 2014) and Strimel (2013) studied various experiences contributing to the preparation of T&E educators. Within these studies they examined the college coursework of T&E educators, including science courses. Litowitz (2013, 2014) conducted an analysis of course requirements by U.S. T&E teacher preparation programs. From this study he found that on average, 42% of T&E teacher education programs only required the completion of Physics I, whereas 33% required students to take either a physics, a biology, or a chemistry course. Only one program (4%) required an advanced level science course, which was Physics II (Figure 1). Based on his analysis of requirements in existing programs, Litowitz (2013, 2014) recommended that the only science course T&E teacher preparation programs should require students to complete is physics.

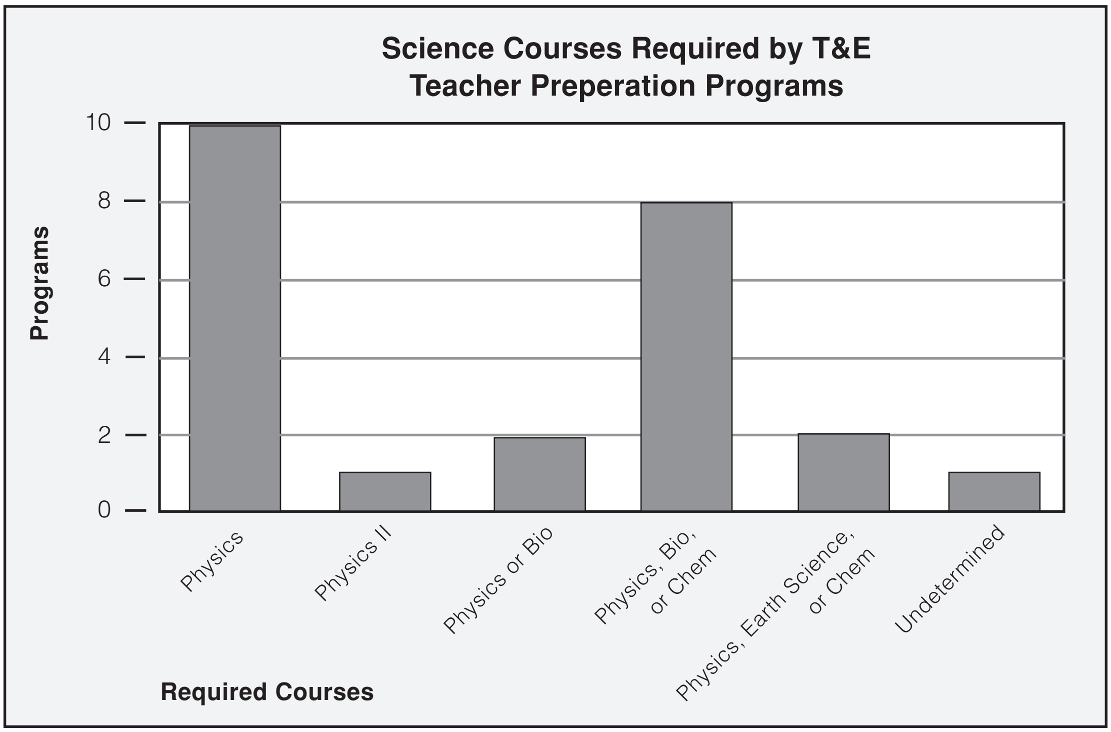

Figure 1. Created from "A Curricular Analysis of Undergraduate Technology & Engineering Teacher Preparation Programs in the United States" by L. S. Litowitz, 2014, Journal of Technology Education, 25(2), p. 75. Copyright 2014 by Virginia Tech. Created with permission.

Strimel (2013) conducted a study surveying 53 teachers who participated in a five-day summer FoT professional development session among four states. One of the research questions in his study examined, "How many college science courses have you completed?" He did not delineate between undergraduate and graduate courses. Of the 53 participants, he found chemistry was the most common course completed. Slightly less than half (42%) reported taking at least one chemistry course, and 19% took at least two chemistry courses. Biology was the next most frequently completed course, and physics was the least completed course (Figure 2). These studies provided good baseline data regarding the shifting preparation experiences of those teaching T&E education and led to further questions about T&E educators' preparation experiences.

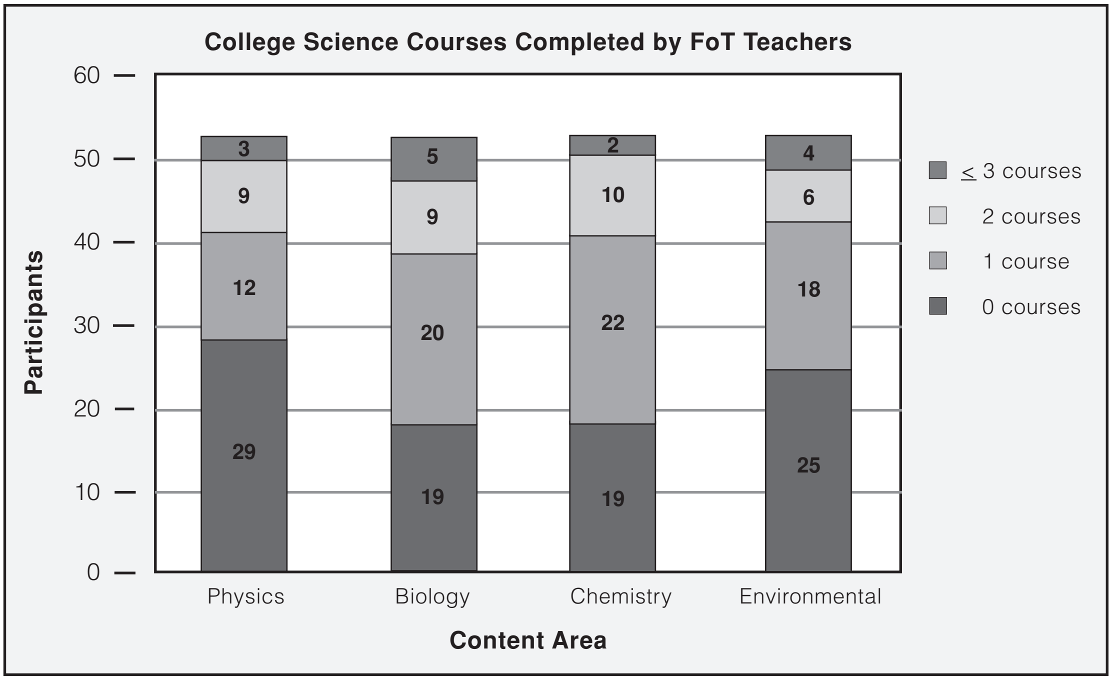

Figure 2. Adapted from "Engineering by Design™: Preparing STEM Teachers for the 21st Century" by G. Strimel, 2013, p. 451. Copyright 2013 by the Technology Environmental Science and Mathematics Education Research Centre, University of Waikato, New Zealand. Adapted with permission.

One international T&E course which is embedded with ample opportunities for making integrative STEM connections is ITEEA's flagship Engineering byDesign (EbD) course, Foundations of Technology (FoT). Many states are using FoT to help satisfy their T&E graduation requirement because it provides the framework for consistent T&E education instruction (Rhine, 2013). It is an introductory high school level learning experience that builds upon students' STEM knowledge from elementary and middle school. The FoT course aims to develop more technologically literate citizens by focusing on three dimensions: knowledge, ways of thinking, and acting and capabilities. The course was designed to engage students, allowing them to explore and increase their understanding of big ideas related to technological concepts. Specifically the course aims to give students a richer understanding of the history of technology, innovation and invention, and applying the engineering design process to solve problems directly related to the designed world (STLs 14-20). Upon completion, students should be able to synthesize major ideas from a broader systems-thinking approach by applying their understanding of core technological concepts learned throughout the course (ITEEA, 2015a). Because of these characteristics, the FoT curriculum was deemed an excellent source for examining the broad demographics and preparation experiences of those teaching it.

Despite being embedded with STEM content and practices, educators teaching T&E courses like FoT must have the adequate content and pedagogical training to properly integrate STEM concepts. Examining the pre- and in-service teacher preparation experiences of those teaching FoT is a viable starting point for informing changes to T&E educator preparation and professional development efforts, as well as enhancing curricular materials. The purpose of this study was to both investigate the demographics and select T&E and science preparation experiences of T&E educators, specifically those teaching FoT. An online survey instrument was created to address the following research questions:

1. What are the demographic and background characteristics of those teaching FoT?
2. To what extent have FoT teachers participated in select formal and informal T&E preparation experiences?
3. To what extent have FoT teachers participated in select formal and informal science preparation experiences?

STUDY METHODOLOGY

The methodology employed in this study was based upon similar research (Love, 2015), which used the same sample to analyze the correlation between preparation factors and teaching of science concepts embedded within FoT. Twenty-four county school systems in an EbD consortium state were solicited to partake in this study, 12 of which agreed to participate. All 233 FoT teachers within those 12 school systems during the fall of 2014 were invited to complete the online Technology and Engineering Educators' Science Pedagogical Content Knowledge (TEES-PCK) survey. After two weeks the survey was closed, resulting in 55 (24% response rate) complete responses, which was deemed acceptable for online surveys (Nulty, 2008). Descriptive statistics were then used to calculate the mean and percentages of the survey responses reported in the following sections of this article.

Survey Instrument

There was no single instrument readily available to collect the detailed preparation and demographic data needed for this study. Therefore, the researcher and a panel of four university faculty members with expertise in STEM education created the TEES-PCK instrument from an amalgam of surveys. The questions in this survey were derived from four instruments previously used within science (Cwik, 2012; Riggs & Enochs, 1990) and mathematics education (Ball & Hill, 2008; Perez, 2013), and were modified to fit the need of this study. The survey included questions examining teachers' self-efficacy, general demographics, informal collaborative and non-collaborative preparation experiences, and high school, undergraduate, and graduate coursework completed. A detailed description of the type of data collected within each section of the survey can be found in Table 4 of Love (2015), and the full survey instrument can be found in Appendix G of that document.

Section II of the TEES-PCK examined teachers' self-efficacy and expected outcomes regarding their teaching of T&E education. These questions were adapted from the renowned Science Teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1990), and the reliability of the questions was tested using Crohnbach's alpha. This revealed high reliability (α =.883) for the self-efficacy questions and an acceptable reliability value (α = .652) for the expected outcome questions.

FINDINGS

Only a summary of the key findings from the TEES-PCK will be presented in this article because of the immense amount of data collected. The full breadth of data can be found in Appendix N of Love (2015).

Select Demographic Data

The majority of participants were Caucasian (93%) males (73%) with a mean age of 43. On average they had taught for 13 years, five of which they spent teaching FoT (Table 1).

Almost half (44%) of the participants held a master's degree; 24% possessed a bachelor's degree; and 4% had an earned doctorate.
Only 84% were certified to teach technology education. The second largest area of certification was business education, and 53% held certifications in an array of other areas (Table 2).

Table 1: *Summary of Participant Demographics and Teaching Experience*

Demographic		n (%)
Gender		
	Male	40(73)
	Female	15(27)
Ethnicity		
	Caucasian	51(93)
	African American	1(2)
	Latin American	0(0)
	Asian	1(2)
	Ugandan-American	1(2)
	African American/ Caucasian	1(2)

Table 2: *Summary of Degrees and Certifications Held by Participants*

Credential Held		n (%)
Degree		
	Bachelor's	14(26)
	Master's	24(44)
	Master's +30	10(18)
	Master's +60	5(9)
	Education Specialist	0(0)
	Doctorate	2(4)
Certification Area		
	Technology Education	46(84)
	Business Education	10(18)
	Mathematics Education	4(7)
	Other	29(53)

Among the degrees held, the majority of teachers (68%) were in technology education, with 40% earning bachelor's and 28% possessing master's degrees in this area. Other notable areas in which participants possessed bachelor's degrees were dispersed among industrial arts (11%), business education (9%), and physical and health education (8%). The second largest area in which participants held master's degrees was administration and leadership (13%), followed by curriculum and instruction (9%). The greatest number of graduate certificates held was in industrial arts (11%). Lastly, only two participants (4%) possessed doctoral degrees; one in administration and leadership, and the other in counseling (Table 3).

Table 3: *Summary of Degrees Held According to Subject Area*

Subject Area	Certificate *n (%)*	BA *n (%)*	MA *n (%)*	Doc *n (%)*
Technology Education	0(0)	22(40)	15(28)	0(0)
Administration/ Leadership	3(6)	0(0)	7(13)	1(2)
Industrial Arts	6(11)	6(11)	3(6)	0(0)
Business Education	1(2)	5(9)	0(0)	0(0)
Physical Education/ Health	0(0)	4(8)	0(0)	0(0)
Curriculum & Instruction	0(0)	2(4)	5(9)	0(0)

Note. BA = bachelor's degree; MA = master's degree; Doc = doctorate.

TEACHER PREPARATION DATA

When examining teacher preparation experiences, the majority (73%) of participants had completed a teacher preparation program and attended some form of FoT training session (51%) (Table 4). Additionally, most (73%) participants reported taking an undergraduate or graduate course that discussed methods to integrate STEM concepts within T&E education.

High School Coursework

Almost all participants (98%) had completed at least one or more high school biology course, and 85% completed one or more chemistry course. Physics was the least taken course (64%) among all high school science classes. Furthermore, a greater portion of participants completed an industrial arts class (65%) than a technology education class (44%) (Figure 3).

Table 4: *Summary of Teacher Preperation and FoT Training Experiences*

Preperation or Training		n (%)
Teacher Preperation		
	No formal training	3(6)
	Previous career	9(17)
	Teacher prep program	40(73)
FoT Training		
	None	14(26)
	One week	18(33)
	< One week	10(18)
	Integrating STEM course	40(73)

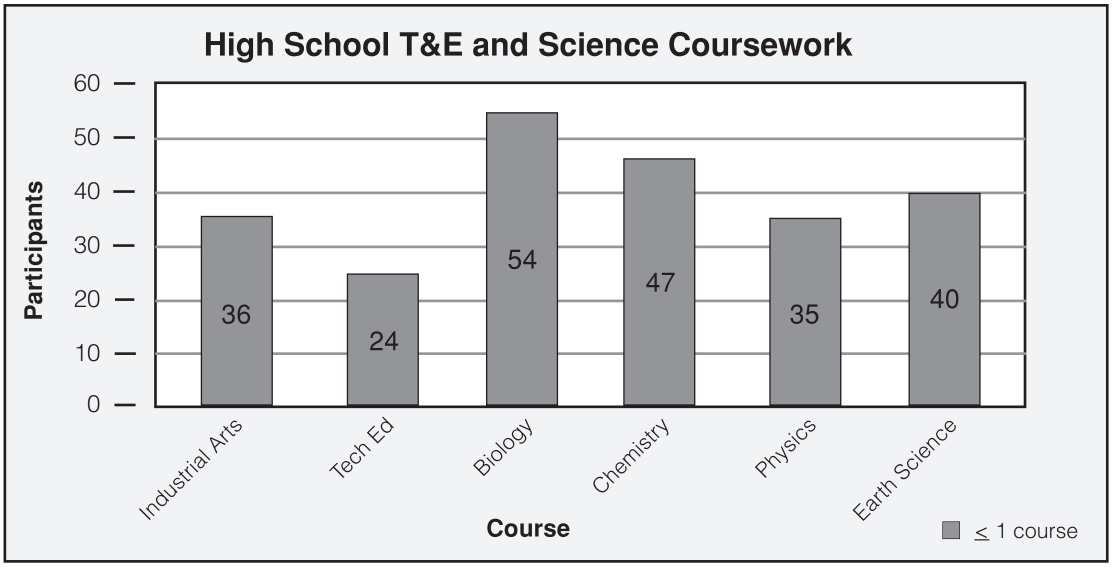

Figure 3. Summary of high school T&E and science coursework completed.

Undergraduate Coursework

When examining the science coursework completed during their undergraduate preparation, biology (27%) and physics (27%) were the most frequent courses, of which participants completed 2 or more (Figure 4).

Further analysis of participants' undergraduate coursework revealed that many completed at least one course in electronics (53%), power, energy, and transportation (PET) (49%), or technology education methods (53%). Very few completed a course in biotechnology (18%) or science methods (15%) (Figure 5).

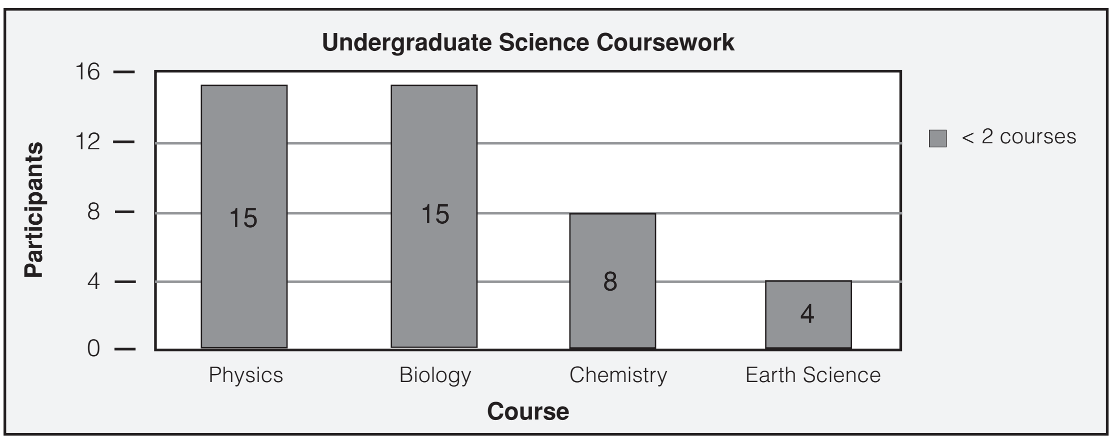

Figure 4. Summary of undergraduate science coursework completed.

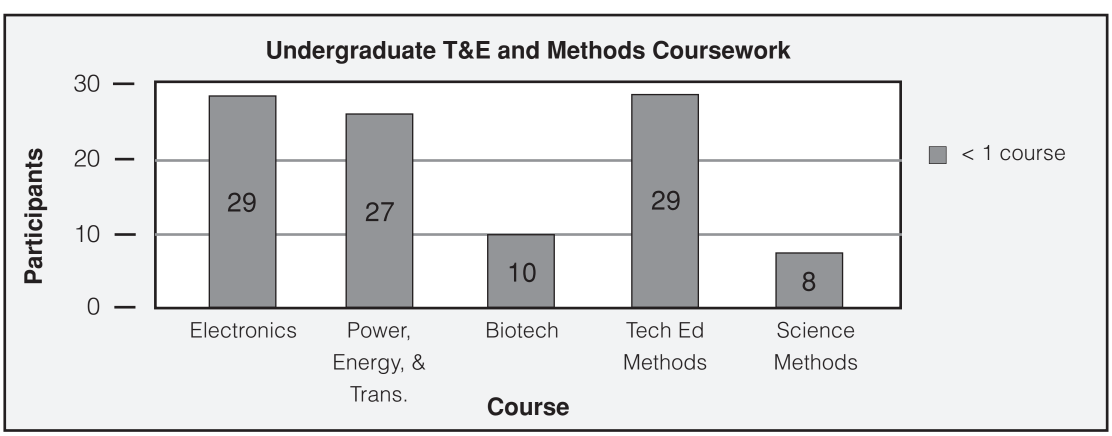

Figure 5. Summary of undergraduate T&E and teaching methods coursework completed.

Graduate Coursework

Regarding graduate coursework, almost half of the students (45%) took a technology education methods course. Other courses that were frequently taken by participants included biotechnology (18%), electronics (15%), and PET (15%). Less than seven percent completed a graduate course about science content (physics, biology, chemistry, space science) or science teaching methods (Figure 6).

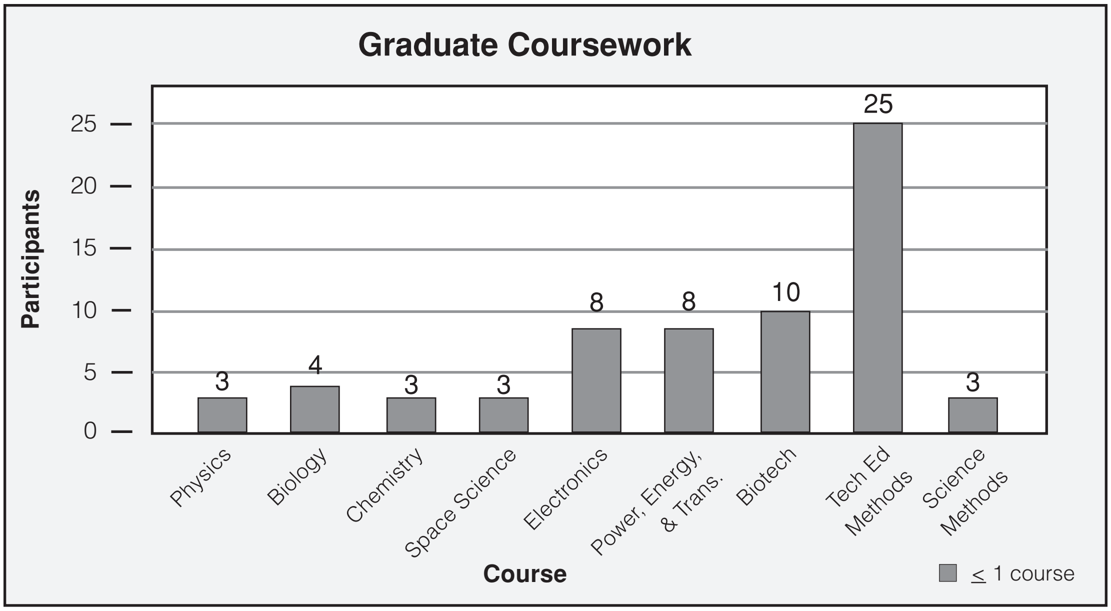

Figure 6. Summary of graduate T&E and science coursework completed.

Informal Experiences

In addition to formal coursework, it was important to examine informal collaborative and non-collaborative experiences that FoT teachers' participated in during the past three years that could have also contributed to their preparation. Most participants (58%) did not engage in any clubs or after-school activities, but among those that did, the most common club that teachers helped with was robotics (25%). These teachers spent more hours reading literature in T&E education (40%) versus science education (22%), and most reported recently participating in a T&E (75%) or science education (65%) workshop/in-service session (Table 5).

Table 5: *Summary of Participants' Informal Non-Collaborative Preparation Experiences*

Experience		n (%)
Informal Non-Collaborative		
	None	32(58)
	Robotics	14(25)
	TSA	7(13)
Literature Read		
	≤ 35 hours in T&E	22(40)
	≥ 6 hours in Science	12(22)
Workshops		
	Science	36(65)
	T&E	41(75)

Note. TSA = Technology Student Association

Teachers spent much more time participating in informal collaborative T&E experiences than science experiences. Observing T&E (69%) or science (16%) classes, and consulting with T&E (67%) or science (33%) specialists were the most frequent collaborative experiences in which teachers participated (Figure 7).

Further analysis of collaborative experiences revealed that most teachers had participated in collaborative T&E educator networks (73%), T&E education committees or task forces (45%), or collaborative science educator networks (38%). Fewer teachers (18%) reported participating in science education committees or task forces.

Only about 25% of the FoT teachers attended either a state or a national T&E conference within the past three years, which was greater than the 9% who attended a similar science conference. When attending these events,

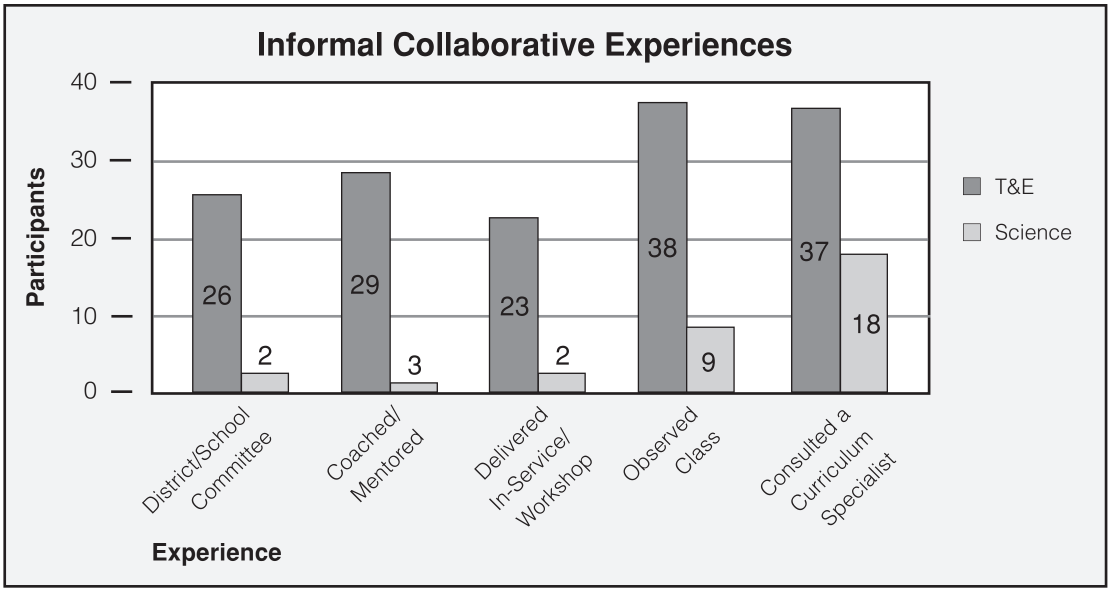

Figure 7. Summary of participants' informal collaborative experiences.

teachers reported attending mostly T&E sessions (35%); however, 18% attended sessions focused on both science and T&E topics. No participants attended sessions focused mainly on science concepts (Table 6).

Participants collaborated with other T&E teachers most frequently, with 36% reporting that they work with these individuals on a daily basis. FoT teachers did not collaborate with physics, biology, or math teachers as often that school year. In fact, 65% reported never collaborating with biology teachers, while slightly more than half (51%) claimed they never collaborated with their school's physics instructor (Figure 8).

Table 6: *Summary of Conferences and Sessions Participants Attended*

Function Attended		n (%)
Conference		
	State or ntl. science	5(9)
	State or ntl. T&E	15(27)
Session		
	Science	0(0)
	T&E	19(35)
	Science and T&E	10(18)
	Unsure	25(46)

Note. Ntl. = national

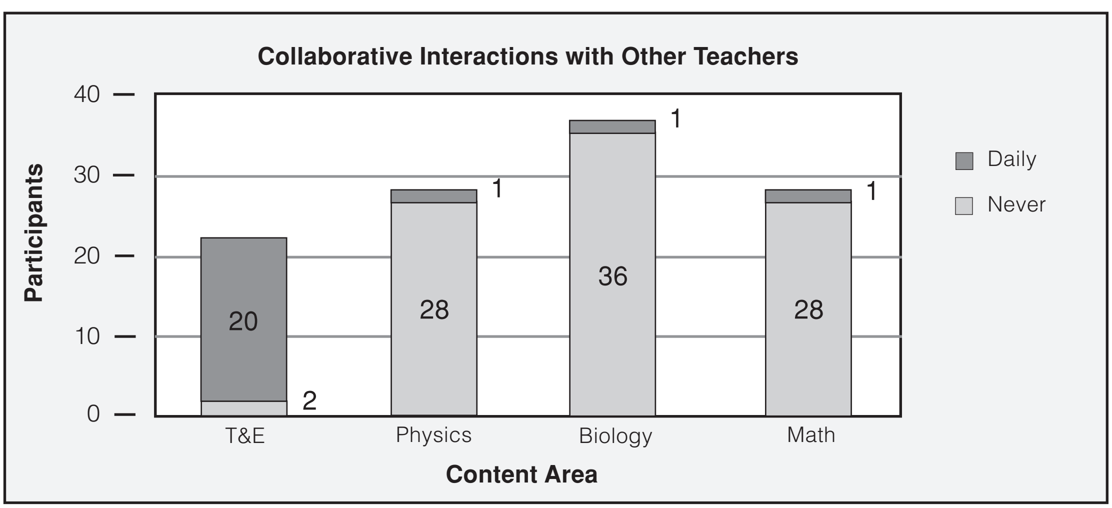

Figure 8. Summary of how frequently participants collaborated with other teachers.

DISCUSSION

The data presented in the findings section help paint a broad picture of the average demographic and preparation experiences of those 55 individuals teaching FoT within 12 school systems of one EbD consortium state. Although the findings provide a general overview of these specific T&E educators, they cannot be generalized to T&E educators in other school systems, states, or who are teaching different curricula. Despite these delimitations, the findings do aid in drawing important conclusions about the participating T&E educators. The remainder of this section discusses the similarities between the findings from this research and larger national studies.

Moye, Jones, and Dugger (2015) conducted a national study examining the status of T&E education among states. In addition, Ernst and Williams (2014) conducted research using the Schools and Staffing Survey, a standardized national reporting data set from the U.S. Department of Education and the National Center for Education Statistics (NCES). This data set examined the demographics, characteristics, and qualifications of 50,606 individuals teaching T&E education in K-12 school districts across the U.S. Table 7 compares the findings among these previous research efforts and this study.

Table 7: *Comparison of Demographic and Preparation Data Among Studies*

	Moye, Jones, & Dugger (2015)	Ernst & Williams (2014)	Love (2015)
Ethnicity (%)			
Caucasian	NR	92	93
African American	NR	5	2
Asian	NR	2	2
Gender (%)			
Male	77.2	75.4	73
Female	22.8	24.6	27
Age (μ)	NR	47	43
Years Teaching (μ)	NR	15.5	13
Degree (%)			
Bachelors	NR	54	24
Master’s	NR	40	44
Ed.S	NR	4.6	0
Doctorate	NR	1	4
Certified to Teach T&E	NR	86	84
Qualification (%)			
Highly Qualified	NR	59	NR
Not Highly Qualified	NR	25	NR
Preperation (%)			
Teacher Prep Program	NR	78	73
Alternative Licensure	NR	22	17

Note. NR = Not reported; Ed.S. = Education Specialist

The consistency among these three studies indicates that the majority of T&E education teachers in the U.S. are Caucasian males in their mid to late 40s, who have completed a teacher preparation program, are certified to teach T&E education, and have been teaching on average for approximately 14 years (Table 7). The lack of women and minorities in STEM fields is a critical issue within the U.S. One method for addressing this shortage is to recruit more women and minority role models to teach P-12 T&E education (Ilumoka, 2012).

One interesting finding that emerged from this study is the variety of content areas in which participants held degrees. Less than 70% held a bachelor's or master's degree in technology education, and 17% held similar degrees in industrial arts. What was most alarming was the amount of participants (17%) teaching FoT who held a degree in business education or physical education, and the fact that only 84% of the teachers were certified to teach T&E education.

The results from this study were also consistent with Strimel's (2013) examination of coursework completed by FoT teachers across four states, which revealed FoT teachers completed a broad scope and limited amount of college science coursework (Table 8).

Table 8: *Comparison of Higher Education Science Courses Completed Among Studies*

Completed ≤ 2 Courses In	Strimel (2013) (%)	Love (2015) (%)
Physics	23	27
Biology	26	27
Chemistry	23	15
Environmental or Earth Science	19	7

When examining the data regarding completed high school courses, physics was taken the least (Figure 3). The findings from the full data analysis of this population (Love, 2015) revealed that high school science courses, especially physics, had the strongest correlation with the level at which T&E educators' taught embedded science concepts. Additionally, FoT and many other T&E courses (e.g. EbD-TEEMS, EbD Advanced Design Applications, EbD Advanced Technological Applications, Project Lead the Way) are naturally intertwined with physics. For example, in Units 3 and 4 of the FoT curriculum, instructors are expected to teach how science concepts, such as thermodynamics, atomic structure, nuclear energy, energy loss and conservation, and electron flow can be applied to solve technological problems. However, given the minimal amount of high school and college physics courses teachers completed, most exhibited a difficult time integrating and teaching these concepts proficiently (Love, 2015). For the aforementioned reasons, it is imperative that students interested in pursuing a career as a T&E educator be advised to complete a minimum of one physics course in high school to experience how physics concepts are taught at the secondary level.

In both Strimel's (2013) research and this study, it was determined that less than a quarter of teachers completed two or more college courses in physics, biology or chemistry (Table 8). In the full data analysis (Love, 2015), college physics courses also showed a strong correlation with how proficient FoT instructors were at teaching science concepts embedded within the curriculum. Litowitz (2013, 2014) found that 42% of T&E programs required students to complete one physics course, and only 4% required students to complete two physics courses. Because of the findings from the full study and the natural application of physics concepts to solve technological design problems, T&E educators should complete not one, but two college physics courses with labs. This study also revealed a lack of undergraduate biology (27%) and biotechnology (18%) courses completed by participants. More T&E teacher preparation programs should require students to complete a course and lab in biology so they have greater content knowledge about biological concepts they are expected to teach in medical, agricultural, and biotechnology units according to the *Standards for Technological Literacy* (ITEA/ITEEA, 2000, 2002, 2007).

From the informal experiences it was clear that participating FoT teachers partook in far more T&E than science related activities. This was apparent from the literature they read, to their participation in workshops, school committees, online networks, and conferences. The high percentage of participants attending mostly T&E conference sessions was also consistent with previous research (Love & Loveland, 2014). The T&E and science educator associations in Maryland created a collaborative professional development opportunity by merging their annual conferences. From this experience, attendees reported gains in their understanding of content and ability to demonstrate concepts from both within and outside of their content area. Some attendees at this conference also reported that simply eating lunch and attending sessions with educators outside of their content area spawned integrative conversations and relationships (Love & Loveland, 2014).

Given the alignment of the data from this study with other recent national studies (Ernst & Williams, 2014; Love & Loveland, 2014; Moye, Jones, & Dugger, 2015; Strimel, 2013) it could be expected that T&E educators from other states would have similar demographics and preparation experiences to those reported in this study.

CONCLUSIONS

By no means does this study suggest that the participating FoT teachers be tasked with teaching science content and practices in lieu of science educators; rather it exposes the importance of preparing them with the baseline content and pedagogical knowledge to explicitly make integrative connections and work collaboratively with science educators to reinforce these concepts. Because of the large amount of T&E content and pedagogical preparation needed to adequately teach the FoT curriculum, perhaps the most viable method for teaching embedded STEM concepts with the greatest amount of integration is to work collaboratively with science teachers (Wells, 2008). Drake and Burns (2004) provide some excellent integrative instructional models that can be utilized by P-12 STEM education programs.

Given the increasing demand on FoT teachers to prepare more STEM-literate citizens, and the continually convergent paths of T&E and science education (Love & Loveland, 2014), the lack of science courses completed by participants was alarming. In Litowitz's (2014) analysis, he noted that courses covering content foundational to the STLs, such as medical, agricultural, and related biotechnologies, were absent from T&E teacher preparation programs' requirements. With the STLs placing an emphasis on teaching concepts from these science-related areas, it would be logical for FoT teachers to complete an ample amount of science content courses in their preparation. This would be expected to increase their content knowledge needed for making integrative connections between science and T&E concepts when teaching the FoT units. Teacher educators are challenged with finding room in already crowded T&E teacher preparation curricula for such courses. This is a delicate balance that must be addressed to better prepare T&E educators, specifically FoT teachers, for teaching STEM concepts.

In addition to the raw data, one of the important contributions of this study to Integrative STEM Education is a unique instrument – the TEES-PCK survey. It could be used or modified for future studies when authors are considering collecting detailed demographic and preparation data. Specifically, the TEES-PCK could easily be utilized to collect data for studies in other disciplines, such as examining science educators' preparation to teach engineering content and practices.

RECOMMENDATIONS

A number of recommendations for practitioners and researchers were derived from this study. Given the limited percentage of FoT teachers from diverse populations, more of these individuals must be recruited to teach FoT, whether through teacher preparation or alternative licensure programs. These individuals could, in turn, serve as role models to recruit additional students from diverse populations to become T&E educators and pursue STEM-related careers (Ilumoka, 2012; Moye, Jones, & Dugger, 2015).

When analyzing the TEES-PCK results, it became apparent that many teachers had started the survey but failed to finish. When reminded about completing it, teachers expressed that the length and detail of the instrument discouraged them from finishing it. For this reason, it is recommended that when using the TEES-PCK in future studies, researchers only use those questions for which they are seeking data. This would decrease the amount of time requested from teachers and be expected to increase participation. Furthermore, because all T&E educators are expected to integrate content from various disciplines (ITEA/ITEEA, 2000/2002/2007), the TEES-PCK should be used in future studies to examine the preparation factors of the broader T&E educator population.

The findings also revealed that FoT teachers participated in far less science than T&E preparation experiences, and a limited amount of opportunities to collaborate with science educators. The full study results (Love, 2015) found that many of these integrative experiences with science educators had a positive influence on the extent to which participants' taught science concepts. Therefore, it is recommended that administrators and school systems provide more accessible integrative professional development opportunities between FoT and science educators to help foster collaborative relationships. Lastly, as T&E teacher preparation programs aim to prepare educators who can integrate STEM concepts more proficiently, they should use the reported findings to inform changes in pre-service coursework requirements. The significance that each course had on the teaching of science content and practices can be found in the full study (Love, 2015).

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