

## **Are Technology and Engineering Educator Programs Really Declining? Reexamining the Status and Characteristics of Programs in the United States**

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### **Abstract**

Decades of research have reported declining trends in undergraduate industrial arts, industrial technology education, technology education, and technology and engineering (T&E) teacher preparation programs (TPPs) (Love et al., 2016; Moye, 2017; Scott & Buffer, 1995; Volk, 1993, 1997, 2000, 2019). Numerous reasons have been cited for this declining trajectory, such as steep costs associated with program materials and equipment, not replacing faculty upon retirement, political action by education departments, lucrative competing industry employment options, negative perceptions of teaching as a career, and other outside factors (Volk, 2000, 2019). However, there are several certification, degree, and coursework pathways preparing T&E educators beyond traditional undergraduate TPPs. Past studies have not accounted for these other preparation pathways and programs. Therefore, this study used content analyses and descriptive statistics to identify active programs offering certification coursework or degrees related to T&E education in the United States (U.S.). Additionally, this study examined various characteristics of those programs. The findings revealed more T&E educator-related undergraduate and graduate programs than reported in previous studies, and there was an increase in the number of bachelor's degrees conferred. The study also found a noticeable difference among program characteristics in areas such as title and focus. This study provides implications for higher education institutions, state departments of education, teacher educators, and researchers to reevaluate the supply of T&E teachers in the U.S. while also reflecting on the focus and characteristics of T&E educator programs.

**Keywords:** Teacher preparation, teacher shortage, technology and engineering education, P-12 engineering education, career and technical education, integrated STEM education.

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### **Introduction**

The steady decline of undergraduate technology and engineering (T&E) teacher preparation programs (TPPs) and the number of graduates from these programs is not a novel issue. Concerns about the declining trajectory were raised as early as the 1970s. Although there are still programs in the United States (U.S.) awarding T&E education degrees, many of which have evolved to keep up with current demands from regional industries and shifts in national educational paradigms (e.g., Integrative STEM education), they continue to face enrollment challenges. As evidence of this, T&E education has been identified as a teacher shortage area in many states since the late 1990s (Moye, 2017; United States Department of Education, 2020).

Scott and Buffer (1995) predicted political and economic demands would threaten the survival of technology education as a profession. Similar concerns were reiterated more than 20 years later as T&E TPPs continued to face drastically declining program and enrollment trends (Love et al., 2016; Moye, 2017; Volk, 2019). As highlighted by Volk (2019), there are several certification, degree, and coursework pathways beyond traditional undergraduate TPPs that are becoming increasingly popular in attempts to address the critical shortage of T&E educators. However, there is a lack of data representing the full breadth of T&E educator-related programs (TEEPs) that offer these various pathways and have program completers entering the profession. Therefore the purpose of this study was to: (a) identify the higher education institutions in the U.S. that are currently offering certification coursework and awarding degrees related to T&E education, and (b) examine select characteristics of the identified programs which could have positive implications for enrollment.

### **Review of Literature**

#### **Studies on Programs and Enrollments**

Although separate issues, previous studies have shown that declining numbers of undergraduate T&E education graduates often coincide with declining numbers of T&E TPPs (Love et al., 2016). Numerous recommendations have been made to remedy the situation, but none have yielded significant or longitudinal results addressing the continual nationwide shortage. In Volk's (1993) analysis of the *Industrial Teacher Education Directories* from 1970-1990, he discovered there was a 24% decline in industrial arts/technology education (IA/TE) program enrollments; however, non-teaching IA/TE degrees awarded by departments that housed IA/TE programs saw a 790% increase. His study also revealed that universities offering both industry-focused industrial technology programs and IA/TE programs reported significantly greater declines in their IA/TE program enrollments than universities that did not offer an industrial technology degree option. In a follow-up study, Volk (1997) examined the 1995 directory and concluded the

continual rate of decline supported his earlier prediction of the profession's demise. In 2000, Volk conducted another analysis using the 1999 directory and again found trends consistent with his previous studies. He also found a noticeable decrease in technology education (TE) programs producing more than three graduates per year. Recent studies have confirmed a continuation in declining undergraduate program and enrollment trends. Love et al. (2016) indicated that there were 6,368 graduates in 1970, but only 245 in 2015. Also declining during this time was the number of T&E TPPs, falling from 203 in 1970 to 43 in 2015.

#### **Alternative Licensure Models: A Slippery Slope**

In Volk's (2000) analysis of the 1999 directory, he predicted that small numbers of graduates from universities in states with large populations would lead them to rely on alternative preparation routes to meet the demand for T&E teachers. His prediction appears to have come to fruition in states like Maryland that have a high demand for T&E educators due to the T&E-related course completion requirement for high school graduation. According to the latest directory (Rogers, 2019), 90% of the undergraduate students enrolled in Maryland's largest accredited T&E education program pursued non-degree post-baccalaureate certification. This signifies that in Maryland, more T&E educators are entering the field through a four-course professional and technical certification pathway than through the university's traditional four-year T&E TPP.

Volk's (2019) latest analysis reiterates his previous concerns about the alarming rise in alternatively certified T&E teachers and the impact this has on T&E TPPs as well as instructional quality. He asserted that short, one-week, or multi-week summer training institute models being implemented to teach out-of-content area educators how to deliver T&E curricula from organizations like Project Lead the Way (PLTW) were undermining the basis for high-quality and specialized preparation experiences traditionally offered by four-year undergraduate T&E TPPs. In support of these claims, Volk (2019) presented research demonstrating that alternatively certified teachers leave the profession at higher rates, and principals perceive these teachers to be underprepared and less effective compared to teachers who graduated from traditional T&E TPPs. He concluded that while programs like PLTW were often well supported by Perkins funding and helped prevent the closure of T&E programs in P-12 schools due to the shortage of T&E educators, it undermined the basis for TPPs and highly-qualified educators.

#### **Concerns about the Quality of T&E Instruction**

The critical shortage of T&E teachers is not unique to the U.S. Reports from Australia and New Zealand indicated the high percentage of out-of-

content educators hired to teach T&E was leading to limited T&E course offerings, watered-down course content being delivered, more theory-based and less hands-on course foci, and increased health and safety issues (Love & Love, 2022). In the U.S., similar concerns have been raised regarding safety and the lack of hands-on design-based learning experiences taught by out-of-content educators (Love et al., in press; Reed & Ferguson, 2021). These studies all concluded that the shortage of highly-qualified T&E educators was threatening the integrity and quality of T&E instruction, jeopardizing the profession's reputation, and contributing to further recruitment and retention issues.

### **Shifts in Program Foci and Delivery Methods**

In attempts to address declining undergraduate T&E TPP and enrollment trends, those overseeing such programs have made many efforts to adapt programs to be more appealing to prospective educators. This has resulted in more programs offering options geared toward elementary STEM (science, technology, engineering, and mathematics). However, as Volk (2000) pointed out, many elementary technology lessons do not require a technology education degree because the lessons are already integrated into existing elementary science and math curricula. This has been more evident since the Next Generation Science Standards (NGSS) called for the inclusion of engineering content and practices. Volk predicted that the addition of elementary technology education program offerings by technology TPPs would not have a significant impact on their enrollment.

Several other creative methods have addressed waning program enrollments and declining institutional support. Texas A&M University developed an Interdisciplinary Technology bachelor's program in the early 1990s to utilize the resources from their strong engineering and technical programs (Scott & Buffer, 1995). Texas A&M University currently offers a "Multidisciplinary Engineering Technology" program, which leads to state certification in grades 6-12 physical science, mathematics, and engineering. Graduate programs have also adapted to address enrollment concerns. Virginia Tech's shift to an Integrative STEM education focus (Wells, 2013) and Millersville University's change toward a broader interdisciplinary focus on "Technology and Innovation" are just two examples (Warner, 2015) (*Note: The graduate programs mentioned from Virginia Tech and Millersville do not lead to certification*). With hands-on design challenges being a foundational component of T&E education, TPPs have frequently questioned the viability of moving to an online format. Valley City State University serves as an example of an undergraduate T&E TPP that has seen growth after transitioning to a fully online format while still requiring hands-on design-based learning experiences for students.

**Content of T&E Related Educator Programs**

After the field officially changed its name from technology education to T&E education in 2009, many TPPs followed suit and added “engineering” to their program name and course titles. Despite these surface-level changes, Fantz and Katsioloudis (2011) discovered that programs were not fully integrating engineering concepts as their program name and course titles suggested. A later study examining the coursework requirements of undergraduate TPPs found that many programs aligned their core technical content courses with most of the designed world areas from the *Standards for Technological Literacy* (Litowitz, 2014). Similar to Fantz and Katsioloudis’s study, Litowitz reaffirmed a lack of undergraduate courses teaching engineering concepts and traditional courses (e.g., manufacturing) were still very prevalent in most programs.

More recently, Bartholomew et al. (2020) highlighted the vast differences in program names and also found unique nuances among TPPs. It was determined the goal of some programs was primarily to prepare T&E educators, while others had an industry-based focus. More specifically, their study found that the classification of T&E education differed drastically among state education departments. Many states classified T&E education under career and technical education (CTE), resulting in a “definite CTE flavor” of those programs (Bartholomew et al., 2020, TEE and CTE section, para. 4). One benefit they found related to this CTE classification was access to much-needed Perkins funding. Furthermore, they found the TPPs taught “a variety of industrial, technology, and engineering-related courses that are loosely comparable, and fall under the CTE umbrella” (Bartholomew et al., 2020, TEE and CTE section, para. 4). Bartholomew et al.’s study suggested that before the profession can address areas in need of improvement, a consensus must be reached regarding what constitutes T&E education and curricular requirements for T&E TPPs.

This variation among courses taught by P-12 T&E educators was also reflected in a recent national study which reported that 37% and 16% of respondents were teaching T&E literacy and pre-engineering courses, respectively (Love & Roy, 2022). When examining the data by region, this study revealed vast differences, such as a higher percentage of materials processing courses taught in the Midwest and more CTE or industry-related courses being taught by T&E educators on the west coast. These studies highlight the amalgam of content and courses that T&E educators deliver to meet the needs specific to their community, state, and region. This also highlights the various content areas and competencies T&E educators must be prepared to teach, impacting the focus and coursework of TPPs.

### Enrollment and Program Data

A number of studies have documented a declining trajectory in undergraduate T&E TPPs and enrollments over the past five decades. However, the Council on Technology and Engineering Teacher Education (CTETE) directories revealed a noticeable increase in students who earned their bachelor's or master's degrees in 2019 (Rogers, 2019).

**Table 1**

*T&E/Technology Education/Industrial Technology Education Degrees and Certifications Awarded from 2015-2019*

Year	Bach.	Cert.	Master's	Doc.	Programs	Source(s)
2015	245	37	165	17	43	Rogers (2015)
2016	210	67	154	31	43	Rogers (2016)
2017	211	34	174	23	40	Rogers (2017)
2018	216	42	127	23	40	Rogers (2018)
2019	307	39	161	14	40	Rogers (2019)
<b>Avg.</b>	238	44	156	22		

*Note.* Avg. = Average; Bach. = Bachelor's degree; Cert. = Non-degree coursework leading to teaching certification; Master's includes Master's of Arts in Teaching (MAT) degrees; Doc. = Doctoral degrees. Graduate certificates and Educational Specialist (EdS) degrees were not counted. CTE and elementary STEM degrees were not included if a program also offered a T&E degree or certification at that level. The breakdown of enrollment by institution can be accessed at Love and Maiseroulle (2021).

In Volk's 2019 analysis, he reported that 14 of the remaining T&E TPPs graduated three or fewer undergraduate students. Of the 203 programs that offered industrial arts in 1970, Volk found that only 15% of them still had an active undergraduate TPP as of 2019. The authors' review of the latest CTETE directory revealed an increase in reported graduates despite a slight decrease in programs. Upon further examination, the authors discovered discrepancies between T&E programs listed on state department of education websites (offering both undergraduate and graduate coursework leading to state certification) and those listed in the CTETE directory. That discovery provided the rationale for this study which sought to identify active higher education programs offering certification coursework or degrees (beyond just the undergraduate level) related to T&E education in the U.S. and examine the characteristics of those programs.

The following research questions (RQ) were developed to guide this study:

- RQ1. Is there an identifiable difference from the literature regarding the number of programs within the U.S. that are currently offering T&E-related educator degrees, certificates, or certification coursework?
- RQ2. To what extent do the foci of degrees offered by the identified programs differ?
- RQ3. What are the characteristics of the identified programs related to select factors that could potentially impact program enrollment?

### **Methodology**

A content analysis was initially used to identify active TEEPs. Additional content analyses were then conducted to examine the characteristics and status of each identified program. To establish a baseline of potential programs, the 2018 CTETE teacher education programs webpage, the two most recent CTETE directories (Rogers, 2018, 2019), and the “Organizations Directory” webpage of the International Technology and Engineering Educators Association (ITEEA, 2021) were analyzed. Volk (1993, 2019) employed similar methods in previous studies. It is important to note that while the CTETE directories provide a reasonable estimate of program information, they rely on self-reported data from contacted programs (Volk, 1993, 2000, 2019). To ensure the accuracy of the data collected, the researchers performed a content analysis of each state department of education’s webpage to identify all programs offering T&E education-related courses and degrees. The researchers then performed a content analysis of each identified TEEP website to determine if the program was still admitting students.

During these analyses, the researchers also examined the mission statements, required/core course descriptions from the university’s current course catalog, and prospective job opportunities published on the program websites to determine if they were preparing students for P-12 T&E education positions. The researchers investigated whether the required/core courses had a T&E literacy focus and/or covered content from the various context areas in the *Standards for Technological and Engineering Literacy* (STEL; ITEEA, 2020) to establish if a program qualified as T&E education-related. Special attention was given to programs with CTE and STEM titles. The researchers removed programs strictly focused on CTE with no connection to the T&E literacy characteristics previously described. Moreover, the researchers found several programs labeled as “STEM education” but focused on science, mathematics, or instructional technology; these were removed from the data to be analyzed. There were

also a number of programs labeled “STEM education,” which featured courses claiming to address engineering content and practices. When analyzing the course descriptions, they were primarily focused on science education; therefore, they were removed from the list of TEEPs. On numerous occasions, the researchers contacted the program chair to obtain more details about the focus of their program, the types of teaching positions their graduates typically accept upon graduation, and if the program was still accepting new students. After each of the two researchers independently conducted these content analyses, they engaged in arbitration until a consensus was reached across all programs. After establishing consensus, an external T&E teacher preparation faculty member reviewed the identified programs and their websites to validate that the identified programs had a T&E literacy focus. These identified programs were then analyzed, and the results were converted to descriptive statistics.

**Findings**

**RQ1: Identifying T&E-Related Educator Programs in the U.S.**

Research question one sought to identify the number of active TEEPs in the U.S. Content analyses of the 2018 CTETE webpage, the two most recent CTETE directories (Rogers, 2018, 2019), and ITEEA’s “Organizations Directory” webpage (ITEEA, 2021) revealed there were 47 programs. Additional content analyses examining the websites for each state department of education and TEEP revealed 70 programs across 35 states (Table 2). The majority of these programs were located on the east coast or in the mid-West (Love & Maiserouille, 2021).

**Table 2**  
*T&E Educator-Related Degree Programs*

Degree and Certificate Programs	Source (n)			
	Rogers (2019)	ITEEA (2021)	Rogers/ITEEA Total	Love & Maiserouille (2021)
Undergraduate Only	8	6	8	18
Graduate Only	4	3	6	13
Undergraduate & Graduate	28	16	33	39
<b>Total</b>	40	25	47	70

*Note.* The Rogers/ITEEA Total column represents the number of programs from both Rogers (2019) and ITEEA (2021) without any duplicate listings.

**RQ2: Foci and Degrees Offered by the Identified Programs**

The second research question examined the degrees, certificates, and certifications offered by the 70 identified TEEPs. When examining the aggregate results, the most common degrees offered were bachelor's (60) and master's degrees (52), with many programs offering a certificate or minor (34). A smaller number of programs offered doctoral degrees (14), certification (i.e., teacher licensing only; 15), or educational specialist options (5). Among the degree foci, T&E education was the most common in all degree categories except certification. Technology education, STEM education (encompassing Integrative STEM Education), and CTE also emerged as popular foci. When collectively examining the program focus and degree level, bachelor's degrees in T&E education (26) and technology

**Table 3**  
*Foci and Type of Degrees Offered Among Active TEEPs*

Program Focus	Degree Type (n)						
	A.A.S	Certifi- cation*	Certificate/ Minor	Bach.	Mas.	Ed.S.	Doctorate
Tech Ed	1	5	2	17	9		
Tech & Eng Ed		3	8	26	11		3
CTE		4	2	4	10		3
STEM Ed		1	9		13	2	3
Elementary STEM			4	2	1		
Skilled & Technical Sciences				2			
Technology			2				
Occupational & Technical Studies						1	1
Tech & Innovation					2		1
Multidisciplinary Engineering & Tech				1			
Industrial Tech Ed		1	2	7	1		
Engineering Ed		1	4	1	3		1
Workforce Ed			1		2	2	2
<b>Total</b>	<b>1</b>	<b>15</b>	<b>34</b>	<b>60</b>	<b>52</b>	<b>5</b>	<b>14</b>

*Note.* Bach. = Bachelor's degrees; Mas. = Master's degrees; CTE = Career and Technical Education; Ed = Education; Eng = Engineering; Tech = Technology; \* = non-degree teacher licensure programs.

education (17) were the most common, followed by master's degrees in STEM education (13). The most popular certificate foci were STEM education (9) and T&E education (8). The most common certification area was technology education (5) despite coursework reflecting a T&E focus. This may have been due to efforts to align with the title of the certification offered by state education departments (Table 3).

Upon further analysis, it was discovered that 58 of the 70 TEEPs offered educator certification either through dedicated certification coursework or in conjunction with degree program completion. Among those 58 programs, 55 provided certification in conjunction with the completion of a bachelor's degree program, one included certification through an undergraduate concentration (B.S. in engineering leadership with a concentration in education), and two Master of Arts in Teaching (MAT) programs resulted in initial certification (Love & Maiserouille, 2021).

### **RQ3: Enrollment Related Characteristics of the Identified Programs**

Research question three investigated select characteristics of the 70 identified TEEPs. The majority of programs were offered by public universities (86%), and approximately 13% of the programs were offered by minority-serving institutions (Table 4).

**Table 4**

*Characteristics of Institutions (n = 70) with Active TEEPs*

<b>Public or Private Institution</b>	<b>n (%)</b>
Public	60 (86)
Private	10 (14)
<b>Minority-Serving Classification</b>	<b>n (%)</b>
Hispanic-Serving Institutions (HSI)	2 (3)
Historically Black Colleges and Universities (HBCU)	6 (9)
Rural Appalachia-Serving Institutions	1 (1)
Non-Minority-Serving Institutions	61 (87)

Approximately 46% of the programs were offered at master's colleges with a strong emphasis on teaching, while 40% were offered at doctoral institutions with the designation of either very high (R1) or high research activity (Indiana University, 2021) (Table 5).

When examining the full range of degree programs offered by institutions, many offered only undergraduate and master's programs (30%), followed by

institutions offering only undergraduate programs (29%). Approximately 13% awarded bachelor's, master's, and doctoral degrees (Table 6).

**Table 5**  
*Carnegie Classification of Active TEEPs (n = 70)*

<b>Classification</b>	<b>Institutions n (%)</b>
Doctoral: Very High Research Activity	13 (19)
Doctoral: High Research Activity	15 (21)
Doctoral/Professional Universities	4 (6)
Master's College: Larger Programs	27 (39)
Master's College: Medium Programs	2 (3)
Master's College: Small Programs	3 (4)
Baccalaureate College: Diverse Fields	3 (4)
Baccalaureate College: Arts & Sciences Focus	1 (1)
Baccalaureate Associate's Colleges: Mixed Baccalaureate Associate's	1 (1)
Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional	1 (1)

**Table 6**  
*Common Degree Offerings by TEEPs (n = 70)*

<b>Degrees Offered</b>	<b>n (%)</b>
Certification Only	1 (1)
Undergraduate Only	20 (29)
Graduate Certificate or Graduate Concentration Only	1 (1)
Master's Degree Only	3 (4)
Undergraduate and Master's Degrees Only	21 (30)
Undergraduate Minor and Master's Degree Only	1 (1)
Undergraduate and Master's Degrees, and Graduate Certificate	5 (7)
Undergraduate Degree and Graduate Certificate Only	1 (1)
Undergraduate and Doctoral Degrees Only	1 (1)
Master's Degree and Graduate Certificate Only	4 (6)
Master's and Doctoral Degrees Only	3 (4)
Bachelor's, Master's, and Doctoral Degrees	9 (13)

Face-to-face was the most common delivery method (36%), and a hybrid format (comprised of face-to-face and online coursework) at the graduate level (29%) was the second most common. Approximately 15% of the programs were offered fully online at the time of this study (Table 7).

**Table 7**  
*TEEP Delivery Methods (n = 72)*

<b>Delivery Method</b>	<b>n (%)</b>
Fully Online Undergraduate	1 (1)
Hybrid Undergraduate	2 (3)
Fully Online Graduate	10 (14)
Hybrid Graduate	20 (29)
Fully Online and Hybrid Graduate Options	14 (20)
Face-to-Face Only	25 (36)

*Note.* Two programs offered online or hybrid undergraduate programs plus online and hybrid graduate programs.

### **Discussion**

While previous research has focused solely on undergraduate T&E TPPs leading to certification, this study also included graduate programs leading to certification (e.g., MAT). Beyond just undergraduate TPPs, this study identified TEEPs which are preparing career changers, out-of-content educators, and others to teach T&E in P-12 settings. Although the authors made a reasonable effort to identify all existing programs carefully, the results are based on data available when this study was conducted.

### **Identified Programs**

For decades the literature reported declines in T&E TPPs and the number of graduates from undergraduate T&E TPPs (Love et al., 2016; Moye, 2017; Scott & Buffer, 1995; Volk, 1993, 1997, 2000, 2019). The 2019 CTETE directory reported there were 40 T&E TPPs. More specifically, Volk (2019) asserted there were 32 undergraduate T&E TPPs still in operation. However, this study discovered 56 bachelor's and two MAT programs that resulted in T&E-related teaching certification in states. Additionally, the CTETE directories revealed that 91 more bachelor's degrees and 34 more master's degrees were conferred in 2019 compared to the prior year (Table 1). That analysis did not include graduates from the 70 newly identified TEEPs (Love & Maiseroulle, 2021), some of which prepare new T&E educators through undergraduate and graduate degree programs, certificates, minors, and/or certification coursework. Therefore, the number of graduates who received certification or completed

coursework to become a T&E educator is most likely higher than reported in the directory (Table 1).

### **Program Focus**

The second research question sheds light on the variety of degrees offered among the TEEPs. This corroborated previous findings (Bartholomew et al., 2020; Love & Roy, 2022), which noted that the focus and classification of T&E education programs in P-12 varied drastically among states. Therefore, it is not surprising that higher education programs also differed in T&E focus to meet the varying needs of P-12 educators and school systems in their region. Similar to prior research (Fantz & Katsioloudis, 2011; Litowitz, 2014), the content analyses in this study revealed ambiguous course titles, especially regarding the term “STEM.” Moreover, the most common certificates or minors offered among programs were in T&E education and interdisciplinary areas like STEM education. Interdisciplinary programs have demonstrated benefits for program enrollments by attracting a broader population of educators and professionals (Warner, 2015; Wells, 2013).

The number of TEEPs titled CTE, industrial technology education, and workforce education is also not surprising given the current classification of T&E education within CTE departments in many states (Bartholomew et al., 2020). The researchers found several CTE programs that offered a T&E concentration or emphasis. Interestingly, 14 out of the 40 programs (35%) listed in the 2020 CTETE directory primarily listed T&E education faculty members with position titles reflecting technical program areas instead of dedicated T&E education positions. Scott and Buffer (1995) referred to this as a dual program model, which raised concerns about the differences in goals between industry-related programs and education-focused programs. Volk (1993, 2019) described how this model has resulted in significantly greater declines in T&E graduates when compared to what LaPorte (1988, as cited in Scott & Buffer, 1995, p. 448) referred to as “pure” technology education programs. The dual program model has also been proposed between engineering and education programs (National Academies of Sciences, Engineering, and Medicine, 2020). However, this has not been very appealing to students wanting to pursue a career in teaching T&E (Volk, 2019). Furthermore, as TEEPs look to hire faculty with interest and expertise in the teaching of P-12 T&E, a dual program model may make it difficult to find qualified candidates. Many graduates of today’s doctoral programs are most likely products of the P-12 technological literacy era and may not have the technical or industry-related expertise that these programs are seeking. Past trends indicate the hiring of faculty without T&E education expertise can contribute to declines in TEEPs (Volk, 1993).

**Program Characteristics**

Addressing the third research question revealed that many TEEPs were offered at public institutions, which is beneficial for program recruitment since public institutions tend to have lower tuition costs than private institutions. This study found four additional TEEPs offered by minority-serving institutions, which play a critical role in providing greater access to TEEPs for students. Moreover, less than eight percent of T&E educators in the U.S. identify as a minority (Ernst & Williams, 2015); therefore, minority-serving institutions play an integral role in preparing educators from underrepresented groups who can serve as role models and inspire underrepresented students to pursue a degree in T&E education.

In regard to Carnegie Classification, there was a close balance among research-focused (doctoral) universities (40%) and teaching-focused (master's college) universities (46%). Most institutions offered bachelor's or master's degrees, with fewer offering bachelor's through doctorate degrees (13%), which allows for valuable research and teaching experience among TEEP students. As Volk (2000) highlighted, doctoral programs are necessary for generating a pool of new scholars to debate and research critical issues and to bring new perspectives to the field.

Additionally, approximately 36% of TEEPs were still offered in a strictly face-to-face format, while 63% of the graduate programs were offered in a hybrid or online format. Given the hands-on nature of T&E education courses, online or hybrid courses can be challenging, especially for undergraduate students who need to develop expertise on hands-on lab activities/processes they will be expected to teach safely. While graduate programs have demonstrated it is possible to provide a rigorous, hands-on, design-based, synchronous, online learning experience for students (Wells, 2013), three undergraduate programs in this study offered either fully online or hybrid course options. The forced transition to online instruction during the COVID-19 pandemic could have helped T&E programs test out the feasibility of online T&E courses that they would not have considered under normal circumstances.

**Conclusions**

The number of newly identified programs in this study is encouraging, especially after the literature from the past five decades had consistently reported declining trends. T&E teacher educators and professional T&E education associations should work to support these newly identified TEEPs that could contribute to the number of highly-qualified candidates available to fill the abundance of P-12 T&E educator openings. While the content analyses indicated several programs had expanded their offerings to areas such as elementary STEM education, a considerable number of program names, course titles/descriptions, and/or faculty position titles continue to reflect the field's

industrial roots. The release of the STEL (ITEEA, 2020) could provide the rationale for institutions to earnestly reexamine the content of their programs.

### **Recommendations**

The findings from this study provide an opportunity to reflect upon the characteristics and status of TEEPs in the U.S., changes that have occurred (or not occurred), and strategies that may help address programmatic declines and the critical shortage of T&E educators. This study did not examine to what extent each course was fully addressing engineering content regardless of title and description; therefore, further analyses are needed in this area. While there were 23 newly identified TEEPs, this study did not survey those programs regarding their enrollment and graduation numbers. Future research and CTETE directories should include these institutions to get a more accurate calculation of the number of T&E education-related graduates in the U.S. Attempts should be made to include individuals who earned state T&E teaching certification from the identified TEEPs, career changers, and out-of-content educators who became full-time T&E educators from a TEEP, and other new T&E educators. Future studies should also examine if there are significant differences between enrollments in programs offering graduate certificates in elementary STEM, STEM education, and other interdisciplinary areas versus more traditional content.

### **Availability of Data and List of Programs**

The full dataset and list of identified TEEPs can be accessed at <https://doi.org/10.26207/1rxf-ck24>

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