K12 Teacher Credentialing Containing Engineering Content in the USA

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ABSTRACT

To gain a better understanding of the landscape of State credentialing options related to the teaching of engineering at the K12 level, NAE/BOSE commissioned this paper and study that describes this landscape and provide relevant details for as many States as it is possible to do so. This project includes the taxonomy of the various types of credentialing offered by each State, and it defines these different types of credentials. A two-phase research method was used in order to investigate each State credentialing/certification program. The first phase of the method examined each State credentialing/certification program through the individual State Department of Education. The second phase focused on Career and Technical Education (CTE) credentialing/certification programs that contain engineering and/or engineering design content. A member check technique was used to help improve the accuracy, credibility, validity, and transferability of the study. Each State credentialing/certification program was thoroughly examined through State Department of Education and CTE teacher credentialing pathways. The results indicate that 94.2% of State teacher credentialing/certification programs contain engineering or engineering design content; however, 5.8% of State teacher credentialing programs do not include any engineering content. Each of these credentialing/certification areas also requires a test that contains engineering content.

Keywords: credentialing, State Department of Education, CTE, engineering design

INTRODUCTION

In an attempt to better and more accurately understand these questions, the National Academy of Engineering (NAE) and Board of Science Education (BOSE) of the National Academies of Sciences, Engineering, and Medicine are conducting a study, *Educator Capacity Building in PreK-12 Engineering Education*, funded by the National Science Foundation. As part of this work, the committee overseeing the study is examining the status of efforts to provide credentials to K12 teachers of engineering. As a matter of policy, the credentialing for K12 teachers resides at the State level, but such policies vary across States, some States may have more than one type of credential, and different credentialing options may have different requirements for educator expertise in engineering. To better understanding of the landscape of State credentialing options related to the teaching of engineering at the K12 level, NAE/BOSE commissioned this paper and study that will describe this landscape and provide relevant details for as many States as it is possible to do so.

The following research questions were addressed in this study:

- Does each State have any teacher credentialing/certification/licensure programs containing engineering content?
- Does each State teacher credentialing/certification/licensure program require a test containing engineering content?

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Contribution of this paper to the literature

- This study includes the taxonomy of the various types of credentialing offered by each State, and it defines these different types of credentials.
- The recent release of the Next Generation Science Standards (NGSS) in the US marks a significant shift in the core concepts and approaches guiding science, technology, engineering, and mathematics education content in the coming years.

LITERATURE REVIEW

Many science, technology, engineering and mathematics (STEM) concepts, especially those learned in the critical formative years of pre-collegiate education are abstract in nature, often taught in vertically articulated course offerings that are frequently unconnected horizontally with other STEM course content (Hoeg & Bencze, 2017). The lack of concept and content connections to authentic applications makes learning difficult for young learners. In addition, few opportunities exist within K-12 education for students to engage in contextually authentic learning-in-doing inquiry and design driven environments in which they are immersed over time greater than a few class periods. Combine these factors with student misconceptions of what engineering practice is and less than optimal instructional models, yields a volatile combination for student attrition and low perceived value for learning STEM subjects (Adelman, 1998).

The aversion to learning basic engineering concepts due to their high abstractness, low perceived value, utility, and often disconnection from applications has triggered a decrease in confidence in STEM learning among entering college students, particularly in the engineering subjects (Demetry & Vaz, 2017). This can be illustrated by the fact that enrollment in U.S. institutions of higher education has grown steadily at all levels rising from 14.5 million students in 1994 to 20.7 million in 2009, but such growth is not fully reflected in science engineering and technology (Ozfidan, Cavlazoglu, Burlbaw, & Aydin, 2017). For example, institutions of higher education in the United States granted engineering degrees in the mid-2000s at a lower rate than in the mid-1980s (Galama, Hosek, & RAND National Defense Research, 2008). The number of American students earning bachelor's degrees increased by 16% over the past 10 years, however, the number of bachelor's degrees earned in engineering decreased by 15% (O'Riley, 2013). Nationally, less than 50% of the students who enrolled in engineering curriculum complete the program (Young, Ortiz & Young, 2017). American Universities typically lose 50% or more of engineering freshmen and sophomore during the first two years of their engineering program. This trend is continuing in the foreseeable future and it can be attributed to (at least) several factors:

- The traditional teaching of math, physics, and engineering and technology concepts are isolated. Each discipline operates within its own silo. Students do not see the relationship of what is taught to what they are interested in learning (National Research Council, 2009).
- Early engineering students fail to identify with and become part of the engineering and technology community through practice, inclusion, and engagement (Atman, at all, 2008).
- Only small populations of high school students find themselves attracted to engineering and technology schools and have never experienced doing research or engineering design (Felder & Brent, 2005).
- Few teachers in K-12 education are academically prepared to teach engineering subjects (Moye, 2009).

Addressing these significant factors in the learning of STEM and especially in coming to know, experience, and integrate engineering practices, as part of the STEM learning continuum is becoming an imperative that pre-collegiate education must address. However, challenges exist when a shift in paradigmatic approach to learning and instruction is introduced to a well-established educational system.

A Move towards Teaching Engineering and Technology Content

The recent release of the Next Generation Science Standards (NGSS) in the US marks a significant shift in the core concepts and approaches guiding science, technology, engineering, and mathematics education content in the coming years (NGSS Lead States, 2013). Most notable is the inclusion of engineering and technology concepts in a framework that emphasizes practices, crosscutting concepts, and core ideas. The repositioning of engineering and technology content within science education brings to light new opportunities and challenges when conceptualizing the design and delivery of instruction in STEM subjects. Moreover, realizing the full potential of the NGSS will require new conceptions of learning and instruction being adopted to include the richness of unifying practice, inquiry, and design across STEM concepts and contexts (NGSS Lead States, 2013).

The NGSS articulates a broad set of expectations for students in science grounded in practices and inquiry. Within these guiding standards are three major dimensions around which grades K-12 science education needs to

be integrated into standards, curriculum, instruction, and assessment. These dimensions include: scientific and engineering practices; crosscutting concepts that unify the study of science and engineering through their common application across fields; and core ideas in four disciplinary areas: physical sciences, life sciences, earth and space sciences, and engineering, technology, and applications of science (NGSS Lead States, 2013).

Integrating the three dimensions of scientific and engineering practice, crosscutting concepts, and disciplinary core ideas that cover traditional scientific fields of study (i.e. physical science, life science, and earth and space science) now includes the addition of engineering, technology, and applications of science (NGSS Lead States, 2013). Integrating the three dimensions could prove illusive, however approaches informed by research on teaching and learning from cognitive sciences combined with aggressive methodological approaches to measuring student learning within the three dimensions can yield promising results. Bruer (1993) in his seminal book *Schools for Thought* argued that, "the National Assessment of Educational Progress (NAPE; often referred to as the Nations report card) results indicate that current curricula, teaching methods and instructional materials successfully impart facts and rote skills to most students but fail to impart high-order reasoning and learning skills" (p. 5). This statement continues to resonate today as it did in 1993. Other researchers have explored transforming the classroom from "work sites where students perform assigned tasks under management of teachers into communities of learning and interpretation, where students are given significant opportunity to take charge of their own learning…attempting to engineer an innovative educational environment" (Brown, 1992, p. 141).

A second and more concerning question arises when the education profession looks towards the credentialing of teacher to teach engineering content. In a recent article in *The Engineering and Technology Teacher,* Moye (2017) argued that when considering the supply and demand of technology and engineering teachers, who knows where the profession stands? In 1997, Weston observed, "Enrollment in and graduation from technology teacher education programs are on a downward spiral" (p.6). Moye (2009) stated, "...over the past two decades, the number of technology education teachers credentialed in the United States has decreased dramatically, and State supervisors reported that they expect more programs to close in the near future" (p.30). Moye's 2009 study concluded that the profession was experiencing "a critical situation" (p. 30). Without recruiting new technology and engineering teachers and retaining current teachers and programs, the profession will continue to experience a "slow death" as Ritz suggested (Volk, 1997). Ultimately, "if we do not address the issues, soon we [the K-12 technology and engineering profession] will be going… going... gone" (Volk, 1997). If we truly believe that all students should study technology and engineering, we need to ask ourselves: What are we doing to ensure there will be a sufficient number of technology and engineering teachers (and programs) to teach those students?

METHODOLOGY

This project includes the taxonomy of the various types of credentialing offered by each State, and it defines these different types of credentials. The researchers investigating each States credentialing/certification programs used a two-phase research method. The first phase of the method examined each States credentialing/certification program through the individual State Department of Education. The second phase focused on Career and Technical Education (CTE) credentialing/certification programs that contain engineering and/or engineering design as shown in **Figure 1**.
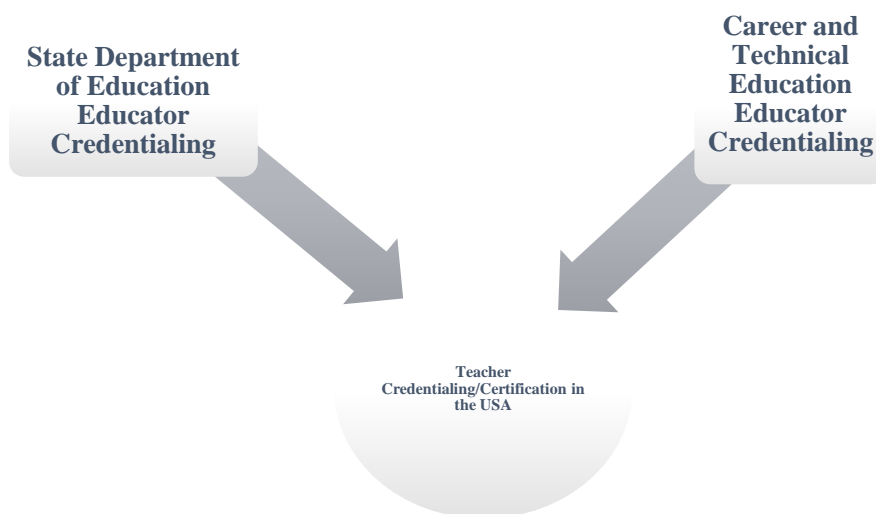

Figure 1. Teacher Credentialing/Certification map

Protocol

To collect data associated with credentialing containing engineering content, each State's teacher credentialing requirements were examined equally. The credentialing/certification programs were closely reviewed within the official websites of the State Department of Education and CTE teacher credentialing sites. While the researchers reviewed the credentialing programs and requirement they used specific search terms such as: "teacher credentialing/certification programs", "CTE credentialing/certification programs", "teacher licensure areas", "teacher certification areas", and "testing information required for licensure areas" among others associated with engineering content. When the researchers went into the State or CTE credentialing/certification programs' URLs, they searched specific terms such as "engineering", "technology education", "STEM", "industrial arts", "engineering and technology education", and "industrial education". Lastly, they also found that each of these terms included engineering and/or engineering design content. Furthermore, testing information for each credentialing/certification area was carefully examined to locate content information within the tests that contained engineering specific content and/or engineering design.

Trustworthiness

In order to establish a baseline methodology to assure trustworthiness of the data collected for each State, a member check, also known as an informant feedback or respondent validation process was used (Denzin, Lincoln, & Giardina, 2006; Ellis, at all, 2008). The informant feedback or respondent validation process is a technique that is used to help improve the accuracy, credibility, validity, and transferability of the study. The purpose of this process is to provide findings that are authentic, original and reliable. For trustworthiness of this project's data and data collection, an inter-rater procedure was used to evaluate the agreement between two experts in the field. One of the experts was a faculty member in engineering and technology education and the other one was a postdoctoral research fellow in education at Texas A&M University. They examined each State's data and procedure of data collection three times per State. Narrative accuracy checks were also completed several times in order to check the authenticity of the work. Member checking provided an opportunity to understand and determine what the researchers intended to do through their actions. It gave the researchers the ability to correct errors and challenge what are perceived as wrong interpretations. Finally, for trustworthiness, the researchers called and/or emailed each States credentialing/certification office or State Department of Education or CTE certification office to confirm the authenticity of the information that they gathered.

RESULTS

In this project, 52 States teacher credentialing/certification/licensure programs were examined to determine whether each States credential/teacher certification area includes engineering and/or engineering design content. The researchers found that n=49 (94.2%) States teacher credentialing programs contain engineering or engineering design content. The credentialing of these teachers was completed either through the State Department of Education or through a CTE credentialing program. Of this n=49 (94.2%), n=7 (13.4%) offered teacher credentialing containing engineering content as a State credential only. Besides, n=37 (71.2 %) of these States offered teacher credentialing containing engineering content at both the State Department of education credentialing office and CTE teacher credentialing. Only n=5 (9.6%) of the States offered CTE teacher credentialing exclusively. And, n=3 (5.8%) states teacher credentialing programs (Arizona, DC, and Puerto Rico) did not offer teacher credentialing that included engineering content as shown in **Figure 2**.
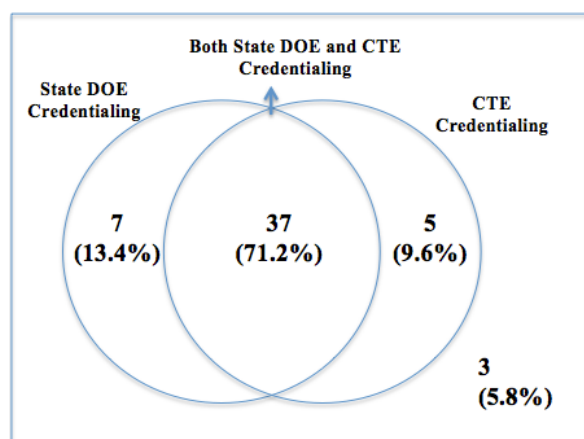

Figure 2. Distribution of credentialing programs in the USA

Table 1 highlights the distribution of credentialing programs containing engineering content. This table indicates that 44 (84.6%) States' Departments of Education include credentialing/certification programs, which contain engineering content, and 42 (80.8%) States CTE credentialing/certification programs include engineering content as well. **Table 1** also points out that 37 (71.2%) States credentialing/certification programs, which contain engineering content, are involved with both State Department of Education and CTE.

Table 1. Distribution of credentialing programs containing engineering content

State Department of Education Credentialing	CTE Credentialing	Both State and CTE Credentialing	Not Found Credentialing	Total Number of States
44 (84.6%)	42 (80.8%)	37 (71.2%)	3 (5.8%)	52 (100%)

Note: The number of States percentiles is given in parenthesis.

Table 2 shows how many States credentialing pathways are offered only through either State Department of Education credentialing or through CTE credentialing. This table indicates 7 States that have engineering intensive credentialing/certification programs are only offered by their State Department of Education. Respectively, these States are as follows: Alaska, Indiana, Kentucky, Maine, Missouri, New Mexico, and Wyoming. **Table 2** also shows 5 States that have engineering concentrated credentialing programs are offered by only CTE. These States are: Alabama, Georgia, Nevada, Oregon, and South Dakota.

Table 2. Distribution of States offering only one credentialing pathway

Only State Department of Education Credentialing	Only CTE Credentialing
7 (13.4 %)	5 (9.6%)

Note: Percent of each State and CTE credentialing is given in parenthesis.

Table 3 shows the most common credentialing/certification areas offered in the USA. This table indicates that 31 States credentialing/certification areas include Technology Education as a certification area, which contains engineering content. The rest of the credentialing/ certification areas are distributed as follows: Engineering and Technology Education or Engineering Technology is included in 19 States, Industrial Technology Education (Industrial Arts) is included in 15 States, STEM is included in 11 States, Engineering or other engineering content is included in 8 States, and General Science or Science is included in 3 States.

Table 3. Most common credentialing/Certification areas contained engineering content

Technology Education	Engineering &Technology Ed.	Industrial Tech. Ed. or Industrial Arts	STEM
31 (59.6%)	19 (36.5%)	15 (28.8%)	11(21.2%)

Engineering, or Engineering Tech.	General Science, or Science		
8 (15.4%)	3 (5.8%)		

Note: Percent of each credentialing is given in parenthesis.

Certification Testing

Testing information for each credentialing/certification area was examined to find content information of testing that includes engineering and/or engineering design content. **Table 4** shows that 30 (57.7%) States required a Praxis exam (Educational Testing Service) particularly, Technology Education test number 5051 (#5051), which contains 20% engineering content. **Table 4** indicates that 16 (30.8%) States required their own exams for teaching licensure areas, which contain engineering content. Lastly, this table highlights that 6 (11.5%) States testing information does not contain engineering content, or testing information is not available or was not verified, although they offer teacher credentialing related to engineering content.

Table 4. Testing information for credentialing containing engineering content

Praxis Exam ETS (#5051)	State Exams	No Exam contained engineering content, or No testing info founded
30 (57.7%)	16 (30.8%)	6 (11.5%)

Note: Percent of testing information is given in parenthesis.

Standards for Technological Literacy

The individual standards presented in *Standards for Technological Literacy* are organized into five major categories, each of which is includes standards: "1-The Nature of Technology; 2-Technology and Society; 3-Design; 4-Abilities for a Technological World; and 5-The Designed" (Dugger, 2001, p.15). Each category includes different standards. There are totally 20 standards at the K-2, 3-5, 6-8, and 9-12 grade levels as shown in **Figure 3** (Dugger, 2001). These standards specify what every student should know and be able to do in order to be technologically literate, and they offer criteria to judge progress toward a vision of technological literacy for all students (Dugger, 2001; Russell, 2005).

Figure 3. Standards for Technological Literacy (Dugger, 2001)

In this study, the researchers found 30 States' teacher credentialing/certification programs require a Praxis Exam, which is Technology Education (#5051). The content of this test includes 20% of the attributes of design, engineering design, and experimentation in problem solving, which all these standards are contained within the category 3 (Design). The other 16 States' teacher credentialing/certification programs require their own test, which includes standards within the categories of 1, 2, 4, and 5. These 16 States' testing includes the following standards: the characteristics and scope of technology, the connections between technology and other fields, the effects of technology on the environment, the design process, technological products and systems, energy, power, Construction, and manufacturing technologies as shown in **Figure 3**. These all standards represent the careful thought of many people and is meant to be used in its entirety (Dugger, 2001). All standards meet for a student to obtain the optimal level of technological literacy at graduation from high school.

Finding and Summary for Each State

An important part of this inquiry methodology was to document and verify a short summary and detailed spreadsheet of the teacher credentialing requirements that include engineering content for each State. In the appended **Excel spreadsheet** accompanying this report, URL's that were also verified through this study are available (see the webpage of this article for the **Excel spreadsheet**). Below is a summary of the finding for each State.

Alabama: Engineering content is available through the Technical Education credential in CTE. To be certified in Career Technologies, teachers need to take a Praxis exam (Technology Education #5051), which includes 20% engineering content.

Alaska: Technology Education and Industrial Arts are available professional certification pathways. Technology Education requires a licensure exam, which includes 20% engineering content in a Praxis Licensure Areas Examination (#5051).

Arizona: Specialized STEM Education Certificate and General Science are available certification areas that mention engineering. General Science is required an Arizona Educator Proficiency Assessment (AEPA) that mention engineering; yet content specific to engineering is not included or confirmed.

Arkansas: Industrial Technology is an available licensure area, which requires a Praxis exam (Technology Education #5051) with 20% engineering content. CTE also includes licensure areas that contain engineering contents such as Exploring Industrial Technology Education and Engineering Design Development.

California: Industrial and Technology Education is an available teaching credential subject area, which requires a California Educator Credentialing Examination (Industrial and Technology Education) that contains engineering content. Designated Subjects CTE Teaching Credential also includes engineering content.

Colorado: Technology education is an available endorsement subject area, which requires a Praxis exam (Technology Education #5051) with 20% engineering content. Colorado uses a State specific PLACE exam. STEM is also a content subject area that includes engineering as a required course subject for CTE credentialing. Colorado authorized teacher preparation program is in Engineering Science degree program.

Connecticut: Technology education (#047) is an available endorsement subject area, which requires a Praxis exam (Technology Education #5051) that contains 20% engineering content. Standards in Technology Education include engineering content as well. Connecticut CTE also includes engineering content.

DC: Educator Credential in DC does not include engineering content. Praxis tests for all licensure areas in DC do not include engineering content. Educational technology is a subject of value to DC, and STEM integration information is available but sparse in CTE.

Delaware: State Standards includes Technology Education certification (#1557), which contains engineering and engineering design content. CTE Teacher Certification areas include engineering and engineering design contents. The CTE teacher license in Technology Education requires a Praxis exam (#5051), which includes 20% engineering content.

Florida: Engineering and Technology Education (Grades 6-12) is an available certification subject, which requires a Florida Teacher Certification Examination (FTCE) (Technology Education 6-12) that includes 10% engineering content. Engineering and Technology Education is also a certification area in CTE.

Georgia: Career, Technical and Agricultural Education (CTAE) encompasses Engineering and Technology (6-12) as a teaching certification field, which requires a Georgia Assessments for the Certification of Educators (GACE) that includes 40% engineering design content. Schools are also certified STEM/STEAM and teachers require professional learning.

Hawaii: STEM certification under Mathematics and Science teaching fields is a certification field, which includes engineering design. CTE also includes Industrial and Engineering Technology as a certification area, which requires a Praxis exam (Technology Education #5051) that contains 20% engineering content.

Idaho: Engineering and Technology Education is available for certification/endorsement, which requires a Praxis exam (Technology Education #5051) that contains 20% engineering content. Technology Education is a Standard Instructional Certificate, which includes engineering content. CTE Engineering Technical Education includes teacher certifications for pre-engineering.

Illinois: Technology Education and Industrial Technology Education are teaching licensure areas. Content area of Illinois Licensure Testing System (ILTS) in Technology Education (#219) includes engineering content. CTE Educator License with Stipulations (ELS) Endorsement includes Technology and Engineering Education as a subject area.

Indiana: Technology Education is an available licensure area, which requires Indiana CORE Assessment (Engineering and Technology Education #018) that contains 30% engineering content.

Iowa: Teaching Endorsements such as Industrial Technology (#140), STEM (#975), and 5-12 Engineering (#974) include engineering content. Industrial Technology and STEM are two different credentialing subject areas in CTE. To be certified in Industrial Technology, teachers need to take a Praxis exam (Technology Education #5051), which includes 20% engineering content.

Kansas: Technology Education (5-8), and Technology and Engineering Education (5-8 and 9-12) are two teaching licensure areas, which include engineering content. Technology Education for teaching licensure includes 20% engineering content in the Praxis Examination (Technology Education #5051). CTE also includes STEM and Technology Education as endorsement subject areas that include engineering content.

Kentucky: Teaching Certificate (Middle/Secondary School 5-12) includes a specialization in Engineering and Technology, or Industrial Education, which contains engineering content. To be certified in Engineering and Technology, teachers need to take a Praxis exam (Technology Education #5051), which includes 20% engineering content. CTE industry certifications contain engineering content for students.

Louisiana: Technology Education is an available teaching certification area, which includes 20% engineering content in the Praxis Examination (Technology Education #5051). Career and Technical Trade and Industrial Education (CTTIE) also includes teaching certification areas that contain engineering content.

Maine: MDOE of certification includes Industrial Arts/Technology (K-12) as a subject area, which requires a Praxis exam in Technology Education (#5051) that contains 20% engineering content.

Maryland: Maryland State Department of Education issues a certificate in Technology Education as a subject area, which requires a Praxis exam (#5051) that contains 20% engineering content. Industry CTE certification includes engineering design content.

Massachusetts: Technology/Engineering (5-12) is an available certification field, which requires Massachusetts Tests for Educator Licensure (MTEL) (Technology/Engineering-33) that contains 16% engineering design content. CTE also includes Vocational Technical Teacher Licensure, which includes Engineering Technology as a subject area.

Michigan: Industrial Technology Education is a teaching endorsement, which includes State standards (IX and TE) that contains engineering design content. Industrial Technology Education is required Michigan Test for Teacher Certification (MTTC) (Industrial Technology #087). CTE also includes Engineering Technology as an endorsement area.

Minnesota: Minnesota Teacher Licensure Examinations include Technology (5-12) as a content area, which contains 40% Fundamentals of Technology as a subarea that includes engineering design content. CTE licensure also includes engineering content under Technology Education.

Mississippi: To be certified in Technology Education (7-12), Educator Licensure requires a Praxis examination (Technology Education #5051), which contains 20% engineering content. CTE includes STEM as an endorsement area, which contains engineering content.

Missouri: Secondary Technology & Engineering is one of the certification fields, which requires Missouri Educator Gateway Assessments (Technology & Engineering #046) that contains 24% engineering content.

Montana: Educator Licensures include Industrial Technology Education as a subject area, which requires a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes engineering as a certification content area that allows for the inclusion of licensed engineers wishing to enter the teaching field.

Nebraska: Industrial Technology Education is one of the certification areas, which contains engineering content within State standards. Industrial Technology Education used to require a Praxis examination (Technology Education #5051) that contains 20% engineering content; however, taking/passing the test is no longer a certification requirement. Industrial Technology Education is also included in CTE endorsement area (#1000), which includes engineering content.

Nevada: CTE includes Technology Education as a teaching licensure area, which includes engineering content. To be certified in Technology Education, teachers need to take a Praxis test (Technology Education #5051), which includes 20% engineering content.

New Hampshire: Comprehensive Technology Education is one of the certification areas, which includes engineering design content. CTE Credentialing/Endorsements for STEM education is also available. ETS and Pearson testing information are available, but they do not include any subject area that contains engineering content could be verified.

New Jersey: Technology Education (#1810) is an available certification area, which contains engineering design content. To be certified in Technology Education, teachers need to take a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE certification in Engineering Technology (#2545) is also available that contains engineering design content.

New Mexico: Technology Education is an available certification field, which includes engineering design content. Certification/endorsement content areas also include Science and Mathematics, which contain engineering content. New Mexico Teacher Assessments (NMTA) include General Science test, which contains engineering content. Percentage of engineering content is unknown or could be verified.

New York: Technology Education is one of the teaching certification areas, which requires a New York State Teacher Certification Examination (NYSTC) (Technology Education #118) that contains 16% engineering content. CTE certification also includes Technology Education as a content area that contains pre-engineering content.

North Carolina: Technology Education (#18829) is a certification area, which contains engineering design content. To be certified in Technology Education, teachers need to take a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes Technology Engineering and Design Education (#820) and Information Technology Education (#765) as licensure areas, which contains engineering content.

North Dakota: Technology and Engineering Education is a certification area, which contains engineering and engineering design. To be certified in Technology Education, teachers need to take a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes Technology and Engineering Education, and Information Technology Education as licensure areas that contain engineering and engineering design content.

Ohio: Technology Education is a certification area, which requires a State assessment (Technology Education #046/047) that contains engineering content. Standards of Technology Education include engineering content. CTE also includes Engineering and Science Technologies as a licensure area.

Oklahoma: Technology Engineering is one of the certification areas, which requires a State certification exam (Technology Engineering #043) that contains engineering content. CTE credentialing also include Technology Engineering and Industrial Technology, which mention engineering content.

Oregon: Industrial and Engineering is an approved CTE credential area, which contains engineering and engineering technology content. To be certified in CTE, teachers need to take a Praxis exam (Technology Education #5051), which includes 20% engineering content.

Pennsylvania: Industrial Arts/Technology Education (#5915) and Technology Education (#6075) are certification areas that contain engineering content. To be certified in Technology Education (PK-12), teachers need to take a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE certifications also include engineering content.

Puerto Rico: Most of the links and resources on the DOE site are broken. Subject areas of Certification/credentials are not available.

Rhode Island: Technology education is a certified education path, which requires a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes Pre-engineering/Engineering Technology credential, which includes engineering content.

South Caroline: Industrial Technology Education is a teaching licensure area, which requires a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes Engineering Technology as a certification area.

South Dakota: STEM is one of the CTE endorsement areas, which requires a Praxis examination (Technology Education #5051) that contains 20% engineering content.

Tennessee: Technology Engineering Education and STEM are two different licensure areas, which include engineering and engineering design contents in State Standards. To be certified in Technology Engineering Education, teachers are required to take a Praxis exam (Technology Education #5051), which includes 20% engineering content. CTE also includes Technology Engineering Education as a licensure area, which contains engineering and engineering design content.

Texas: Texas has stand-alone engineering teacher education content standards. Technology Education is a certified education path, which includes engineering design in State standards. Technology Education certification area is required TExES exam (#171), which includes engineering content. Credentialing is also available in Physical Science, Math, and Engineering as a single composite teacher certification, which requires TExES exam (#174) that contains engineering content correlated to State engineering teacher education standards. CTE also includes certification areas, such as Technology Education that contain engineering content.

Utah: Information Technology Education, and Technology and Engineering Education are available certification areas, which contains engineering content. To be certified in Technology Education Endorsement, teachers need to take Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes Technology and Engineering Education as a license area.

Vermont: Design and Technology Education is an available certification area, which includes engineering content in State standards. CTE also contains Engineering as a licensure area. No engineering content was found in Educator Licensure testing (Praxis Core & Praxis II).

Virginia: Technology Education is a certification area, which requires Technology Education (#5051). Assessments for teacher licensure require Technology Education Praxis exam (#5051) that includes 20% engineering content. CTE includes Technology Education as a certification area, which contains engineering and engineering design.

Washington: Technology Education is an available teaching certification area, which requires a Washington Educator Skills Test (Technology Education #40) that contains engineering content. CTE also includes Technology Education as a certification area, which contains engineering content.

West Virginia: Technology Education (#608) is a certification area, which requires a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes STEM as a teacher certification area that contains engineering content.

Wisconsin: Technology Education is a licensure pathway, which requires a Praxis examination (Technology Education #5051) that contains 20% engineering content. CTE also includes Technology and Engineering Education as a certification area.

Wyoming: Industrial and Technology/Education and STEM are available endorsement areas. To be certified in Industrial and Technology Education, teachers need to take a Praxis exam (Technology Education #5051), which includes 20% engineering content. This teacher certification is administered through career and technical education (CTE). Formal initial teacher preparation in this content area has been discontinued in 2017.

CONCLUSION

In an attempt to better and more accurately understand these questions, the National Academy of Engineering (NAE) and Board of Science Education (BOSE) of the National Academies of Sciences, Engineering, and Medicine are conducting a study, *Educator Capacity Building in PreK-12 Engineering Education*, funded by the National Science Foundation. To gain a better understanding of the landscape of State credentialing options related to the teaching of engineering at the K12 level, this commissioned paper describes the teacher credentialing landscape for engineering content in K-12 teacher certification and provides relevant details for each State. Each State credentialing/certification program was thoroughly examined through State Department of Education and CTE teacher credentialing pathways. A member check technique was used to help improve the accuracy, credibility, validity, and transferability of the study.

The researchers found that 94.2% of States teacher credentialing/certification programs contain engineering or engineering design content; however, 5.8% States teacher credentialing programs do not include any engineering content. Findings indicate that 84.6% of State Department of Education includes credentialing/certification programs that contain engineering content, and 80.8% of States credentialing/certification programs under CTE include engineering content. Results also show that each credentialing/certification area requires an exam that contains engineering content. According to the findings, 31 (59.6%) States required a Praxis exam (ETS) particularly in Technology Education (#5051), which contains 20% engineering content, and 16 (30.8%) States required their own exams for teaching licensure areas, which contain engineering content. The content of these required tests include suitable standards within *Standards for Technological Literacy*. These standards specify what every student should know and be able to do in order to be technologically literate, and they offer criteria to judge progress toward a vision of technological literacy for all students.

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