2006-1510: ARE CONCEPTS OF TECHNICAL & ENGINEERING LITERACY INCLUDED IN STATE CURRICULUM STANDARDS? A REGIONAL OVERVIEW OF THE NEXUS BETWEEN TECHNICAL & ENGINEERING LITERACY AND STATE SCIENCE FRAMEWORKS

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Are Concepts of Technical & Engineering Literacy Included in State Curriculum Standards? A Regional Overview of the Nexus Between Technical & Engineering Literacy and State Science Frameworks

Abstract

The use of technology in the classroom has been a driving force behind developing a technically literate society. Reform documents such as *Science for All Americans: Project 2061* [1], *Benchmarks for Scientific Literacy* [2] and the *National Science Education Standards* [NSES] [3] include sections titled, Science and Technology and The Nature of Technology, as a means to foster technical literacy for students in grades K-12. In NSES, the goal of the Science and Technology content standard is for all students to develop "abilities of technological design and understanding about science and technology." These reform documents have been the framework to foster science, technical and engineering literacy for students in grades K-12 across the United States as guided by their state science frameworks, however are states achieving this goal? Although these documents promote the need for understanding technology as it applies to science, how have states incorporated these principles into their own science curriculum standards? This investigation is part 2 of a multi-series project to understanding how public schools are training students to become technically literate. In part 1 presented at the 2005 ASEE Conference, we defined technical literacy to be "the ability of an individual to make informed decisions based upon an evolving understanding of the fundamentals of modern technologies." To accomplish this goal, we proposed the Engineering Education Frameworks [5] (EEF), which defined a pathway toward technical literacy for high school students. It was our intent to develop this set of guidelines to address technical literacy for secondary public schools. These Frameworks were designed to facilitate and promote the simultaneous teaching of multiple science disciplines in concert with mathematics while incorporating engineering concepts and designs. In part 2 of this project, we explore how various states in the United States include aspects of EEF in their science state frameworks as a means to foster technical and engineering literacy as suggested by science reform documents. This regional overview of 49 state science frameworks, including the District of Columbia and the ITEA standards [4], tackles the question: how do state science frameworks incorporate engineering concepts into their secondary science curriculums? Our findings indicate that many states include various aspects of EEF content standards and widely use the term technology but fail to identify the context of engineering concepts as it relates to the disciplines in science. It is important to assess how states are incorporating technology and engineering concepts into their state science curriculum frameworks as promoting technical and engineering literacy in secondary schools may result in fostering interest in careers in engineering.

Introduction

As the world becomes more technically oriented, educators have an increasing challenge to keep their curriculums relevant and evolving to maintain pace with globalization. Science educators, in particular, have the responsibility to introduce students to the most current trends in the discipline. This challenge not only is limited to the discipline of science but also introduces how technology merges with it. The marriage of technology and science is not a new endeavor but one that has been outlined in reform documents since the late 1980's. It was through these reform initiatives that science educators have developed curriculums to shape the future of science education.

The first reform document to appear in 1989, *Science for All Americans: Project 2061* (SFAA) [1] recommends a way of "thinking that is essential for all citizens in a world shaped by science and technology." This long-range, multi-phase initiative began in 1985 as an attempt designed to spring board the nation in its efforts to achieve scientific literacy. It is based on the notion that "the science-literate person is one who is aware that science, mathematics and technology are interdependent human enterprises with strengths and limitations; understands the key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes." Technology plays an essential role in this objective. In the chapter, *The Nature of Technology*, technology and engineering are discussed as means to promote scientific literacy. The chapter is divided into three distinct yet related areas: (1) the connection of science and technology, (2) the principles of technology itself, and (3) the connection of technology and society. It also defines engineering as the systematic application of scientific knowledge. The emphasis on engineering is a pervasive theme throughout this document.

In a second and an equally important chapter titled, *The Designed World*, technology and human activity is discussed and reference is made to how these influences have shaped the environment and our lives. This chapter outlines eight basic technological areas that can promote scientific literacy: (1) agriculture, (2) materials, (3) manufacturing, (4) energy sources, (5) energy use, (6) communication, (7) information processing, and (8) health technology. As each section defines a basic technological framework necessary for a person to become scientifically literate, it is important to note that the emphasis to include technology and engineering in this important reform document was purposeful and explicit.

A second document, *Benchmarks for Science Literacy* [2] was designed as part II in the reform efforts initiated by SFAA. [1] The Benchmarks [2] was prepared as a tool to describe how to achieve the goals set forth in SFAA [1]. It was suggested to be a companion to SFAA not a substitute and outlines what students should know by the time they complete their K12 science education. This document emphasizes scientific literacy and a common core of learning that contributes to this goal. The Benchmarks [2] delineates grade levels, K-2, 3-5, 6-8, 9-12 and sets specific content knowledge goals at each level. Technology is the theme that transcends this document and an emphasis on technology is recommended throughout the content areas. It is important to note that both SFAA [1] as well as Benchmarks [2] acknowledges that technology does not traditionally have a place in the general curriculum so many students fail to learn about it and fail to develop engineering problem skills as a result. As most technology has been taught traditionally in tech-ed classes (formally industrial arts) where the emphasis is vocational, academic students in upper level science and mathematics classes often do not take advantage of courses taught with the emphasis on technology. Again, as a result of this oversight, they fail to be introduced to engineering concepts and modes of technology that contribute to scientific understanding.

The *National Science Education Standards* (NSES) [3] were written in response to the Benchmarks [2] document and to establish national science educational standards. Although Benchmarks provided the seminal work addressing science content standards, the call to create a comprehensive document that addressed multiple aspects of science education was initiated. The development of NSES [3] targeted more than science content standards as addressed in Benchmarks, it also incorporated several other important components necessary for a comprehensive science educational program. As the Benchmarks [2] outline guidelines for science content, NSES [3] outlines guidelines in six additional areas in science education. These areas include: (1) standards for teaching science, (2) professional development of science teachers, (3) assessment in science education, (4) science content, (5) science educational programs, (6) science education systems. Using these guidelines, school districts can conduct a comprehensive science education program.

Similar to Benchmarks [2], NSES [3] addresses content areas that blend the discipline of science with technology. In Content Standard E: *Science and Technology*, the intent is to "establish connections between the natural and designed worlds and provide students with opportunities to develop decision making abilities." To achieve this goal, it is recommended that students need to develop: (1) abilities to distinguish between natural and human-made objects (benchmarks of grades K-4), (2) abilities of technological design (benchmarks of grades K-12), and (3) an understanding about science and technology (benchmarks of grades K-12). Similarly, an additional content standard F: *Science in Personal and Social Perspectives* addresses the social aspect of science thus encouraging students to build a foundation on which to base decisions that will affect them later in life. This content standard recommends that students understand the impact of how science and technology affect local, national and global issues and challenges. It includes topics in personal and community health, population growth, natural resources, environmental concerns and natural and human-induced hazards.

As these reform documents stress the nexus between science and technology for science education, the International Technology Education Association (ITEA) takes the next step in addressing standards for technological literacy. The ITEA document, Standards for Technological Literacy: Content for the Study of Technology (Technology Content Standards) [4] defines what a student should know and be able to do in order to be technologically literate. Similar to Benchmarks [2], this document promotes the notion of technological literacy and sets objectives for students in grades K-12 to achieve this goal. There are 20 standards that specify what every student should know and be able to do in order to be technologically literate. This comprehensive outline is the basis for technology education in most high schools but rarely transcends into mathematics and science curriculum. It targets students who normally enroll in tech-ed classes and introduces basic engineering concepts to these students. Although a comprehensive document, it has a narrow audience in public education and it not employed as extensively as it should as many students fail to take advantage of these course offerings.

Each state in the United States has written science education frameworks that guide their science programs in grades K-12. Many use the Benchmarks, NSES [3] or both as the guiding framework for science content often reflecting this content through the traditional science disciplines, e.g. earth science, biology, chemistry and physics. As demonstrated in this brief expose, Benchmarks [2] and NSES [3] recommend the blend of technology into the science frameworks as a means to promote scientific literacy. As science educators develop and revise their science curriculums, the inclusion of technology and engineering concepts, as recommended by these documents, would augment their curriculums. We contend that the context of engineering and technology can enhance the way science is taught in the K-12 curriculum and can not only bring relevance and interest for the students but can also promote technical and scientific literacy. It is at this junction that this research project was born.

Methodology

This investigation is part 2 of a multi-series project to understanding how public schools are training students to become technically literate. In part 1 presented at the 2005 ASEE Conference, we presented a paper titled, *Engineering Frameworks for a High School Setting: Guidelines for Technical Literacy for High School Students.* [5] In this document, we defined technical literacy to be "the ability of an individual to make informed decisions based upon an evolving understanding of the fundamentals of modern technologies." To accomplish this goal, we proposed the Engineering Education Frameworks (EEF), which defined a pathway toward technical literacy for high school students. This document described several content strands that can theoretically be incorporated into science curriculums. It was our intent to develop this set of guidelines to address technical literacy for secondary public schools. The essence of this document was to facilitate and promote the simultaneous teaching of multiple science disciplines in concert with mathematics while incorporating engineering concepts and designs.

In part 2 of this project, we explore how various states in the United States include aspects of EEF in their state science frameworks as a means to foster technical and engineering literacy as suggested by science reform documents. This regional overview of 49 state science frameworks including the District of Columbia and the ITEA document tackles the research question, how do state science frameworks incorporate engineering concepts into their secondary science curriculums?

Using EEF as our theoretical framework, each state's science framework was analyzed for disclosure of its engineering content standards as defined in EEF. By examining how much engineering is written into the science frameworks, we can infer the extent of engineering being addressed in the high schools. Our primary focus is on secondary science education (grades 9-12) as this is the targeted age group in the EEF document. Forty-nine state science framework documents (including the District of Columbia) and the ITEA document were considered in this evaluation. The documents used in this research were found in the website: http://edstandardsorg/StSu/Science.html [6]. Not all 50 states were included in this analysis, as the State of Iowa does not post their science framework online and thus was not included. Since several states are currently revising their science curriculums, the most current science framework document was analyzed and when several alternatives were presented, the latest version was considered.

This analysis was conducted by three graduate students who are funded by a National Science Foundation grant titled, da Vinci Ambassadors in the Classroom – The Galileo Project (NSF Project #DGE-0139307). Each student's background reflected a different approach, perspective and mode of analysis to this project. Two students are pursuing a Ph.D. through the

School of Engineering (in the departments of mechanical and electrical engineering) and the third is completing a Ph.D. through the Neag School of Education (in science education).

The EEF document [5] defines technical literacy and describes a means to achieve it for high school students. In order to train students to become "technically literate," we outline content standards to achieve this goal. These content standards, also used as codes for this analysis, are listed in Table 1. Suggestions to include additional codes were made by other engineering Fellows after reviewing the EEF document [5] and these suggestions were included in this analysis. These additional codes included: environmental (EN), structural (ST) and manufacturing (MN). During the review of each state science framework, several additional codes emerged and were also included in the analysis. These additional codes are: systems (SY), tools (TL) and socioeconomics (STS).

It is important to note that there was not a one to one correspondence between the EEF code and the state science framework content. For example, we were not looking for merely any time the word "food and medicine" was used but instead, we were investigating phrases that inferred the use of food or medicine with the intent of introducing engineering concept such as genetic engineering, DNA manipulation of food products, or understanding how CAT scans work. The EEF codes outlined core engineering concepts that students must understand or perform to receive an integrated science/engineering education. While some of these codes are taught in a science curriculum (e.g. power and energy are taught in physics), the understanding of these codes from an engineering perspective differs in how this understanding is applied to science and current technology in our society. As we reviewed each state science framework, we continually assessed our understanding of this basic principle.

To better understand the struggles we encountered during the analysis portion of this research, we give an illustrated example of what we found as a "typical" science content objective and our ideal of how an engineering concept might integrate into a science curriculum. Although this example (Table 1) is extensive, it demonstrates the differences between "typical" science objectives and the ideal integration of engineering concepts in science curriculums. The content objective in this example is Ohm's Law. Ohm's Law and applying it to a circuit to calculate an unknown variable is considered a content objective for "typical" science, particularly physics, but is not considered engineering. In order to be considered engineering it is essential to understand how the resulting behavior of the designed system satisfies a human need. An engineering problem using this content objective, Ohm's Law, would act as the context to teach this concept.

Table 1: Example of a Science Objective Compared to Engineering Concept Objective

"Typical" Science Objective	Science Objective Integrating Engineering Concepts
The student should be able to: Demonstrate an understanding of Ohm's Law.	The student should be able to: Demonstrate an understanding of Ohm's Law by designing an irrigation system to determine how much water pressure is needed to irrigate an area of crops. The student can model this fluid system using an electrical schematic, to determine the pressure needed for the fluid to flow, as similar to the

	voltage for a current in a circuit. Here the end goal satisfies a human need for irrigation and uses modeling to make the connection to an electrical circuit and Ohm's Law.

Similarly, the phrase "problem solving" was used multiple times throughout the state science frameworks. When taken in context in each science discipline, we realized that students were merely doing "cookbook" laboratory exercises assigned by the teacher. For example, in a typical physical science class, students "solve problems" that determine the voltage needed for 2mA of current through two 50Ω resistors. As we were investigating how engineering might be integrated into science frameworks, we were searching for evidence where students would develop their own circuit diagrams based on the physical fluid system and determine data based on reasonable assumptions that they have made about their design to solve the given problem. As students design products within constraints of their given requirements, they can make intelligent decisions by weighing trade-offs for an efficient design. This is how an engineer operates when posed with a problem. Illustrated above, we would consider this to be an example of the engineering paradigm (EP) described in EEF. Each content bullet in each state science framework was reviewed in this manner and thus confirms how this process of analysis was not only extensive but exhaustive. Given the nature of this analysis, we eliminated the need for software text databases that only targets words and/or phrases that appear to be similar to our elaborate coding schematic.

Twice a week during the fall 2005 semester, the three graduate student authors met to discuss 6-7 different state science frameworks. Each student performed an independent and systematic analysis of each state science framework in order to characterize the extent to which EEF content standards were included in these documents. The EEF content standards were used as our objective benchmark. The objective of this approach was to determine how closely each state science framework aligned with the EEF document [5]. A similar methodology was suggested by Swanson [7] as one technique when comparing state science education standards with coding schematics which he conducted when exploring science standards and evolution concepts.

Each of three graduate students involved in the analysis came from different perspectives and disciplines e.g. engineering (mechanical and electrical) and education (science education) thus lively discussion commenced with regard to acceptable coding designations (Table 2). Discussions continued until consensus was reached for each science strand and science discipline in the individual state framework. This analysis took several months to complete as each state framework was unique and individual rater's evaluation and discussion was extensive. Triangulation of the data was a key component in our analysis, which took into consideration validity and inter-rater reliability.

Table 2: EEF Codes Used for Analyzing Secondary State Science Frameworks

EEF Code Name	EEF Code Initials	Description of EEF Code
Power & Energy	PE	Technology associated with the acquisition, generation, distribution, and various uses of power and energy.

Information & Communications	IC	Delivers an understanding of how modern communications systems function from the physical hardware to the theory of communication media as well as hands on experience with various devices.
Transportation	TR	From physical infrastructure, to the machines responsible for delivery, the technology behind the transportation of physical products is the cornerstone of modern civilization
Food & Medicine	FM	This covers the technology behind advances in modern medical diagnostic equipment and treatments to the technology responsible for feeding a planet of billions of people.
Environmental*	EN	Concepts of environmental practices such as water treatment design, effects on the environment
Structural*	ST	Concepts relating to the design of physical structures such as buildings and bridges as well as micro and nano scaled structures
Manufacturing*	MN	Concepts of mass production, product machinability, material selection, product life, metal forming, and cutting technology
Problem Solving	PS	A realm of science used as the foundation of the PS/DM/EP continuum
Decision Making	DM	The second tier in the PS/DM/EP continuum. It is problem solving plus constraints applied and considered
Engineering Paradigm	EP	The top tier of the PS/DM/EP continuum. Includes PS as well as DM resulting in a product.
Tools	TL	Engineering tools that apply technology to develop simulations, computer modeling, advanced mathematics, instrumentation, etc.
Systems	SY	Concepts of component need, component interaction, systems interaction, and feedback. The interaction of subcomponents to produce a functional system is a common lens used by all engineering disciplines for understanding, analysis, and design.
Socioeconomic	STS	Science, Technology & Society, concepts relating to technological advancement/hindrance with societal and economic factors. See explanation in results section of this document
Subcodes	Eth, Ei	Concepts relating technological advancement/hindrance with ethical and environmental issues

Results and Discussion

Using both quantitative and qualitative analysis of the engineering content as defined in EEF, we found that region-wide there is a discrepancy in the incidence of engineering concepts that were present in the various state science frameworks. This analysis was conducted for 49 state's science frameworks in the United States including the District of Columbia and the ITEA standards [4]. As mentioned earlier, the State of Iowa was not included in this analysis, as their state science frameworks were not found online. In this analysis, we used regional average as a means to describe our data. The regional average is the average of engineering content standards found as defined in EEF content standards [5] per state. The number of states per region varies and is depicted in Table 3. While the ITEA standards [4] were analyzed in the same manner as the rest of the state science documents, it is important to note that the ITEA standards [4] focuses on technology education as opposed to the inherent integration of engineering content with science curriculum that we were investigating. While ITEA standards [4] are included in the qualitative analysis section of this paper, it was not used in direct comparison with any of the other regional data presented here. Some states use ITEA standards [4] as the baseline to include technology in their science curriculums.

Figure 1 depicts the depth and breadth of the state science frameworks that were mapped to EEF content standards [5]. The depth of engineering content is defined per region as the total number of incidences of EEF content standard codes identified in the state science frameworks divided by the number of states in that region. This computation constructs a state average for each region and was used for regional comparison. As defined, the depth of engineering content demonstrates a quantitative measure of how many of the EEF content standards were actually included the state science frameworks for a given region. In descending order of the highest incidence of EEF content standards found, the regions were ranked as follows: 1) New England, 2) Mid-Atlantic, 3) Great Lakes, 4) Southwest, 5) Southeast, 6) Pacific, 7) Midwest, and 8) Mountain.

Also shown in Figure 1 is the breadth of the EEF content standards in each region. The breadth of engineering content is defined as the total number of engineering content standards identified in each state in the region divided by the number of states in that region. This computation constructs a state average for each region that was used for regional comparison. For this analysis, the regions are ranked as follows: 1) New England, 2) Mid-Atlantic, 3) Great Lakes, 4) Southwest, 5) Southeast, 6) Pacific, 7) Midwest and 8) Mountain. It is equally important to note that in terms of regional comparisons the north/northeast region, specifically 1) New England, 2) Mid-Atlantic, and 3) Great Lakes, contain both the depth as well as breadth of EEF content standards written into their science curriculum.

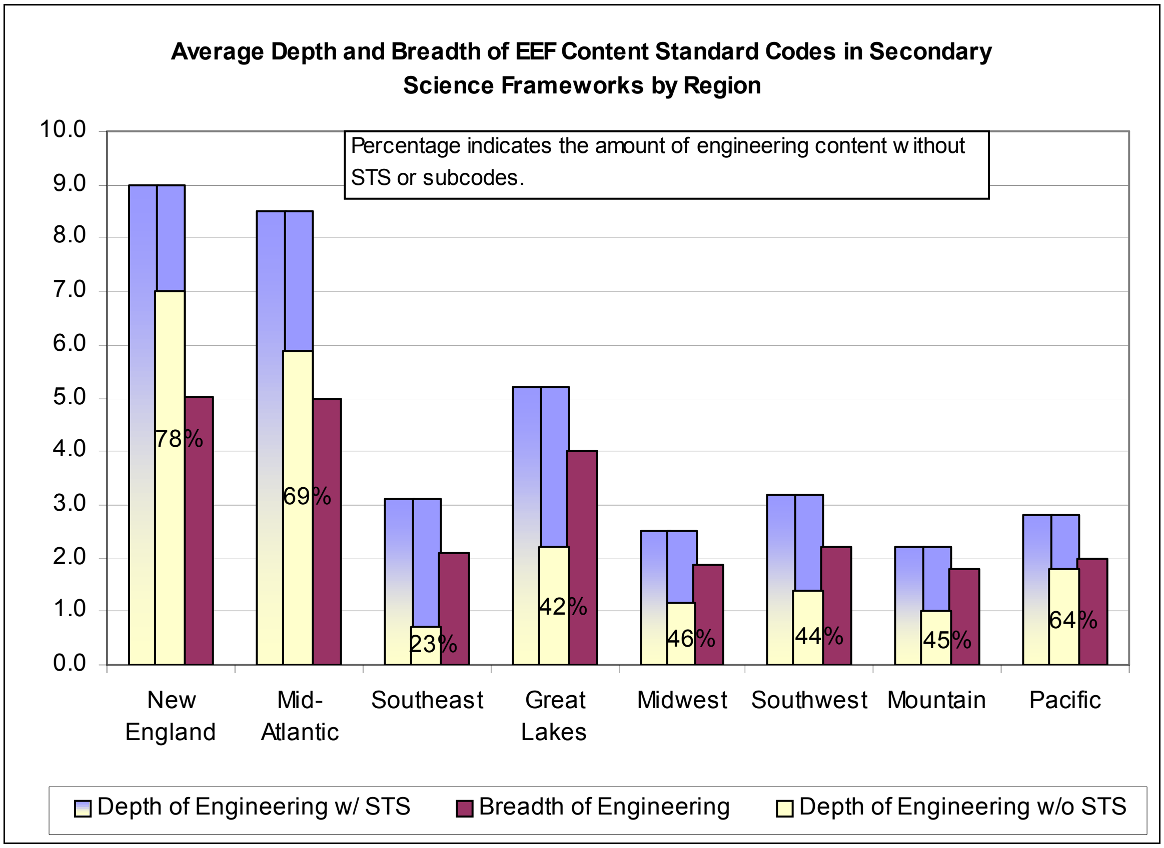

Figure 1: Regional comparison of the depth and breadth of mapped frameworks

In Table 3, the top 3 highest scoring states with reference to the depth of integration of engineering concepts into science frameworks have been ranked. The states are Pennsylvania, Delaware and Massachusetts. Included in this table is how these states compare to the ITEA standards [4].

Table 3: Top States Ranked by Depth of EEF Content Standards

State	**Incidence of EEF content standard codes**
Pennsylvania*	18
Delaware	16
Massachusetts*	14
ITEA	18

*** A complete integrated approach to science and technology**

It is interesting to note that the nexus between engineering concepts and states science frameworks revolves around socioeconomic issues. This may be in part due to the influence of the science, technology and society (STS) movement in science education that began in the 1980's. Particularly, the socioeconomic content is described as how economics, politics and ethics coupled with technological development permeates the discipline of science. It is the means by which state science frameworks incorporate technology into their curriculums. While

STS has been the traditional link between science content and technology, it is not a sufficient means to introduce engineering education and technical literacy into the high school setting. Instead, it is vital that science education focus on actual technology-based content integrated into the science curriculum as a means to promote technical literacy.

Figure 2 is a graphic representation of the regions where EEF content standards are most prevalent in the science curriculums. This is based on a state average of the number of EEF concepts found in that region. Data compiled for this graph reflects the EEF content standards exclusive of the socioeconomic codes (STS) and the subcodes of ethics and environmental issues. The regions are ranked as follows: 1) New England (highest incidence of EEF content), 2) Mid-Atlantic, 3) Great Lakes, 4) Pacific, 5) Southwest, 6) Midwest, 7) Mountain, and 8) Southeast (lowest incidence of EEF content).

Figure 2: Regional averages of EEF Content Standards Codes (Exclusive of STS & Subcodes)

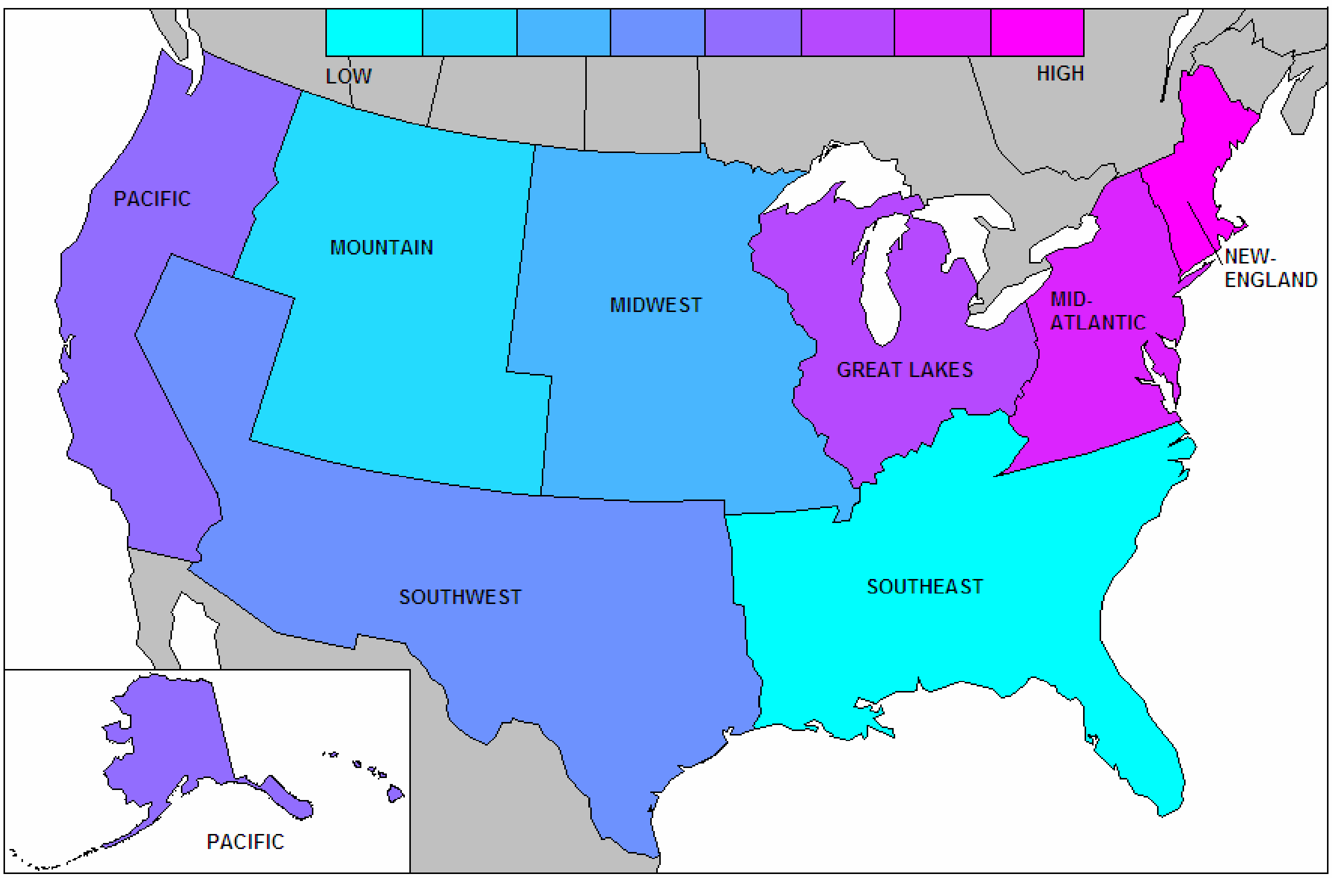

Table 4 ranks the regional average. This table coordinates data depicted in Figure 2. It is important to note that with the exception of the top 3 regional averages, New England, Mid-Atlantic and Great Lakes, the remaining 4 regional average less than two EEF content standards per state. It is also worthwhile to note that the Southeast region averages less than one EEF content standard per state (there are 10 states in that region). From Figure 1, it is clear that the regions in the north/northeast have a deeper integration of engineering with their science curriculums than the rest of the country.

Table 4: Breakdown of Regions by Incidence of EEF Content Standard Codes Found Exclusive of STS & Subcodes
(Based on regional average by state)

Region (number of states per region)	**Ave Incidence of EEF Content Standard Codes in Regions**
New England (N=6)	7
Mid-Atlantic (N=8 with DC)	5.9
Great Lakes (N=5)	2.2
Pacific (N=5)	1.8
Southwest (N=5)	1.4
Midwest (N=6 - no IA)	1.1
Mountain (N=5)	1.0
Southeast (N=10)	0.7

When each state is compared individually, the states that rank in the top 3 in depth of EEF content standards identified (exclusive of STS and subcodes) are listed in Table 5. This data represents states that encourage the theory and technology behind engineering without the influence of society (STS). Note that data from the ITEA was included in this analysis.

Table 5: Top States Ranked by Depth of EEF Content Standards
(Exclusive of STS and Subcodes)

State	**Incidence of EEF Content Standard Codes** (exclusive of STS & subcodes)
Pennsylvania*	16
Massachusetts*	13
New York*	9
Vermont*	9
ITEA	14

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In Table 6, the breadth of EEF content standards for the top states is represented. Note that we consider Pennsylvania, New York, and Vermont science frameworks to integrate EEF content standards into their science strands instead of delineating them out as separate content areas. The maximum number of EEF content standard codes is 13. Note that data from the ITEA was included in this analysis.

Table 6: Top States Ranked by the Breadth of EEF Content Standards

State	Breadth of EEF Content Standards
Pennsylvania*	11
Delaware	7
New York*	7
Ohio	6
Vermont*	6
West Virginia	6
ITEA	9

***Complete integration of science and technology in curriculum document.**

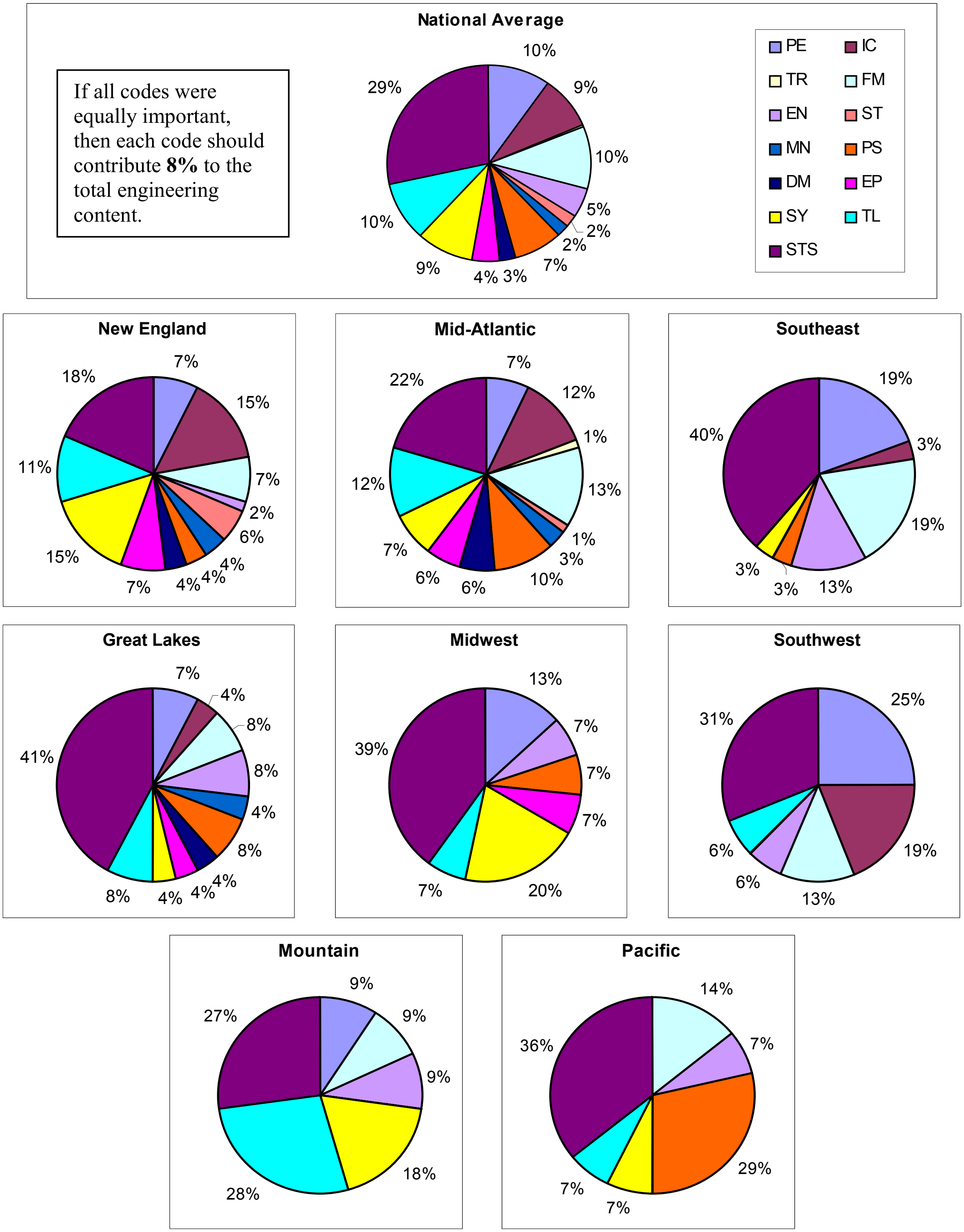
A more detailed look at the breadth of mapped frameworks can be seen in Figure 3. In this analysis, the percent contribution of each EEF content standard is shown and compared to a compiled national average. It is important to note that not one of the regions includes all 13 EEF content standard codes however the New England and Mid-Atlantic regions closely represent 12 of the 13 codes.

Overall, the national average per EEF content standard demonstrates that engineering concepts are introduced in science curriculum albeit minimally. For example, the EEF content standards "power and energy" (PE), "food and medicine" (FM) and "engineering tools" (TL) each contribute 10 percent to the national average in science curriculums. The focus of inclusion of general engineering concepts is primarily in these areas as they correspond with science disciplines, e.g. power and energy is found in physics disciplines and food and medicine is found in biology disciplines. Since engineering tools (TL) incorporates models and simulations, it is often found in multiple science disciplines.

Another point of interest relates to the code, systems [SY] (shown as yellow). The contribution of systems content distributed across the regions varies significantly. The use and analysis of systems is the most common element that is discussed and employed in various engineering disciplines. The interaction of subcomponents to produce a functional system is a common lens used by all engineering disciplines for understanding, analysis, and design. Furthermore, systems are the thread that permeates other EEF content standards. All the regions, with the exception of the Southwest, have incorporated systems into the science curriculums. We feel that systems can provide an excellent platform for fostering and incorporating engineering content into science curriculums.

The most important observation in this data is the inordinately large percentage represented by STS content (shown in purple). This is direct evidence that science curriculum writers have used STS as the bridge between science and technology. This demonstrates a means to embrace engineering education however it falls short of the target. Although technology and its integration in science disciplines is stressed in documents such as *Science for All Americans: Project 2061* [1], *Benchmarks for Science Literacy* [2], the *National Science Education Standards* [3], we have found that states science curriculums at large are doing a poor job of integrating science content, technological applications with the creative and methodical critical thinking skills of problem solving, decision making, and the engineering paradigm that we defined. In order to achieve technical literacy for *all* students in high school, it is essential that the science curriculum writers identify engineering concepts as a context in which to teach science. Using engineering as a context in order to teach science enhances both content science knowledge as well as fostering technical literacy. It is insufficient to teach STS as the only means to interest students in technology and peripherally engineering but instead, the focus needs to be on fostering technical literacy for all students by integrating engineering concepts in all science disciplines. If we are truly training students for futures in technology and engineering, we need to start in the K-12 arena through the already established science curriculums.

Figure 3: Comparison of percent contribution to total number of mapped frameworks.



Conclusion

This extensive research investigation explored how science frameworks in 49 states, the District of Columbia, and the ITEA standards [4] integrated engineering content standards into their curriculums. The selected engineering content standards meet specific criteria as described in the Engineering Education Frameworks (EEF) [5]. The EEF content standards were designed to facilitate and promote the simultaneous teaching of science and mathematics while incorporating engineering concepts and designs into already established science curriculum. In chorus, the EEF content standards were refined to include additional content standards giving the document more depth. This investigation is the first step toward assessing the extent of integration between the current state science frameworks and the EEF content standards. The quantitative data presents evidence that an average state in the northeast region has a richer depth and breadth of engineering content integrated into their science standards than other regions of the United States. Some states, Pennsylvania, New York and Vermont, have been recognized for their complete integration of technology with science education standards. These states have ranked higher than states that differentiate content standards by discipline in concert with technology. This establishes a metric to measure society's literacy in technology and engineering and may result in fostering student interest in career opportunities in engineering. The analysis also reveals that every region focuses more on the societal impacts of technology and engineering instead of the fundamental content of engineering. This indicates that less focus is aimed at student learning of the fundamentals of engineering and technology that will enhance their education and enlighten them with regard to making informed decisions about the future of a technology. By promoting technical and engineering literacy through EEF, students will become informed individuals that are capable of solving the complex problems of the future.

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