TN Department of Education | College, Career and Technical Education

Program of Study Justifications for STEM

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Engineering, Technology, and STEM Education

2016-17 Program of Study	Level 1	Level 2	Level 3	Level 4
Engineering	Principles of Engineering and Technology (5924)	Engineering Design I (6139)	Engineering Design II (6140)	Engineering Practicum (6141) -and/or- AP Physics (3238, 3239, 3234, or 3240)
Technology	Principles of Engineering and Technology (5924)	Digital Electronics (5925)	Robotics & Automated Systems (6143)	Engineering Practicum (6141) -and/or- AP Physics (3238, 3239, 3234, or 3240)
STEM Education	STEM I: Foundation (6144)	STEM II: Applications (6145)	STEM III: STEM in Context (6146)	STEM IV: STEM Practicum (6147)

Description

Engineering is a program of study designed for students interested in the various disciplines of engineering and engineering technology. Course content is arranged around four sequenced, progressive courses that provide students with the opportunity to develop critical thinking skills and understanding of engineering concepts. Students then apply these skills in conjunction with the multi-step engineering design process to solve real-world problems. The capstone Engineering Practicum course places students with industry partners to complete a design project, report the results, and present their project before an audience.

The Technology program of study is for students who wish to pursue careers in robotics, electronics, and related engineering and technology fields. Course content introduces students to the principles of engineering and the engineering design process, then progresses to apply these skills in the context of robotics, electronics, and automated systems. Upon completion of this POS, students will have gained valuable training in an Engineering Practicum and be prepared for advanced study in a variety of STEM fields at the postsecondary level.

STEM Education program of study designed for students interested in the exciting careers available in the high-demand fields of science, technology, engineering, and mathematics. This program of study is uniquely structured to offer students an overview of STEM fields, occupations, and applications in the first year, followed by more specialized study of the scientific inquiry or engineering design process in subsequent years, culminating in a portfolio and internship experience.

Upon completion of these POS, students will be prepared to pursue engineering studies or an advanced study in the STEM field of their choice at a variety of postsecondary institutions.

Job Outlook

The need for STEM education is reaching a critical importance in Tennessee. Gaps in relation to STEM occupations, academics, and college and career readiness are keeping our state from fully reaching its potential and its ability to lead the nation economically in STEM related careers. STEM education stands as a key strategy for Tennessee's economic future. It will help foster economic development by creating opportunities for our citizens which have been limited in the past. STEM education helps build critical thinking and analysis skills by addressing how our students view and experience the world around them.

Right now, we have a shortage of qualified STEM job applicants to fill the demand our state needs now and in the future. In order to ensure we have a ready workforce to fill the pipeline of STEM related career needs, we need to ensure that the students in Tennessee are well prepared to fill this deficit. Failure to do so will lead our state's STEM-related companies to seek other means to meet demand, including taking their business outside our state or importing their talent from outside our borders.

In April 2014, Tennessee ECD Assistant Commissioner Ted Townsend presented statewide STEM employment data that predicted an 11.5 percent growth in STEM occupational employment from 2013 to 2023. The highest growth rate (21.8 percent) is predicted for Mathematical Sciences occupations.[1] This is evidenced (Figure 1 and 2 below) in the fact that in the last three years, there has been an 8.0 percent growth in STEM-related employment that is quickly outpacing the national average of 6.8 percent.[2]

[1] Examination Management Services, Inc. (EMSI) as cited in the "State of Tennessee" presentation by Assistant Commissioner Ted Townsend, April 25, 2014, West Tennessee STEM Hub Conference, Jackson, Tennessee.
[2] Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited March 9, 2016)

Figure 1 and 2. STEM Occupations with the Fastest Employment Growth in Tennessee

Figure 1.

STEM Occupations	2013 Jobs	2023 Jobs	% Change	Median Hourly Earnings
Mathematical Science	2,262	2,756	21.8%	$30.59
Engineers	28,108	31,667	12.7%	$38.80
Drafters, Engineering Technicians, and Mapping Technicians	13,226	14,032	6.1%	$23.32
Life Scientists	3,337	3,676	10.2%	$30.17
Physical Scientists	4,339	4,800	10.6%	$34.16
Social Scientists and Related Workers	8,141	9,420	15.7%	$30.90
Life, Physical, and Social Science Technicians	6,061	6,657	9.8%	$20.97
Total	**65,475**	**73,009**	**11.5%**	**$31.96**

Figure 2.

Occupation	Job Openings, Projected 2012-22	Employment		Median annual wage, 2013	Typical entry-level education
		2012	2022		
Computer Systems Analysts	2,080	8,810	10,890	$75,430	Bachelor's degree
Computer User Support Specialists	1,450	6,940	8,390	41,190	Associate degree
Medical and Health Services Managers	1,360	7,360	8,730	80,030	Work experience, plus bachelor's degree
Health Specialties Teachers, Postsecondary	1,350	4,970	6,320	66,740	Master's degree
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	1,200	10,360	11,560	68,460	Moderate-term on-the-job training
Civil Engineers	970	3,720	4,690	84,850	Bachelor's degree
Network and Computer Systems Administrators	950	5,700	6,650	62,960	Bachelor's degree
Software Developers, Applications	950	4,480	5,420	80,850	Bachelor's degree
Computer and Information Systems Managers	930	5,140	6,060	102,040	Work experience, plus bachelor's degree
Industrial Engineers	620	4,900	5,510	80,260	Bachelor's degree

STEM occupations are intrinsically embedded in the advanced manufacturing sector as well. Advanced manufacturing job creation in Tennessee far outpaced national growth at 27.1 percent in Tennessee compared to 8.7 percent nationally from 2010 to 2015. Tennessee, over the last three years, has reported the second largest percentage increase in the Southeast in manufacturing GDP, which reached $48.1 billion in 2014. This accounts for 16 percent of the state's total GDP.[3] With its attractive business climate and strategic location, Tennessee is home to a strong base of

[3] Tennessee Department of Economic & Community Development (2015). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited March 9, 2016)

manufacturers representing many diverse industries, led by the state's automotive sector, which in recent years has converted into a regional and national powerhouse.[4] In industries such as these, employers like Alcoa, Eastman Chemical, and Bridgestone are in need of STEM skilled technicians and engineers who can design, maintain, and operate complex production systems.

The STEM occupation gaps are real. If we want to maintain and advance our economic stability and workforce, we need to make it our goal to increase the number of students who come though and out of our STEM Programs of Study prepared for these high-demand STEM-related careers.

Not only do we have a shortage of talented workers, students who choose to pursue these careers are often inadequately prepared to take on the challenges these positions demand. Secondary and postsecondary students are often lacking critical thinking, problem solving, and collaborative skills that are imperative for success. Unfortunately, the academic shortcomings of these students are felt by the employers. Students traditionally have the book knowledge needed to apply for a job; however, when they are faced with a real world application, they find it difficult to apply their knowledge, problem-solve, conduct research, and proactively seek solutions.

Tennessee has approximately 950,000 elementary, middle and high school students, whose academic achievement is our greatest priority. It is our job to ensure that we offer the students in

Tennessee the best opportunities – not only to succeed in the classroom- but to be able to apply those successes in the workplace.

The gaps in our state's STEM-related academic achievement scores can be best addressed through STEM supported integrative instruction. The 2015 ACT Condition of College & Career Readiness affirms this:

- Only 30 percent of 2015 ACT-tested graduates in Tennessee met the ACT College Readiness Benchmark in math. [5]
- Only 29 percent of 2015 ACT-tested graduates in Tennessee met the ACT College Readiness Benchmark in science.[5]

The 2015 Statewide End of Course results in high school algebra and sciences also showed evidence of STEM academic gaps with only moderate gains in the percent of students proficient or advanced from 2014 to 2015. These gains do not show evidence that we will be able to sustain a pipeline of STEM proficient workers for Tennessee.[6]

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[4] Muro, M., Andes, S., Fikri, K., Ross, M., Lee, J., Ruiz, N., & Marchio, N. (2013). Drive! Moving Tennessee's Automotive Sector up the Value Chain. Brookings Institution. Retrieved from: http://www.brookings.edu/research/reports/2013/10/04-tennessee-automotive. (visited March 9, 2016)

[5] ACT. *The Condition of College & Career Readiness. (2015)* On the internet at: http://www.act.org/research/policymakers/cccr15/pdf/CCCR15-NationalReadinessRpt.pdf

[6] Tennessee Department of Education (2016) Retrieved from: https://www.tn.gov/education/topic/tcap-results-at-a-glance (visited March 9, 2016)

[7] University of Tennessee Knoxville Center for Business and Economic Research, Academic Program Supply and Occupational Demand Projections: 2008-2018. http://cber.bus.utk.edu/pubs/mnm118.pdf. (visited March 9, 2016)

Figure 3. Statewide end of course assessments

TCAP End of Course Results by Subject

	Algebra I		Algebra II		Biology I		Chemistry	
	#Tested	%P/A	#Tested	%P/A	#Tested	%P/A	#Tested	%P/A
2015	64,176	65.6	61,491	54.2	75,775	65.2	60,650	44.2
2014	68,215	62.4	64,321	47.9	70,808	63.5	60,368	37.7

When students transition to postsecondary, we also see a large disconnect between students' interest in STEM-related majors compared to the demand for STEM-related careers. There is a great need for increased postsecondary completions in these STEM knowledge-intensive areas as shown in the figure 3 below. [7]

Figure 3. Postsecondary STEM related majors

Career Pathway	STEM	Average Graduates Per Academic Year*		Average Openings** 2008-18	Average Annual Graduate Deficit
		2000-08	2008-18		
Programming and Software Development Pathway	*Yes*	*131*	*281*	*678*	*-397*
Marketing Pathway		9	37	397	-360
Human Resources Pathway		73	140	447	-307
Business Financial Management and Accounting Pathway		1,319	1,192	1,376	-184
Environmental Service Systems Pathway	*Yes*	*7*	*0*	*149*	*-149*
Construction Pathway	*Yes*	*19*	*88*	*200*	*-112*
Correction Services Pathway		14	24	104	-80
Business Financial Management Pathway		2	1	79	-78
Administrative and Information Support Pathway		183	113	181	-68
Biotechnology Research and Development	*Yes*	*8*	*23*	*70*	*-48*

*Note: *Award levels less than an associate's degree are excluded; **Job openings with educational requirements lower than an associate's degree are excluded*

The gaps in career and college readiness can be felt from a very early age. Students are not connecting the dots between their interests and potential STEM–related careers. They need to know what STEM careers are and the pathway to get there. There exists a noticeable gap between a student's interest in STEM and his/her intentions to pursue STEM careers.

Eighty-eight percent of STEM jobs will require postsecondary education or training by 2018. Presently, Tennessee cannot fulfill this projection. They are not prepared academically to meet those demands because they do not know what jobs exist and the skills required to obtain these jobs. Due to preconceived perceptions of the complexity of math and science, many students are also quick to dismiss STEM careers. For many students, the decision to study STEM-related courses and careers starts long before postsecondary, arguably as early as elementary school.

- Nearly four in five STEM college students (78 percent) say that they decided to study STEM in high school or earlier.
- One in five (21 percent) decide in middle school or earlier.
- More than half (57 percent) of STEM college students say that, before going to college, a teacher or class got them interested in STEM. [8]

According to the ACT Report, between 2011 and 2015, the percent of students interested in STEM decreased by one percent while STEM related occupations are increasing rapidly. [9]

Figure 4. STEM Report

Tennessee STEM Report

Attainment of College and Career Readiness

Overall STEM Interest

- Between 2011 and 2015, the percent of students interested in STEM decreased by 1%.

Student STEM Interest Trends: 2011–2015, State vs. Nation

		2011	2012	2013	2014	2015
Percent	Tennessee	49%	49%	49%	48%	48%
	Nation	48%	48%	48%	49%	49%
N Count	Tennessee	33,551	33,695	33,803	33,370	32,818
	Nation	780,541	804,507	868,194	899,684	939,049

Gaps evidenced in relation to STEM occupations, academics, and college and career readiness are keeping our state from fully reaching its potential and its ability to lead the nation economically in STEM- related careers. By embedding STEM strategies and applications across all career clusters, we will be able to close the gaps in relation to STEM occupations, academics, and college and career readiness.

Postsecondary Pathways

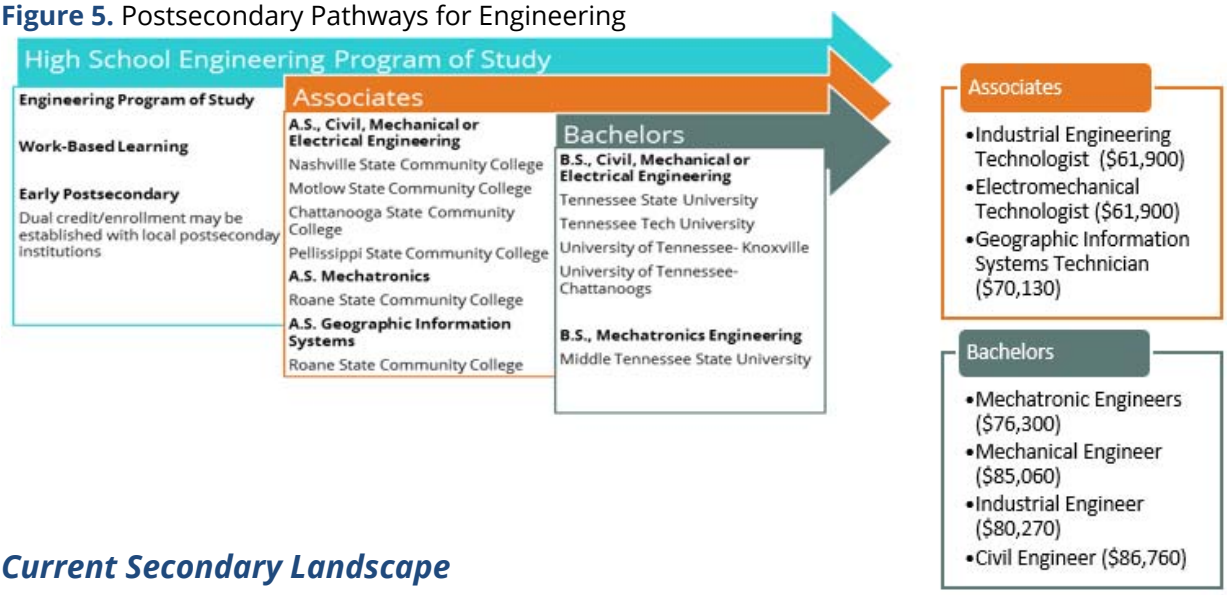
Upon completion of these programs of study, students will be better prepared to enter the STEM workforce or to further their training at postsecondary institutions. The chart below outlines the related career opportunities and the training necessary for engineering and technology. A high school diploma is entry level expectation for many occupations, but postsecondary education is necessary for many. Looking at the table below from the Jobs4Tn.gove publication, *The Demand for STEM Jobs in Tennessee*, most require a postsecondary degree.[10] This is due to the high amount of math, science and technical skill needed for these positions.

[8] *ACT. The Condition of STEM 2015. Tennessee* On the internet at: http://www.act.org/stemcondition/15/pdf/Tennessee.pdf

[9] *ACT. The Condition of STEM 2015. Tennessee* On the internet at: http://www.act.org/stemcondition/15/pdf/Tennessee.pdf

[10] Jobs4Tn.gov. The *Demand for STEM Occupations in Tennessee*. Online at: https://www.jobs4tn.gov/admin/gsipub/htmlarea/uploads/STEMReport.pdf. (Visited on March 9, 2016)

Figure 5. Postsecondary Pathways for Engineering



Current Secondary Landscape

Currently, the Engineering program of study courses are offered in 13 counties and in 18 schools. The Technology program of study is currently offered in 12 counties and 17. STEM Education program of study leads the count with it currently being offered in 21 counties across the state at 28 different schools.

Figure 6. Open enrollment analysis

	Engineering
2014-15	20
2015-16	18
	Decrease
	Technology
2014-15	16
2015-16	17
	Increase
	STEM
2014-15	13
2015-16	28
	Increase

Recommendation

STEM Across the Career Clusters

The need for STEM strategies and applications within our Career and Technical Education offerings are critical for helping close the gaps we see here in Tennessee. We need to broaden our horizons and see where we can integrate both CTE standards with STEM education applications making our courses more rigorous, and in turn better preparing our students for college and career.

STEM education is gaining momentum across the nation as business leaders routinely call for more STEM-ready graduates broadly and within specific industry and specialty areas at the national, state

and local levels.[11] In Tennessee, our districts and schools are offering high-quality Career Technical Education (CTE) programs that impart critical academic, technical and employability skills. More specifically, we already have programs of study in place that are preparing students for careers in the STEM fields. However, STEM must not be viewed as a separate enterprise within and in isolation from CTE. Simply put, our high-quality CTE programs can provide a strong foundation for and serve as a delivery system of STEM competencies and skills for a broader range of students.

The 16 Career Clusters aligned clearly to the STEM disciplines and specific STEM careers. For example, within the Agriculture, Food & Natural Resources Career Cluster, students learn the foundational knowledge and skills to seek careers in horticulture, animal science, environment science, mechanical engineering or food science. Within the Arts, A/V Technology, & Telecommunications Career Cluster, students can prepare for careers in graphic or web design, video production, fiber optics and other diverse industries.[12]

For the Career Clusters that are not naturally associated with STEM, STEM strategies and applications can still be found. For example, students in the Business Management & Administration Career Cluster can apply STEM strategies to help analyze information, understand the life cycle of a research and development (R&D) process, and develop organizational management skills. Students can also learn about science and technology policy, intellectual property and patents, public health issues, and how to conduct statistical analyses to evaluate a policy or program through the Government & Public Administration Career Cluster. All of these skills have basic STEM competencies, and have a direct application of knowledge of science, technology, engineering and/or mathematics. [13]

CTE and STEM are naturally connected given their focus on integrated learning, the application of knowledge and skills, and career preparation. The department of student success should work collaboratively across the career clusters to help identify where CTE is delivering high-quality STEM skills and competencies successfully, where efforts need to be shored up, and how to best scale those programs with the greatest value to students, employers and our nation.[14]

The Figure 8 below gives a sampling of specific examples of the types of STEM-focused or STEM-related careers students can prepare for by participating in CTE programs aligned to The National Career Clusters Framework.

[11] *CTE is Your STEM Strategy.* On the internet at: http://www.careertech.org/sites/default/files/CTEYourSTEMStrategy-FINAL.pdf
[12] *CTE is Your STEM Strategy.* On the internet at: http://www.careertech.org/sites/default/files/CTEYourSTEMStrategy-FINAL.pdf
[13] *CTE is Your STEM Strategy.* On the internet at: http://www.careertech.org/sites/default/files/CTEYourSTEMStrategy-FINAL.pdf
[14] *CTE is Your STEM Strategy.* On the internet at: http://www.careertech.org/sites/default/files/CTEYourSTEMStrategy-FINAL.pdf

Figure 7. Career Clusters and Sample Related STEM Careers[15]

Agriculture, Food & Natural Resources	• Foresters and Conservation Workers • Food Science Technicians • Veterinarians • Marine Biologists • Water Resource Specialists • Agriculture Technicians • Agriculture Engineers	**Hospitality & Tourism**	•Museums/Zoos/Aquariums Personnel • Parks and Gardens Rangers • Brewers • Pastry and Specialty Chefs
Architecture & Construction	• Architects • Civil Engineers • Civil Engineering Technicians • Surveyors • Drafters • Cost Estimators	**Human Services**	• Developmental Psychologists • Personal Trainers • Mental Health Counselors • Massage Therapists
Arts, A/V Technology & Communications	• Graphic Designers • Telecommunications Engineering Specialists • Multimedia Artists & Animators • Audio Technicians	**Information Technology**	• Programmers • Hardware, Software Engineers • Computer Support Specialists • Information Security Analysts • Database Administrators • Webmasters • Video Game Designers
Business Management & Administration	• Accountants • Auditors • Operations Research Analysts	**Law, Public Safety, Corrections & Security**	• Emergency Medical Technicians • Firefighter/Inspectors • Fire-Prevention and Protection Engineers • Brownfield Redevelopment Specialists and Site Managers
Education & Training	• STEM K-12 or postsecondary Teachers • Speech-Language Pathologists	**Manufacturing**	• Aircraft Mechanics and Service/ Avionics Technicians • Automotive Mechanics • Mechanical Engineers • Electronics Engineers • Electronics Engineering Technicians • Wind Turbine Service Technicians • Welders
Finance	• Actuaries • Financial Analysts • Financial Planners • Loan Officers • Investment Bankers	**Marketing**	• Interactive Media Specialists • Market Researchers • Forecasting Managers • Inventory Manager/Analysts
Government & Public Administration	• Patent Officer • Cryptographers • Policy Analysts • Climate Change Analysts • Intelligence Analysts	**STEM**	• Any/all of careers listed
Health Science	• Physicians • Nurses • Geneticists / Biotechnology Researchers • Biologists • Dietitians and Nutritionists • Dental Hygienists	**Transportation, Distribution & Logistics**	• Transportation Planners • Transportation Engineers • Occupational Health and Safety Technicians • Transportation Vehicle, Equipment and Systems Inspectors

STEM Education courses can easily be embedded into the majority of our current programs of study in the different career clusters. The current STEM Education standards allow for an array of real world problems using different STEM applications to be adapted to the standards. Because of the natural fit for integration of STEM across all career clusters and the need of districts for a diverse,

[15] *CTE is Your STEM Strategy.* On the internet at: http://www.careertech.org/sites/default/files/CTEYourSTEMStrategy-FINAL.pdf

rigorous and cost effective STEM program offerings, I am recommending expansion of the career exploration standards to include STEM terminology, applications, and project-based learning opportunities in all career clusters to be used to help educate students on STEM pathways within this program of study per the STEM Strategic Plan.

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