TN Department of Education | College, Career and Technical Education

Program of Study Justifications for STEM

Engineering, Technology, and STEM Education

2017-18 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) -or- **Dual Enrollment** Engineering (4124)	Engineering Practicum (6141) -and/or- AP Physics (3238, 3239, 3234, or 3240) -or- **Dual Enrollment** Engineering (4124)
		Industry Certification: Certified Solidworks Associate (CSWA)- Academic		
Technology	Principles of Engineering and Technology (5924)	Digital Electronics (5925)	Robotics & Automated Systems (6143) -or- **Dual Enrollment** Technology (4125)	Engineering Practicum (6141) -and/or- AP Physics (3238, 3239, 3234, or 3240) -or- **Dual Enrollment** Technology (4125)
			Industry Certification: Certified Solidworks Associate (CSWA)- Academic	
STEM Education	STEM I: Foundation (6144)	STEM II: Applications (6145)	STEM III: STEM in Context (6146) -or- **Dual Enrollment** STEM Education (4126)	STEM IV: STEM Practicum (6147) -or- **Dual Enrollment** STEM Education
			Industry Certification: Certified Solidworks Associate (CSWA)- Academic	

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.

Finally, the STEM Education program of study is 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 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.

STEM is the fifth fastest growing occupational cluster in the South and the seventh largest employer, with projections of 2.6 million workers by 2020. STEM jobs are central to the innovation and technological growth of this state. This in turn makes many policy and business leaders strong proponents of increasing the STEM-education pipeline. STEM jobs pay well at every level, presenting graduates with vast opportunities to launch a career and a life. It is a trend that remains consistent across time, making STEM jobs a strong factor in increasing the broader state tax base.[1]

STEM occupations are intrinsically embedded in our advanced manufacturing sector as well. Compared to the national rate of 5.2 percent, job creation in Tennessee is soaring in manufacturing fields, accounting for $30.2 billion in manufactured goods exported every year and a 9% overall increase over the last four years.[2] With its attractive business climate and strategic location, Tennessee is home to a strong base of manufacturers representing many diverse industries, led by the state's automotive sector, which in recent years has converted into a regional and national powerhouse.[3] 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.

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.[4] This is evidenced in the fact that in the last three years, there has been a 6.8 percent growth in STEM-related employment that is quickly outpacing the national average of 5.8 percent.[5]

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[1] Rosenblum, I., & Kazis, R. (n.d.). Middle-Skill STEM State Policy Framework. Retrieved May 19, 2017 from: http://www.jff.org/publications/middle-skill-stem-state-policy-framework

[2] Tennessee Department of Economic & Community Development (2017). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited May 15, 2017)

[3] 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 May 19, 2017)

[4] 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.

[5] Tennessee Department of Economic & Community Development (2017). Retrieved from: http://www.tnecd.com/industries/advanced-manufacturing/. (visited May 19, 2017)

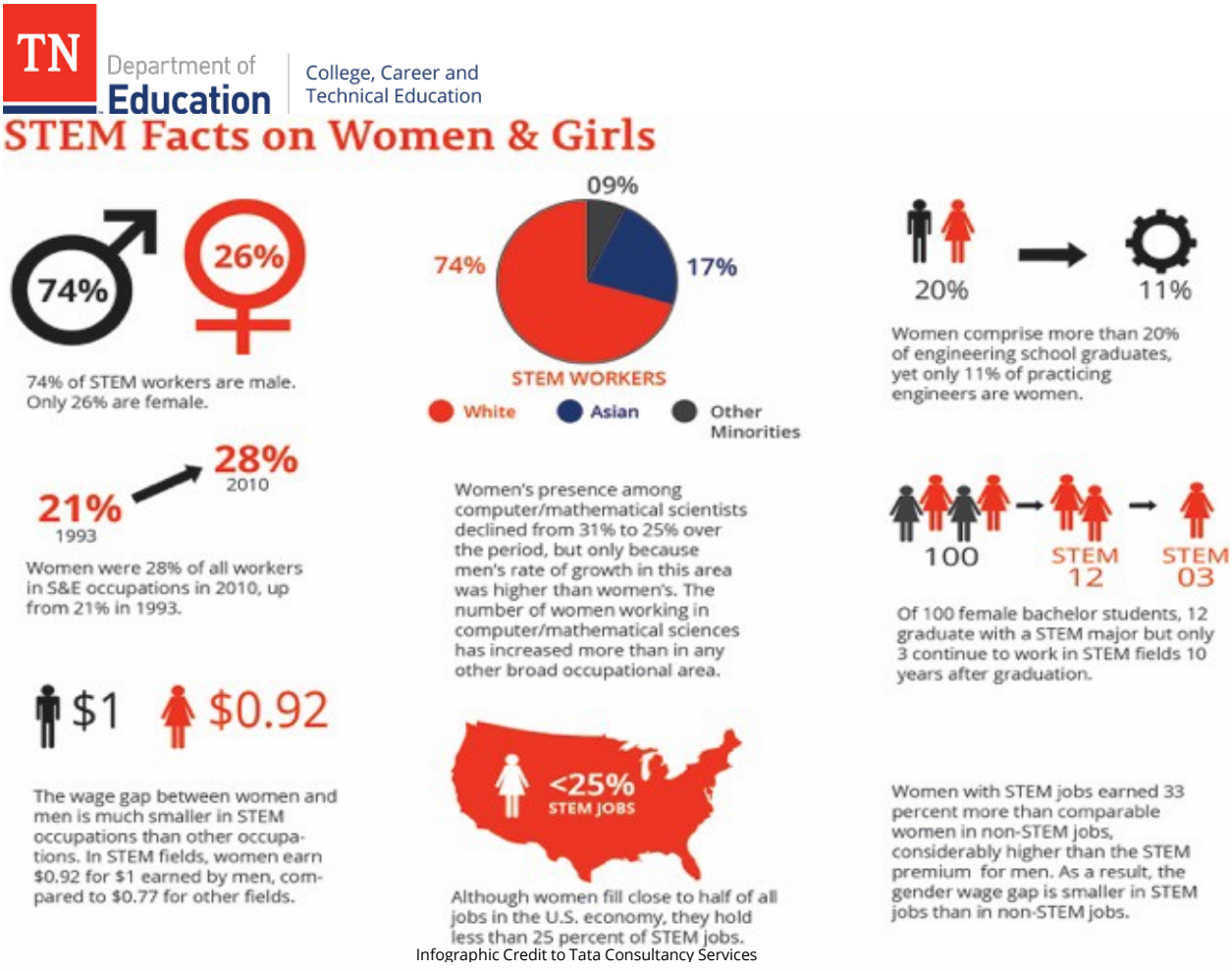
As Tennessee strives to maintain and advance its economic stability and workforce, we must make it our goal to increase the number of students who come through and out of K–16 education prepared for these high-demand STEM-related careers. Unfortunately, students who choose to pursue these careers are 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. This too often affects their on the job performance. Students often struggle not only with academic knowledge when applying for a job, but they also face challenges involving real world applications like problem solving, conducting independent research, and proactively seeking solutions.

As a state, we also recognize that we must close the STEM gap for women and minorities. Women and minority groups represent approximately 70 percent of college students in the U.S., but receive only 45 percent of the undergraduate degrees awarded in STEM disciplines.[6]

STEM is not only the place where the vast majority of the highest paying jobs are found, it is also the place where the wage gap between men and women is the smallest. Currently, in STEM fields, women earn 92 cents for every dollar earned by men, compared to 77 cents for other non-STEM fields.

Even as STEM careers offer the smallest gender wage disparity, the following sobering statistics illuminate the urgency to invest more girls and minorities in the field:

[6] Executive Office of the President: President's Council of Advisors on Science and Technology (2012). "Report To The President Engage To Excel: Producing One Million Additional College Graduates With Degrees In Science, Technology, Engineering, and Mathematic. https://energy.gov/sites/prod/files/Engage%20to%20Excel%20Producing%20One%20Million%20Additional%20College%20Graduates%20With%20Degrees%20in%20STEM%20Feburary%202012.pdf



Infographic Credit to Tata Consultancy Services

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.

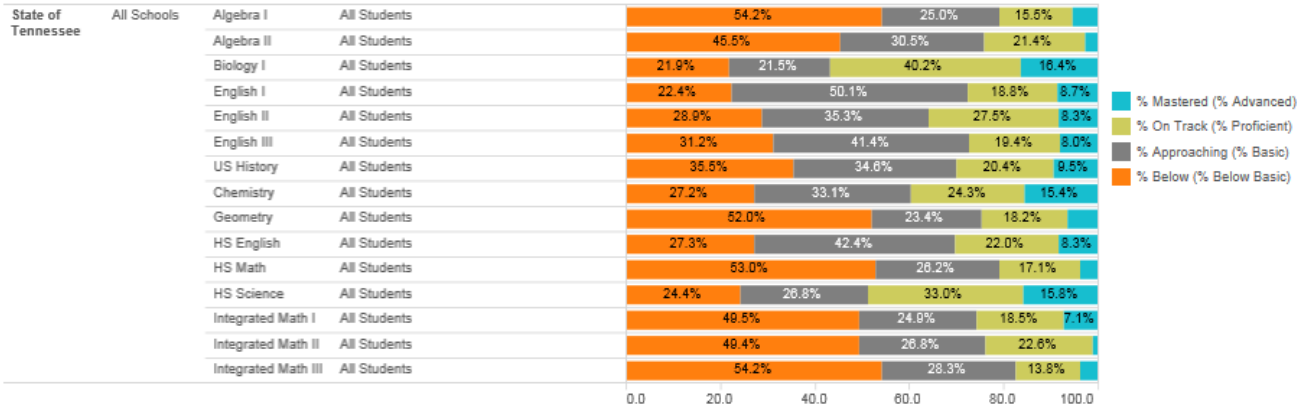
Not only do we have a shortage of talented workers, students who choose to pursue these careers are often inadequately prepared to take on the challenges these positions demand. Secondary and postsecondary students are often lacking critical thinking, problem solving, and collaborative skills that are 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 2016 The Condition of STEM 2016 affirms this:

- Only 37 percent of 2016 ACT-tested graduates in Tennessee met the ACT College Readiness Benchmark in math. [7]
- Only 37 percent of 2016 ACT-tested graduates in Tennessee met the ACT College Readiness Benchmark in science.[7]

The 2016 Statewide End of Course results in high school algebra and sciences also showed evidence of STEM academic gaps. These results do not show evidence that we will be able to sustain a pipeline of STEM proficient workers for Tennessee.[8]



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.

[7] ACT. *The Condition of STEM 2016. (2016)* On the internet at: http://www.act.org/content/dam/act/unsecured/documents/STEM2016_43_Tennessee.pdf

[8] Tennessee Department of Education (2016) Retrieved from: https://www.tn.gov/education/topic/report-card (visited May 19, 2017)

- Nearly 4 in 5 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. [9]

According to the ACT Report, between 2012 and 2016, the percent of students interested in STEM decreased by three percent while STEM related occupations are increasing rapidly. [10]

Tennessee STEM Report

Attainment of College and Career Readiness

Overall STEM Interest

- Between 2012 and 2016, the percent of students interested in STEM decreased by 3%.

Student STEM Interest Trends: 2012–2016, State vs. National

		2012	2013	2014	2015	2016
Percent	Tennessee	49%	49%	48%	48%	46%
	National	48%	48%	49%	49%	48%
N Count	Tennessee	33,695	33,803	33,370	32,818	32,719
	National	804,507	868,194	899,684	939,049	1,009,232

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.

[9] ACT. *The Condition of STEM 2016. (2016)* On the internet at: http://www.act.org/content/dam/act/unsecured/documents/STEM2016_43_Tennessee.pdf

[10] ACT. *The Condition of STEM 2016. (2016)* On the internet at: http://www.act.org/content/dam/act/unsecured/documents/STEM2016_43_Tennessee.pdf

Occupations in this program of study have bright outlooks nationally and statewide. **Figure 1 and Figure 2** outline the related career opportunities in Tennessee.

Figure 1. Tennessee long term employment projections for STEM-related occupations in Tennessee for the 2014-2024 projection period.[11][12]

Occupation	2014 Estimated Employment	2024 Projected Employment	Total 2014-2024 Employment Change	Total Percent Change	Median Salary
Software Developer Applications	4,840	6,160	190	27.00%	$82,740
Mechanical Engineer	4,660	5,030	200	8.00%	$85,500
Geospatial Information Scientists and Technologists	2,130	2,160	40	2.00%	$72,220

Figure 2. State and national trends for STEM-related occupations with positive projections 2014-24[13][14][15]

United States	**Employment**		**Percent Change**	**Projected Annual Job Openings**
	2014	**2024**		
Software Developer Applications	718,400	853,700	19%	23,800
Tennessee	**Employment**		**Percent Change**	**Projected Annual Job Openings**
	2014	**2024**		
Software Developer Applications	4,840	6,160	+27%	190

[11] Tennessee Department of Labor and Workforce Development, Job4TN Online. (2017). *Occupational Projections (Long-term)*. Retrieved from https://www.jobs4tn.gov/vosnet/analyzer/results.aspx?session=occproj

[12] Tennessee Department of Labor and Workforce Development, Job4TN Online. (2017). *Occupational Employment and Wage Rates (OES)*. Retrieved from https://www.jobs4tn.gov/vosnet/analyzer/results.aspx?session=occproj

[13] Career One Stop. (2017). *Occupation Profile, State and National Trends. Retrieved from* http://www.onetonline.org/link/summary/15-1132.00

[14] Career One Stop. (2017). *Occupation Profile, State and National Trends. Retrieved from* https://www.onetonline.org/link/summary/17-2141.00

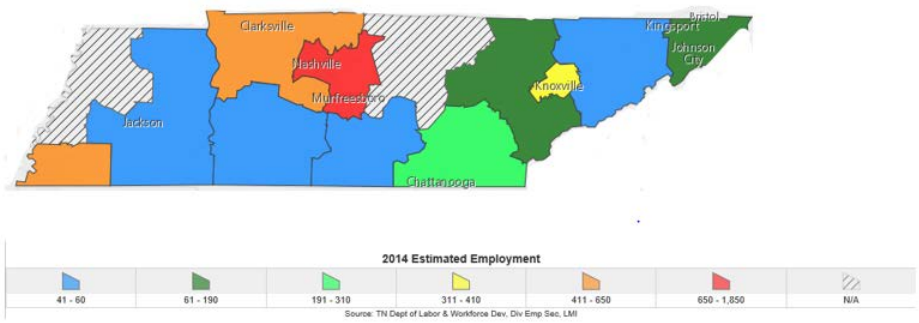
[15] Career One Stop. (2017). *Occupation Profile, State and National Trends. Retrieved from* https://www.onetonline.org/link/summary/15-1199.04

United States	Employment		Percent Change	Projected Annual Job Openings
	2014	2024		
Mechanical Engineer	277,500	292,100	+5%	10,250
Tennessee	**Employment**		**Percent Change**	**Projected Annual Job Openings**
	2014	**2024**		
Mechanical Engineer	4,660	5030	+8%	200

United States	Employment		Percent Change	Projected Annual Job Openings
	2014	2024		
Geospatial Information Scientists and Technologists	233,000	240,800	+3%	3,770
Tennessee	**Employment**		**Percent Change**	**Projected Annual Job Openings**
	2014	**2024**		
Geospatial Information Scientists and Technologists	2,130	2,160	+2%	40

Job opportunities for STEM occupations, limited to the above three professions listed above, are strongest in urban and surrounding areas in Tennessee. **Figure 3** shows that more STEM occupations in Tennessee are employed and needed in the Memphis, Nashville, and Chattanooga areas than in surrounding areas.

Figure 3. 2014 Estimated Employment[16]



[16] Tennessee Department of Labor and Workforce Development, Job4TN Online. (2017). *Occupational Projections (Long-term)*. Retrieved from https://www.jobs4tn.gov/vosnet/analyzer/results.aspx?session=occproj

Postsecondary Pathways

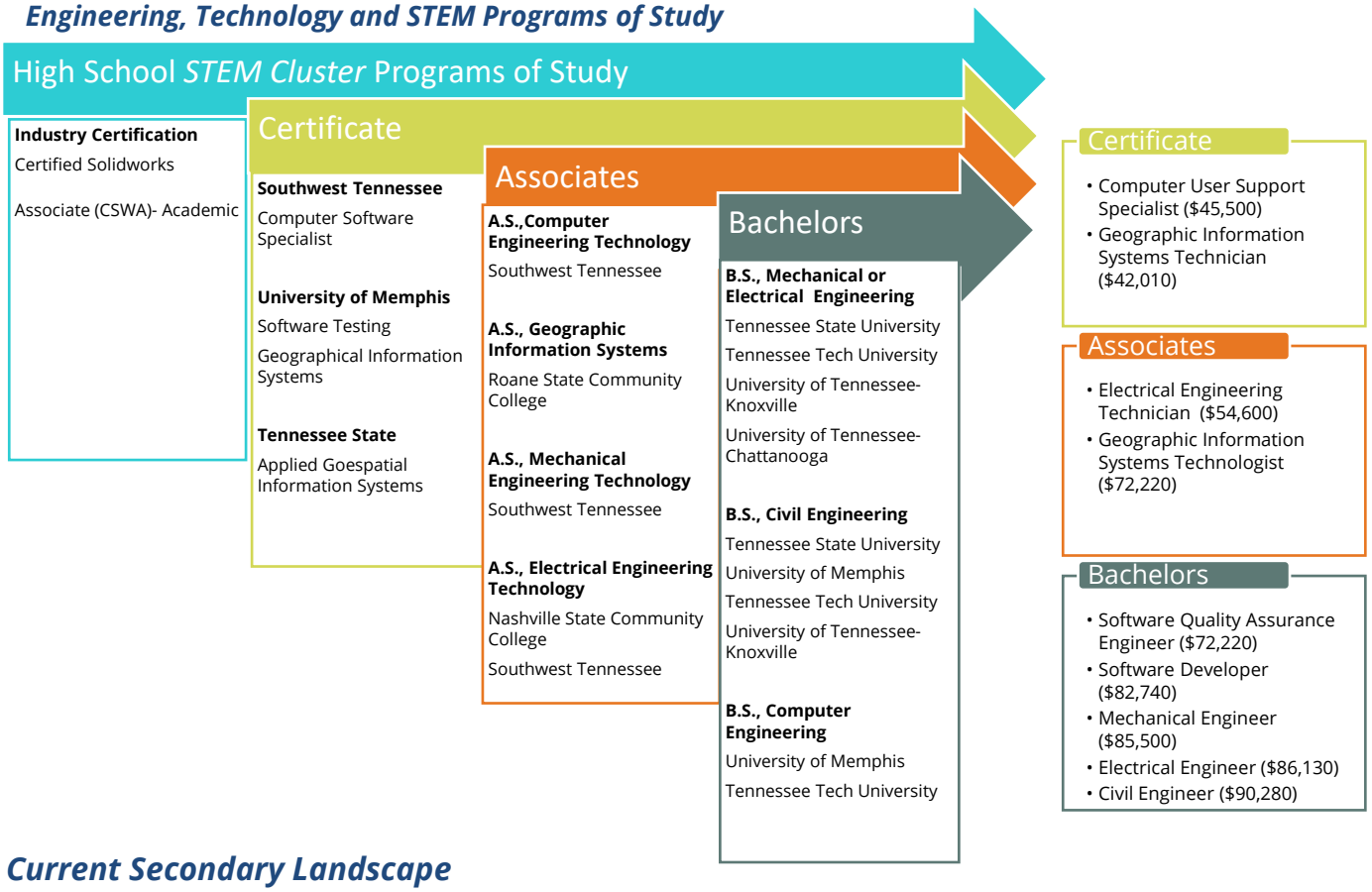
Upon completion of these programs of study, students will be better prepared to enter the STEM workforce or to further their training at postsecondary institutions. The chart below outlines the related career opportunities and the training necessary for engineering and technology. A high school diploma is entry level expectation for many occupations, but postsecondary education is necessary for many. **Figure 4** below from the Jobs4Tn.gove publication, *The Demand for STEM Jobs in Tennessee*, most require a postsecondary degree.[17] This is due to the high amount of math, science and technical skill needed for these positions.

Figure 4. 2014 STEM Occupations with the Fastest Employment Growth in Tennessee

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

[17] Jobs4Tn.gov. The *Demand for STEM Occupations in Tennessee*. Online at: https://www.jobs4tn.gov/admin/gsipub/htmlarea/uploads/STEMReport.pdf. (Visited on May 19, 2017)

Figure 5. Postsecondary Pathways[18]



Current Secondary Landscape

In the 2016-2017 school year, 118 schools in Tennessee responded to the demand to grow local talent in emerging STEM fields and instituted special programs of study in the STEM cluster. District data from SY 17-18 suggest that 104 schools will implement a STEM program of study at the beginning of the SY.[19] These figures demonstrate that there is an appetite among schools—and students—to explore STEM at the high school level, which bodes well for the growing number of postsecondary institutions to offer STEM-related programs.

Figure 6. Open Enrollment Analysis[20]

	Engineering
2014-15	20
2015-16	18
2016-17	32
2017-18	34

[18] Tennessee Department of Labor and Workforce Development, Job4TN Online. (2017). *Occupational Employment and Wages.* Retrieved from https://www.jobs4tn.gov/vosnet/analyzer/results.aspx?session=occproj

[19] Tennessee Department of Education. (2017). Student Enrollment Data. Retrieved from Author's calculation of student enrollment data.

[20] Tennessee Department of Education. (2017). Student Enrollment Data. Retrieved from Author's calculation of student enrollment data.

	Technology
2014-15	16
2015-16	17
2016-17	28
2017-18	22

	STEM Education
2014-15	13
2015-16	28
2016-17	58
2017-18	48

Student Enrollment[21]

Engineering POS

SY	Principles of Engineering and Technology	Engineering Design I	Engineering Design II	Engineering Practicum
2013-14	367	0	0	0
2014-15	1287	130	48	0
2015-16	1840	459	143	99

Technology POS

SY	Principles of Engineering and Technology	Digital Electronics	Robotics & Automated Systems	Engineering Practicum
2013-14	367	33	0	0
2014-15	1287	140	293	0
2015-16	1840	437	349	99

[21] Tennessee Department of Education. (2017). *Student Enrollment Data*. Retrieved from Author's calculation of student enrollment data.

STEM Education POS

SY	STEM I	STEM II	STEM III	STEM IV
2013-14	0	0	0	0
2014-15	586	217	97	0
2015-16	1101	444	162	48

STEM Concentrators[22]

Engineering

	Engineering
2013-14	0
2014-15	56
2015-16	129

Technology

	Technology
2013-14	0
2014-15	52
2015-16	82

STEM Education

	STEM Education
2013-14	0
2014-15	9
2015-16	81

Recommendation

Through advisory council meetings and discussions with industry and postsecondary partners, it is the recommendation to add more Advanced Placement courses to the Level 4 course options in the STEM Education pathway. These additional AP courses will be appropriately aligned and course sequences will be given. It was also recommended that the STEM Education POS changes its name to Applied STEM to help eliminate the misconception that this POS focuses on teacher prep for STEM instead of STEM applications. Recommendations were given to promote the Autodesk Inventor certification. It is well recognized by industry and postsecondary. These recommendations will add rigor and relevancy to the established courses already in place.

[22] Tennessee Department of Education. (2017). Student Enrollment Data. Retrieved from Author's calculation of student enrollment data.

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Engineering, Technology, and STEM Education

2018-19 POS	Level 1	Level 2	Level 3	Level 4
Engineering	Principles of Engineering and Technology (5924)	Engineering Design I (6139) **AP Computer Science Principles**	Engineering Design II (6140) -or- **Dual Enrollment** Engineering (4124) -or-	Engineering Practicum (6141) -or- **Dual Enrollment** Engineering (4124) -or- AP Physics (3238, 3239, 3234, or 3240) -or-
		Industry Certifications: Certified Solidworks Associate (CSWA)- Academic **Autodesk Inventor**		
Technology	Principles of Engineering and Technology (5924)	Digital Electronics (5925) **AP Computer Science Principles**	Robotics & Automated Systems (6143) -or- **Dual Enrollment** Technology (4125) **Industry Certification:** **Fanuc Certification**	Engineering Practicum (6141) -or- AP Physics (3238, 3239, 3234, or 3240) -or- **Dual Enrollment** Technology (4125) -or- **AP Computer Science A**
		Industry Certifications: Certified Solidworks Associate (CSWA)- Academic **Autodesk Inventor**		
STEM Education **Advanced STEM Applications**	STEM I: Foundation (6144)	STEM II: Applications (6145) **AP Computer Science Principles**	STEM III: STEM in Context (6146) -or- **Dual Enrollment** STEM Education (4126)	STEM IV: STEM Practicum (6147) -or- **Dual Enrollment** STEM Education (4126) -or- **AP Calculus, AP Biology, AP Computer Science A**
		Industry Certifications: Certified Solidworks Associate (CSWA)- Academic **Autodesk Inventor**		

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Career One Stop. (2017). *Occupation Profile, State and National Trends. Retrieved from*https://www.onetonline.org/link/summary/17-2141.00

Career One Stop. (2017). *Occupation Profile, State and National Trends. Retrieved from* https://www.onetonline.org/link/summary/15-1199.04

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Tennessee Department of Labor and Workforce Development, Job4TN Online. (2017). *Occupational Employment and Wage Rates (OES)*. Retrieved from https://www.jobs4tn.gov/vosnet/analyzer/results.aspx?session=