



Massachusetts Department of Higher Education

Technology Talent Initiative *Workforce Plan**

Spring 2014



*Accepted by the Board of Higher Education under the title, "Technology Workforce Analysis."

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Executive Summary

Framework and Context

The Department of Higher Education's (DHE) *Vision Project* addresses the need to align education and training programs offered by the state's 29 public higher education institutions to meet the workforce requirements of Massachusetts' leading innovation and economic sectors: Health Care, Technology, Life Sciences and Advanced Manufacturing. These sectors are each experiencing significant growth and shifts due to rapidly changing market forces. Professionals in these fields, whether incumbent employees or new workers, will be required to maintain a portfolio of unique knowledge, skills and abilities that are up-to-date and relevant to the demands of their industries. As such, Massachusetts' public higher education institutions must be at the center of the effort to strengthen the pipeline of students pursuing these fields. The Commissioner of Higher Education and the DHE are committed to strategic, long-term planning to support the commonwealth's public campuses. This work is imperative to ensure the health of our Massachusetts economy and the prosperity of its citizens.

Workforce development planning in this context requires continuing collaboration among employers, industry representatives, academic leaders and government officials. Employers are best able to articulate required job competencies and near term employment demand. Industry representatives' project broader and longer-term market trends and can identify transformative forces affecting the marketplace. Academic leaders coordinate the assets of education to address the needs of an ever-changing pipeline of students. And government officials establish budgets and set public policy to allocate state resources.

The Department of Higher Education has therefore embarked on a new process to develop and maintain sector-specific workforce plans in collaboration with educators, employers, industry leaders and other government partners. The first example of such a workforce plan, issued by the DHE in October of 2012, addressed the health care sector with a focus on nursing as the largest occupation group. Now in implementation, the Health Care Workforce Plan prompted development of a system wide 2-year to 4-year transfer agreement: the Nursing Education Transfer Compact (NETC), which resulted in Massachusetts' selection as one of nine states to participate in the national Academic Progression in Nursing (APIN) grant program. Through the development of the nursing workforce plan, the DHE has also engaged campus leaders in curriculum alignment and capacity enhancement initiatives for nursing education pathways and is now addressing the looming faculty shortages.

Using these successful efforts as a model, we now turn our attention to the workforce needs of technology companies and employers of information technology professionals.

Technology Workforce

The following analysis illustrates why it is critical that the technology workforce be the focus of statewide prioritization. Massachusetts is regarded globally as a leading center of technology innovation,¹ a role long defined by its concentration of universities,

¹ Massachusetts Technology Collaborative, John Adams Innovation Institute. 2013. Index of the Massachusetts Innovation Economy.

research institutions, entrepreneurial startups, technology companies and professional service firms. The pool of exceptional talent in Massachusetts has driven the success of these internationally recognized organizations and is chief reason competitive technology companies enter and remain in Massachusetts. To maintain this competitive position and support the expansion of opportunities, Massachusetts must address the fluid and expanding demand for a knowledgeable and skilled workforce.

Despite the historic concentration of our talent pool, both employment data and anecdotal feedback from employers show that demand for a workforce skilled in contemporary and cutting-edge technology is growing, but not met by supply. Talent shortages are evident through persistent job vacancies, a situation that is projected to worsen over time. This report is an analysis of the economic, workforce and educational landscape impacting the technology talent pool.

By way of summary, this report demonstrates that there is a critical gap between the number of degrees granted in Computer Science and Information Technology at our public institutions and the current and projected growth in jobs requiring those credentials. Data suggest that, in the aggregate, degree granting in these fields should double to fill the gap in qualified talent.

As a result of these findings, the Department of Higher Education plans to launch a technology talent initiative* to convene leaders from across higher education institutions with employer representatives and industry sector representatives to: (1) assess the scope and scale of the technology talent gap, (2) qualify the need for curriculum and program alignment to address unique student needs while accelerating their progress and rate of successful completion, and (3) build sustainable capacity for the future. This effort will build on prior collaborative work and will leverage key ongoing statewide projects.

This technology workforce planning initiative will address the following critical areas:

- Curriculum alignment/enhancement to address contemporary technology and application environments
- Connections to broad policy efforts focused on STEM (Science, Technology, Engineering and Mathematics) education from kindergarten through higher education.
- Development of a diverse pipeline of students, particularly African-Americans, Latinos and women, interested in studying and pursuing computing and IT careers.
- Ongoing labor market analysis to support plans for building capacity in IT/CS programs, including “middle skill” jobs
- Best practices for supporting adult and traditional students and especially, more diverse populations
- Seamless and accelerated transfer from community colleges to 4-year institutions
- Current and projected faculty shortages

Report Summary

Section I: Offers descriptions of differing employers and occupational fields that make up the broad technology workforce. The job categories to be covered by this work include those connected with both technology companies (those developing new technologies) as well as information technology (IT) employment which exists within all industries. This section also details the academic disciplines and degree programs linked with the job categories described. We will also explore the extent to which changing technology trends are creating new job categories and a need for new degree programs.

Section II: Addresses national and state employer perspectives on demand for prospective employees educated in computing and information technology fields, and explores current data and workforce projections. Further, this discussion will include a comparison of degree production in relevant disciplines at Massachusetts' public institutions.

Section III: Highlights specific areas of workforce demand that correspond to both 2-year and 4-year programs.

Section IV: Spotlights some critical connecting issues, including those related to efforts to build the STEM pipeline, the importance of focusing on diversity in CS and IT fields, and the importance of encouraging interest in computing and technology fields among students in grades K-12.

Section V: Describes previous and current collaborative efforts in Massachusetts which will be complemented by and integrated with the work described here.

Section VI: Presents an initial framework for continued statewide technology workforce alignment efforts as facilitated by the Department of Higher Education.

I. Technology: Education and Workforce Landscape

The Technology Workforce is broad and complex, and includes workers employed by tech companies, as well as information technology departments that exist in nearly all companies across the spectrum of industries. Unlike the Healthcare sector (specifically the nursing workforce), the professionals in the technology workforce are largely unregulated. Technology jobs vary widely in scope and definition, and new occupations frequently emerge. It is important to frame this workforce to differentiate areas of job growth and demand for corresponding degree programs.

Technology professionals are, in broad terms, employed in two distinct contexts:

Computer Scientists: most often employed by technology (“tech”) companies to create the next generations of innovative products and services for business and consumer markets, (Google, Cisco, etc).

IT professionals: employed in both technology companies and nearly every other sector of the economy. These workers plan, design, build and support technology systems that enhance operational effectiveness and increase enterprise competitiveness.

Computer Scientists

Computer Scientists are most often employed by technology companies--home to creators and inventors. These professionals are responsible for new software, applications, methods of analyzing data, and innovative ways to conduct business and utilize technology. These employers require a workforce able to support high-level product development, website architecture management, software engineering, business analysis and support services related to the creation, development, marketing, production and sale of technological tools.

The Association of Computing Machinery (ACM) defines the work of computer science graduates:

The work of computer scientists falls into three categories: a) designing and building software; b) developing effective ways to solve computing problems, such as storing information in databases, sending data over networks or providing new approaches to security problems; and c) devising new and better ways of using computers and addressing particular challenges in areas such as robotics, computer vision, or digital forensics. . .²

Tech companies also hire professionals with degrees in software engineering, which is sometimes its own degree program, and sometimes a concentration within a computer science major. Software engineers generally design, develop and implement software solutions, often in a large scale context, such as defense, financial services or healthcare. Some tech companies also require employees with degrees in computer engineering, which is more focused on the design of hardware and software systems using/containing computers such as cell phones, surgical tools, digital audio devices, and automobile computer systems.

² Association for Computing Machinery, www.computingcareers.org

Information Technology (IT) Workforce

Information Technology is everywhere. IT professionals work in financial services, insurance, clean energy, retail, health care, utilities and more. These workers are essential to the implementation and support of the technological infrastructure that ensures the competitive operation of nearly every kind of employer. IT professionals are needed in areas like networking, database administration and management, records management, cyber security, data analytics, and client/desktop support.

Given the large numbers of IT roles and varied demands of companies needing IT talent, there are often many differing education pathways to IT jobs, including 2-year and 4-year degrees in information technology, industry training and certification, and on the job experience. IT professionals use a great deal of system specific knowledge in addition to conceptual foundations. In addition to degrees, some roles require industry-specific credentials, such as the Cisco Certified Network Administration and credentials issued by industry associations such as the CompTIA A+, Security+ or Linux+ certificate. IT professionals are defined by their knowledge of IT systems, however many IT professional roles are translational—focusing on helping non-IT professionals meet business objectives.

High-level IT management requires a skilled blend of technological skill sets and an understanding of how technology could be deployed to better achieve company goals. IT management professionals, such as Chief Information Officers (CIOs) are often educated in information systems (IS) degree programs. Most often an information systems program is located in a business department or business school and is focused on the use of information and computing technology within that context. Graduates of these programs understand how information systems can support a company, know how to improve processes using information technology, and are able to use technology to impact company performance. The chart below details the occupations in each of these broad categories.

Computer Science and Information Technology Occupations, Massachusetts

| <i>Standard Occupation Title (SOC)</i> | <i>Number Employed</i> | <i>Median Pay</i> | <i>Entry Pay 25th Percentile</i> |
|---|------------------------|-------------------|---|
| Computer Science and Management | | | |
| <i>Computer and Information Systems Managers</i> | 15,890 | 130,890 | 91,240 |
| <i>Software Developers, Systems Software</i> | 29,220 | 109,000 | 75,390 |
| <i>Computer and Information Research Scientists</i> | 860 | 106,770 | 69,100 |
| <i>Software Developers, Applications</i> | 26,720 | 96,680 | 69,650 |
| <i>Computer Science Teachers, Postsecondary</i> | 800 | 94,940 | 58,630 |
| <i>Computer Programmers</i> | 8,040 | 76,220 | 52,750 |
| Information Technology | | | |
| <i>Computer Network Architects</i> | 4,800 | 106,740 | 73,090 |
| <i>Information Security Analysts</i> | 2,600 | 89,000 | 57,720 |
| <i>Computer Occupations, All Other</i> | 3,530 | 88,630 | 61,220 |
| <i>Computer Systems Analysts</i> | 16,060 | 84,230 | 59,250 |
| <i>Database Administrators</i> | 4,420 | 80,680 | 54,080 |
| <i>Network and Computer Systems Administrators</i> | 9,940 | 79,400 | 56,470 |
| <i>Web Developers</i> | 4,640 | 73,250 | 43,730 |
| <i>Computer Network Support Specialists</i> | 5,040 | 68,770 | 46,760 |
| <i>Multimedia Artists and Animators</i> | 590 | 62,460 | 41,850 |
| <i>Computer User Support Specialists</i> | 17,500 | 56,580 | 38,680 |
| Total all occupations | 3,202,080 | 43,420 | 23,620 |

Source: BLS. 2012 Occupational Employment Statistics. Massachusetts.

Emerging Occupational Fields and Degrees

Emerging technologies have created demand for new functions within traditional organizations and a corresponding demand for new IT/Tech education programs. For example, recent technological advancements have enabled greater quantities of data to be generated by smart phones, laptops, GPS devices and social media applications. This increased data collection, or “Big Data,” has dramatically changed the way many companies conduct business by demanding much greater capacity for development of technology for analysis and the expertise of people to analyze it.

Other emerging technologies have also given rise to related interdisciplinary fields, including:

- Health Informatics: Managing computing and information systems in health care
- Gaming and animation: A combination of programming and creative design applied to entertainment and also education and training systems
- Bioinformatics: A discipline at the intersection of biochemistry, biology, and computer science.

Interdisciplinary Impacts of Technology on Traditional Occupations and Education Programs

The shifting technology environment has also impacted fields not traditionally requiring education or training in computing or information technology. The health care sector provides an example of this important transition. Health care providers are now much more effectively and broadly using technology to manage all aspects of patient care and the management of health care data and patient records. Health care workers at all levels of the care continuum must possess much greater facility in the use of technology, even in jobs that previously never required any technology skills.

These shifts in technology used across occupational roles have necessitated the integration of computing and information technology into degree programs where such courses traditionally weren't required. The need for greater digital literacy across disciplines has been widely recognized and also suggests a need to consider the way this increased demand will further challenge the capacity of computer science and IT departments.

II. Technology Talent Requirements: The Skills Demand and Supply Gap

Technology itself is at once both rapidly evolving and increasingly pervasive in the workplace and at home. In the past several years, this has meant dramatic change for every kind of enterprise: corporations, non-profits, and all levels of government. It also means that, because of the swift growth in this sector, there are many more technology jobs than there are qualified candidates to fill them.

Employer Perspectives

Technology and IT leaders are starting to voice a collective concern about the projection of a significant workforce gap between the growth expectations for large, small and emerging companies and the amount of qualified candidates entering the workforce. Acknowledgement of this gap is reinforced by employers both nationally and here in Massachusetts.

Microsoft is one of the companies at the center of this conversation. In their recent report, “A National Talent Strategy: Ideas for Securing U.S. Competitiveness and Economic Growth,” Microsoft expressed that “[t]here is an urgent demand for workers trained in the STEM fields, yet there are not enough people with the necessary skills to meet that demand and help drive innovation.” Microsoft has urged support of public colleges and universities and called for an increased capacity in higher education to graduate more students with STEM degrees, particularly with a focus on computer science.³

In their “State of the IT Skills Gap” report, CompTIA surveyed over 1,000 IT and business managers globally. The results showed that 82% of managers consider IT important or very important to their business objectives, compared with 79% in 2010.⁴ However, 93% of managers felt that there is an overall skills gap among their IT staff.⁵ These findings reinforce the importance of increasing the number of new graduates from IT programs, and highlight a critical need to ensure sufficient educational resources for incumbent workers.

Massachusetts industry leaders echo these national concerns. Recently, the Department of Higher Education (DHE) collaborated with the Massachusetts Technology Leadership Council (MTLC) to produce a report entitled, “The Truth Behind the Talent Crisis.” MTLC surveyed its membership and held three roundtable discussions with CEOs, hiring managers, and recruiting directors of large, midsize, and small tech companies. All of these leaders indicated a challenge in attracting sufficient numbers of qualified candidates in technology roles. In each group, difficulty finding the employees necessary to meet the demands of Massachusetts tech companies was consistently in the top 3 critical areas of their business.⁶ Specifically, 36% of top C-level company leaders reported that challenges with talent acquisition and retention was the top barrier to company growth, and 76% of those leaders reported that talent challenges were among the top three barriers to company growth.⁷ Concerns were greater among front line talent directors seeking viable candidates to fill company demands. 45% reported that the difficulty finding and retaining talent was the number 1 barrier to company growth, and 81% named it within the top three barriers.⁸

Critical shortages are also affecting the Commonwealth of Massachusetts itself as an employer, where IT departments in all state government agencies are anticipating a significant number of retirements over the next several years. Given the rapid changes over time in information technologies, state agencies will need to plan for an incoming

³ Microsoft Corporation. A National Talent Strategy: Ideas for Securing U.S. Competitiveness and Economic Growth. 2013.

⁴ CompTIA, State of the IT Skills Gap. February 2012. p. 3

⁵ Id., p. 8

⁶ Massachusetts Technology Leadership Council, The Truth Behind the Talent Crisis, 2014.

⁷ Id.

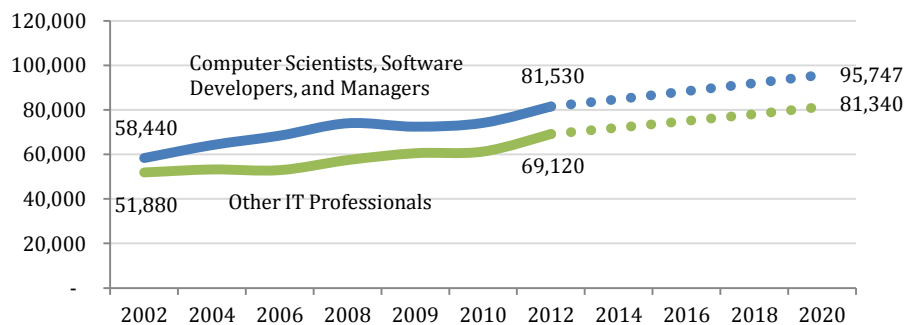
⁸ Id.

workforce with a very different skill set. Currently, nearly 60% of the Commonwealth's IT staff is over 50, and fewer than 2% of employees are under the age of 30. Ensuring a trained workforce to meet the objectives of government agencies is considered a critical path issue. As a result, Governor Patrick's Workforce Planning Initiative, launched by the Human Resources Division, is focused on IT departments within the state agencies.

Technology and the Massachusetts Economy: Talent Demand

The talent gap described by employers is validated by a variety of labor market data, including job growth, compensation, and employment rates. In Massachusetts, people in computer science and IT occupations now number 150,650.⁹ Demand for CS and IT professionals has risen at a pace far outstripping that of the broader economy. According to the U.S. Department of Labor, from 2002 and 2012, information and computing technology jobs grew nationally by 36%, while total jobs grew only 2%.¹⁰ In Massachusetts, information and computing technology jobs grew even faster at 40%, (see chart below) while total employment grew less than 1%. Many tech sector leaders in Massachusetts believe that even more jobs could have been added in the state and have called for the creation of 100,000 additional technology jobs between 2010 and 2020.¹¹ The BLS conservatively projects 31% growth in information and computer technology jobs from 2010 through 2020.

Massachusetts technology workforce employment, 2002-2020



Source: Bureau of Labor Statistics. Occupational Employment Statistics various years and 2014-2020 Occupational Employment Projections.

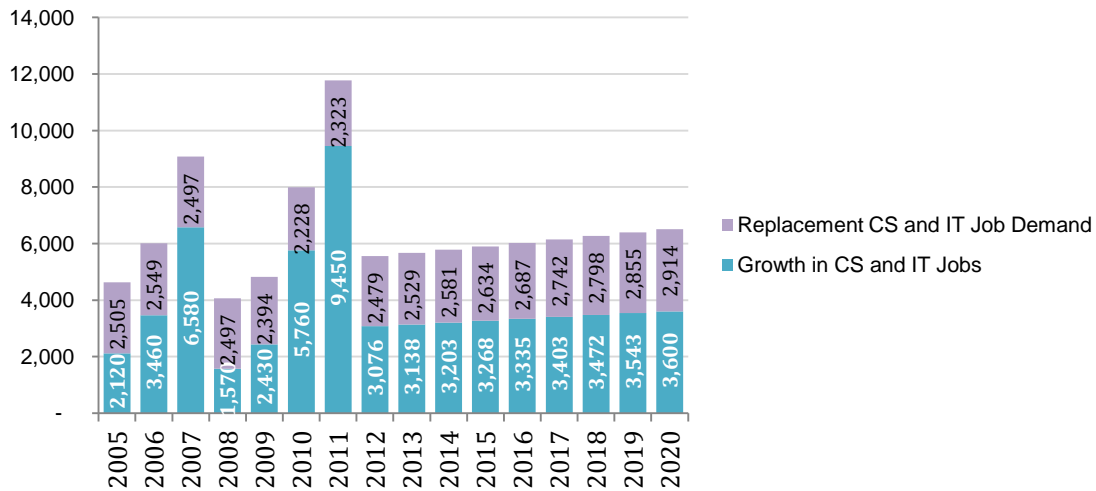
Because of the cyclical impact of economic forces, the average need for new computer science and IT professionals may not reflect annual peaks in demand. As demonstrated in the chart below, each year an average of 6,600 additional people become employed as computer science or information technology professionals in Massachusetts. However, the number of people entering employment as CS and IT professionals in Massachusetts ranged from 4,000 in 2008 to almost 12,000 in 2011. This volatility in hiring will be a challenge to address with higher education program capacity, and the peaks of hiring in 2007, 2010 and 2011 suggest that the projected averages growth may be well underestimated.

⁹ U.S. Department of Labor. Bureau of Labor Statistics. 2013. Occupational Employment Statistics.

¹⁰ U.S. Department of Labor. Bureau of Labor Statistics 2002 and 2012. Occupational Employment Statistics.

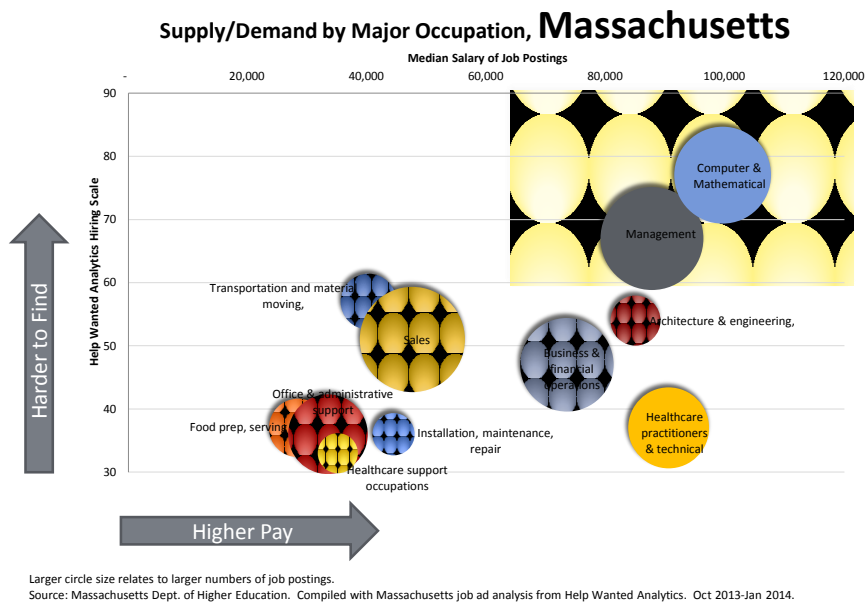
¹¹ Massachusetts Technology Leadership Council. MassTLC 2020 Jobs Growth Challenge, www.masstlc.org/?2020challenge

Annual Need for New Computer Science and Information Technology Professionals, Massachusetts¹²



These professions are also highly valued in our economy, a reflection of imbalance between supply and demand. The following chart indicates that computer and mathematical occupations represent the highest paying jobs in Massachusetts and are the most difficult to fill.¹³ As an additional indicator of high demand in technology fields, unemployment rates in technology occupations are much lower than in the economy as a whole, with 4% unemployment from 2006-2010, juxtaposed with 7% in the economy as a whole.¹⁴

SUPPLY VS. DEMAND DATA FROM ONLINE JOB ADS



¹² Source: Massachusetts EO Labor and Workforce Development. Occupational Employment Statistics and Projections.

¹³ Massachusetts Dept. of Higher Education. Compiled with Massachusetts job ad analysis from Help Wanted Analytics. Oct 2013-Jan 2014.

¹⁴ 5-year ACS data 2006-2010. EEO-ALL14. Massachusetts

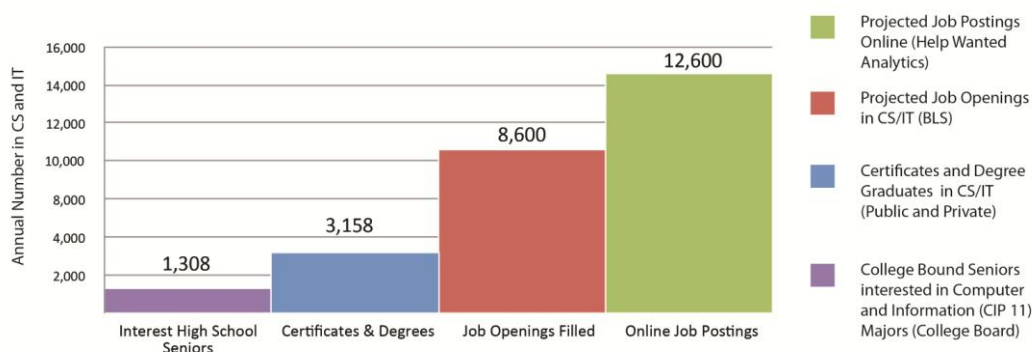
Technology and the Massachusetts Economy: Talent Supply

Looking at these job growth requirements as compared to degree production in computer science and information technology fields shows a significant and growing gap. In 2012, there were 4,020 new jobs filled and 2,425 replacement jobs filled (as a result of people leaving the occupation or retiring).¹⁵ These figures do not include job mobility within an occupation—individuals moving from one IT position to another. In the same year, employers posted 12,000 unique job ads for Massachusetts IT positions online – twice the number filled.¹⁶

Even using conservative estimates, the number of jobs available in computing and technology fields far exceeds the number of available workers with the requisite education and skills to meet growing demand.¹⁷ In 2012, 150,650 people, or 5% percent of people employed in Massachusetts worked in an IT occupation.¹⁸ According to Help Wanted Analytics, a company that aggregates online job postings, 15% of college workforce jobs in Massachusetts are in IT professions while only 4% of degrees and certificates granted in Massachusetts are in fields aligned with IT and computer careers.¹⁹

Meanwhile, Massachusetts public and private higher education institutions only granted 3,158 degrees in computer science or information technology fields. Using any measure of data, comparing degree production in our (public and private) higher education institutions is far lower than workforce demand. Massachusetts reflects national trends, with about 47% of projected job openings that require computer science or IT degrees capable of being filled by the number of degrees granted in the state.²⁰ **This would suggest that in order to meet projected demand, we would, on average, need to graduate at least twice the current number of graduates in computing or technology programs.** The following graph illustrates this supply/demand mismatch.

Massachusetts Technology Workforce Supply/Demand Mismatch



Sources: College Board, Massachusetts Department of Higher Education, BLS, and Help Wanted Analytics.

¹⁵ Calculations by the Massachusetts Department of Higher Education based on BLS 2010-2020 Occupational Projections and 2012 Occupational Employment Statistics for Massachusetts.

¹⁶ Help Wanted Analytics. 2013.

¹⁷ Analysis by the Massachusetts Department of Higher Education using data from Help Wanted Analytics using College Labor Market definition from Andrew Sum and Ishwar Khatiwada, Center for Labor Market Studies, Northeastern University.

¹⁸ Bureau of Labor Statistics. Occupational Employment Statistics.

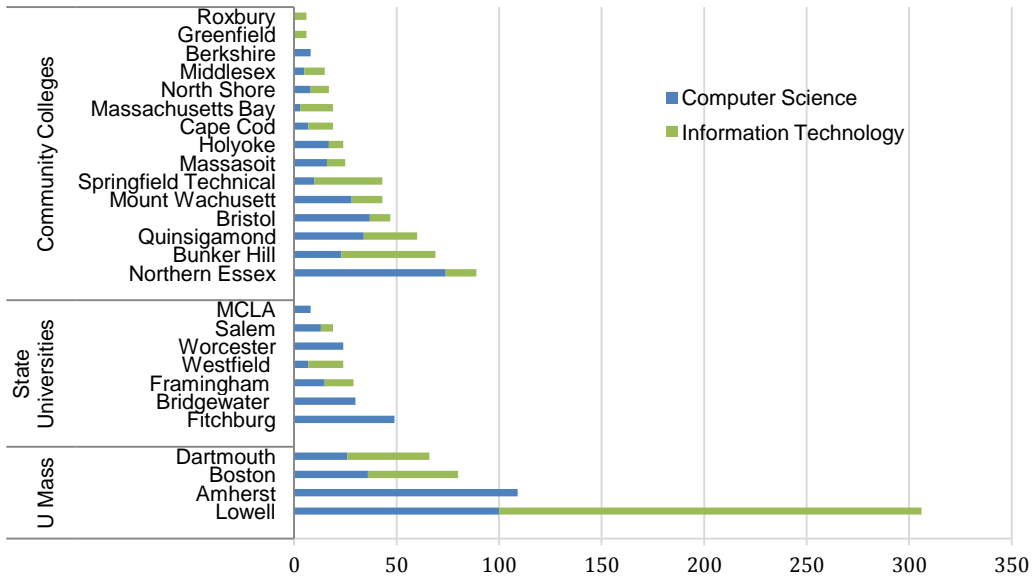
¹⁹ National Center for Education Statistics. IPEDS completion survey.

²⁰ Id.

III. The Opportunity for Public Higher Education

Massachusetts currently benefits from a wealth of well respected computer science and IT programs on our public campuses. These programs have produced graduates who are now high-level contributors in the technology workforce. The chart below demonstrates the distribution of degrees and certificates in computer science and/or information technology awarded in 2012.

Degrees and Certificates in CS/IT Awarded by Massachusetts Public Colleges and Universities, 2012

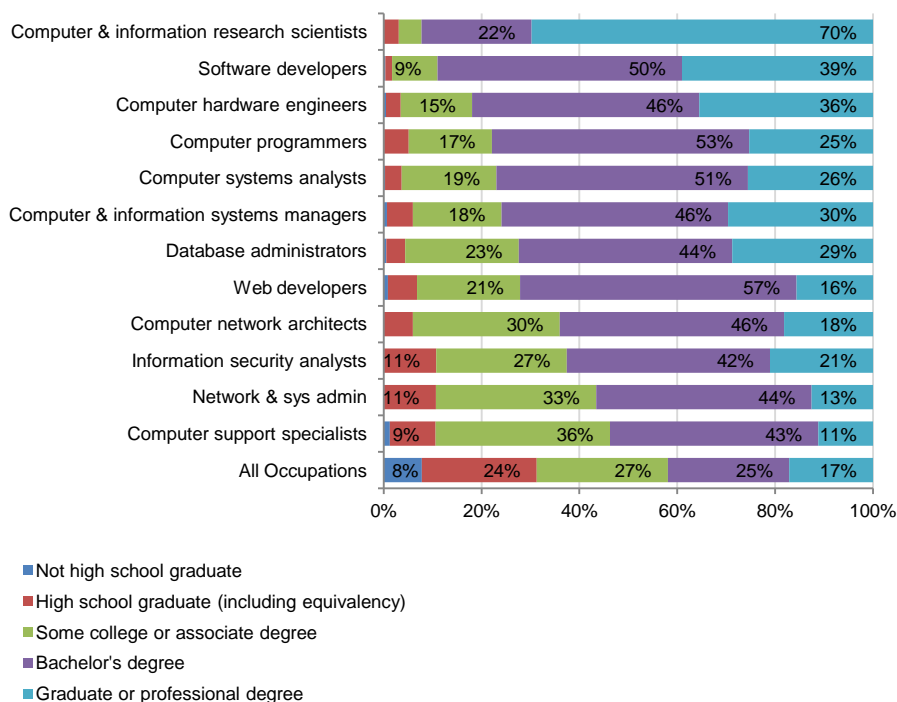


Source: IPEDS.

However, it is clear from the data above that we must expand our pipeline of graduates in CS and IT fields. This technology workforce planning initiative is intended to build on our current resources to support campus degree and certificate programs in computer science and information technology. This initiative will strive to find ways to further build these programs and understand how to ensure alignment with workforce trends on regional, state and national levels. Since technology is such a diverse field, there are many career pathways across the spectrum of degree attainment and as aligned with specific industry growth. Massachusetts public higher education institutions offer certificate programs, 2-year associate degree programs, 2-year transfer programs to 4-year programs, 4-year degrees, masters, and PhD programs.

The following chart demonstrates the range of employment opportunities as demonstrated by educational attainment of the current workforce.

Educational Attainment of the Technology Workforce²¹



Source: U.S. Department of Commerce. American Community Survey. Massachusetts.

Research conducted by the Georgetown Center on Education and the Workforce has helped illuminate the projected job opportunities distributed across educational attainment. Their analysis indicates that in the aggregate in Massachusetts, 24% of projected total jobs in computers and mathematical sciences will be filled by those with a 2-year associate's degree or less.²² Remarkably, 65% of that number will require less than a 2-year degree, with the majority requiring some college/certificate program.²³ Of the jobs requiring at least a bachelor's degree, 51.6% will require a bachelor's alone and 34.1% will require at least a master's degree.²⁴

It is clear that our efforts to meet the pipeline demand focus across all campuses. While evidence suggests that employers could meet more of their needs with those educated in 2-year programs than they might realize, the data still suggest that many of the critical talent shortfalls exist in fields that require a 4-year degree, particularly in computer science. This highlights the importance of all Massachusetts public campus segments, including 2-year transfer programs at our community colleges, 4-year degree programs at our state universities and UMass, and masters and PhD programs at UMass. In the following section, we'll explore some of these opportunities in turn.

²¹ Source: U.S. Dept. of Commerce. American Community Survey. 2006-2010 5 Year Average.

²² Georgetown Public Policy Institute Center on Education and the Workforce, *Recovery: Job Growth and Education Requirements through 2020*, State Report, Massachusetts, June 2013, p. 53.

²³ *Id.*

²⁴ *Id.*

Opportunity for Community Colleges/“Middle Skills”

Data suggest that there are job opportunities in several critical IT occupations that require some higher education, but less than a four-year degree, or what are known as “middle skill” jobs. BATEC (Broadening Advanced Technological Education Connections) has done critically important work in Massachusetts analyzing opportunities for jobs that require higher education but less than a four-year degree. In a recent report entitled, “Sizing the Middle-Skill Employment Gap,” BATEC explored job growth in specific information technology fields focusing on four metropolitan regions, including the Boston metro area. The BATEC report reviewed the gap in data, information and computing. Specifically, the report shared that, “using modeled economic data, we sized the employment opportunity available for skilled community college graduates. The data suggests that there are specific opportunities on both a national and regional level for job seekers to obtain middle-skill entry points into IT careers.”

The report specifically studied the following occupations:

- Computer Systems Analysts
- Medical Records and Health Information Technicians
- Web Developers
- Big Data Cluster

While many of the jobs in these occupations do require a four-year degree, categories were analyzed precisely because a significant percentage of the job opportunities in these fields can be successfully filled by a person with some higher education but less than a four-year degree. The most interesting of BATEC’s findings observed that demand for Computer Systems Analysts, Web Developers, and each of the three occupations in the Big Data Cluster is outpacing the rate of education in these fields. In particular, BATEC’s analysis suggests that the projected growth for middle skill workers is significantly underserved in the Boston Metro region.

Using the Burning Glass real time labor market analysis tool, Complete College America also recently shared data analysis related to Massachusetts participation in the Guided Pathways to Success initiative. In doing so, they highlighted important opportunities in IT job categories most often associated with degree attainment of less than a four-year degree:

- Computer Support Specialist
- Network Systems Analyst
- Network/Systems Support Specialist

Among IT managers nationally, the top priority in 2012 was cyber-security, along with data storage, network infrastructure, and mobility.²⁵

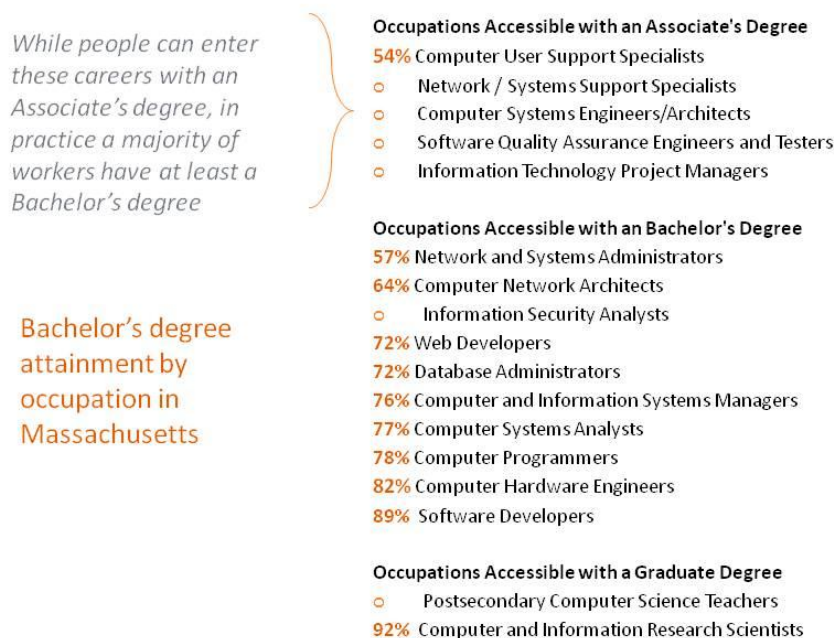
Demand for Four-Year degrees

Although it is clear that there are significant opportunities for those graduating from 2-year programs, the majority of jobs in technology fields will strongly prefer four-year degrees. The chart below illustrates the percent of CS and IT professionals who have at least a bachelor’s degree for high growth occupations, reflecting the value this

²⁵ CompTIA, State of the IT Skills Gap. February 2012. p. 5

marketplace places on four-year degrees. Job ads for CS and IT positions frequently emphasize high-level cognitive skills, not just familiarity with specific software or systems. Employers emphasize critical thinking, communication, teamwork, and problem solving skills, closely paralleling the essential learning outcomes of higher education.²⁶ Four year programs have more time to develop depth and breadth of technical and interdisciplinary knowledge. The most relevant higher education programs are Computer Science, Information Technology, Information Systems (Business School), Software Engineering (Engineering), and also Digital Design (Art). Degrees in Math, Physics, and Engineering also develop foundational skills, computer programming, and facility with sophisticated software tools that are highly transferable to CS and IT careers.

Computer Science and IT Jobs by Education Requirements



Source: U.S. Department of Commerce. American Community Survey. Educational Attainment by Detailed Occupation.

While it is critical to educate employers around the ways that our 2-year programs are producing graduates with the skill sets to meet their needs, the data still demonstrates that a large portion of the workforce need is for candidates with at least a four-year degree. National data reinforces this assertion as well. Georgetown's Center on Education and Workforce recently released national data showing that "[t]wo-thirds of STEM job ads require a BA and 11 percent require an advanced degree. Roughly three out of four STEM online job ads are for IT occupations."²⁷ Aggregating these two data points, it's clear that the larger share of demand within the technology workforce is for those with a 4-year

²⁶ Association of American Colleges and Universities. LEAP. Essential Learning Outcomes.

²⁷ Georgetown University Center on Education and the Workforce. The Online College Labor Market. April 2014.

degree. Georgetown's data also showed that software developers are the most in demand occupation for those with a Bachelor's degree.

Ultimately, it will be imperative that future work continue to deepen the way we understand specific workforce demand. Starting with labor market data, we are looking at a broad range of academic programs that prepare students for careers in computer science or information technology professions, and will continue to analyze more deeply any way that industry shifts may (or may not) impact program delivery.

IV. Complementary Topics

STEM Demand

In 2012, DHE's Vision Project showed a significant gap between projected degree production and degrees needed in STEM fields. This was represented by a 54% gap through 2018 in Bachelor's degrees in STEM fields, and a 27% gap through 2018 in Associate's Degrees.²⁸

In June of 2013, the Georgetown University Public Policy Institute Center on Education and the Workforce published a critical study of the link between economic viability and educational attainment, titled, "Recovery: Job Growth and Education Requirements through 2020." The findings in the report reflect nationally the issues highlighted by the Vision Project at a state level in Massachusetts. The Georgetown report broke down their research into specific fields, allowing analysis of computer science and IT occupations within the broader STEM context. Their findings show that, of STEM fields, computer and mathematical sciences occupations (and consequently degree holders in those fields) represent the highest workforce demand.

STEM and healthcare occupations continue to be the broad fields with the fastest job growth matched with wage growth. In Massachusetts, STEM occupations are showing a 23% growth rate to 2020, with computers and mathematical sciences comprising half of all jobs requiring STEM training. In other words, new jobs in computing/technology fields will outnumber those in architecture, engineering, life sciences and physical sciences combined.

These statistics reflect the priorities of the Governor's STEM Advisory Council, outlined in "Massachusetts' Plan for Excellence in STEM Education—Version 2.0: Expanding the Pipeline for All." Of the five goals in the plan, two address the critical linkage of the work to build the STEM pipeline with postsecondary education and workforce alignment. Goal four aims to "increase the percent of students completing post-secondary degrees or certificates in STEM subjects," and goal five seeks to ensure that "STEM degrees and certificate attainment will be aligned with corresponding opportunity in STEM-related fields to match the state's workforce needs for a STEM talent pipeline."²⁹ Aggregating the data regarding CS/IT as a portion of STEM employment needs, it would follow that the efforts to achieve the goals of STEM Plan 2.0 in Massachusetts will necessarily require integration with the efforts described here.

²⁸ Massachusetts Department of Higher Education. Time to Lead: The Need for Excellence in Public Higher Education (The Vision Project). September 2012, p. 32.

²⁹ Massachusetts Governor's STEM Advisory Council. A Foundation for the Future: Massachusetts' Plan for Excellence in STEM Education, Version 2.0: Expanding the Pipeline for All, November 13, 2014, p. 4.

K-12 Pipeline

It is impossible to explore the importance of growth in the pipeline of graduates in computer science and information technology disciplines without understanding the critical need to build our K-12 pipeline. We know that it is imperative to expose young people in elementary and secondary grades to technology in a way that inspires them to pursue computing and IT fields at a post-secondary level.

In addition to urging greater support for higher education programming aimed at increasing the numbers of computer science graduates, Microsoft also made clear that its own National Talent Strategy demands strengthening the country's STEM pipeline. In Massachusetts, industry leaders have vocalized that the challenges they face in meeting their talent needs must be addressed by enhancing the resources available to our students in the K-12 system.

Data regarding preferences of graduating high school seniors illuminate some connection to the shortfall of graduates in computer science and IT fields. Over the past 15 years, the interest of graduating seniors, while on an upward trajectory after many years of downward trend, is still only at 2.5%. Only 1308 of the 50,000 college-bound seniors in Massachusetts who took the SAT in 2013 indicated they are interested in majoring in Computer Science or IT Services – 150 more students than the year before. While the focus of this initiative is centered on our public higher education institutions, it's clear that developing the pipeline necessary to fuel the technology sector depends on exposing young people to computing concepts during primary and secondary education.

Diversity

It will be impossible to fill the technology talent gap without investing in all members of our society with potential to succeed in technology fields, and this effort is an exciting opportunity to continue good work that has focused on supporting women and underrepresented groups in computing. Although some data exists to suggest a new upward trend in the numbers of women and underrepresented groups pursuing computer science and information technology degrees and careers, the percentages of those groups in technology fields remains extremely low and exists in the context of downward or stagnant entry into computing and technology fields over the past 10 years.³⁰

One of the more startling statistics is the dramatic *decrease* in participation of women in computing and information technology occupations of the past 20 years. The percentage of women in these occupations was at its high of 36% in 1991, dropping to only 25% in 2009.³¹ African-American and Hispanic women make up only 3.5% of the technology workforce.

On Massachusetts public campuses, the number of students enrolling in computer science and IT programs is showing improvement, but still reflects trends in the field. Just 21% of students in computer science programs and 25% of those in IT programs are women. Further, African-American students currently comprise only 4% of computer science majors and 7% of IT majors at our public institutions, far from the 9% of African-

³⁰ The College Board, 2013.

³¹ National Center for Women and IT (NCWIT): the Facts, 2009, p. 14

American people from the ages of 18-24 in our general population. Latino students number at 6% and 7% in those programs, respectively, far lower than the 13% of young people in our general population.

| CIS & IT Students by Race (Not Including Foreign Students) | | | | | | | | |
|--|-------------------|-------|--------|-------|-------------------|-------|--------|-------|
| | Public | | | | All Institutions | | | |
| | White, Non Latino | Asian | Latino | Black | White, Non Latino | Asian | Latino | Black |
| CS | 72% | 9% | 6% | 4% | 63% | 15% | 5% | 4% |
| IT | 65% | 7% | 7% | 7% | 55% | 8% | 7% | 7% |
| CS & IT Total | 69% | 8% | 7% | 5% | 59% | 11% | 6% | 6% |
| All Fields | 75% | 5% | 6% | 6% | 67% | 7% | 6% | 7% |

Source: NCES. IPEDS. U.S. Citizens and Permanent Residents Only. Degrees and Certificates All Levels. 2008-2012.

| CIS & IT Students by Gender | | | (this includes foreign students) |
|-----------------------------|--------|---------|----------------------------------|
| Women in CS & IT | Public | Private | |
| CS | 21% | 22% | |
| IT | 25% | 24% | |
| CS & IT Total | 23% | 23% | |
| All Fields | 59% | 58% | |

Source: NCES. IPEDS. 2008-2012. Degrees and certificates all levels.

These numbers also reflect the challenge of engaging young people’s interest in computing and technology fields before they enter postsecondary education. Participation in the Advanced Placement (AP) Computer Science exam is often an indicator of the pipeline of students likely to pursue computer science after high school. Of those high school students in Massachusetts who took the AP exam in 2013, only 18% were women, 8% were Hispanic/Latino students and 3% were African-American.³²

These statistics indicate both a social justice mandate and an economic development imperative. As public educators, we must ensure that all of our young people have the opportunity to pursue and excel in our most lucrative and fastest growing fields. And as policymakers focused on the long-term economic viability of our commonwealth, it is essential that we have all of our human talent to meet the needs of those companies who employ the computing and technology workforce.

V. Massachusetts Higher Education CS/IT Collaborations

The Department of Higher Education and several Massachusetts public higher education institutions have led prior efforts focused on computer science and IT, and it is important to note that any future coordinated statewide effort will benefit from much of the work described below. Furthermore, several statewide technology and IT industry groups

³² The College Board, AP Test Taking Data 2013, as reported by The Commonwealth Alliance for Information Technology Education in *Keep Massachusetts Innovating: The Economic and Educational Landscape for Information Technology and Computing in Massachusetts*.

have actively worked to support the pipeline of students who represent their future workforce. The following describes some of these prior and/or current projects that have laid the groundwork for the efforts that will flow from the findings in this report. Several of the organizations described here will also be collaborative partners in ongoing work.

CITI

In early 2000, the Commonwealth Information Technology Initiative was formed at UMass Amherst and funded in part by the Department of Higher Education. CITI's work focused on: 1) Building an Information Technology-Fluent Workforce, 2) Increase the Use and Integration of Information Technology by Educators, 3) Strengthening Information Technology Curriculum in Public Higher Education, and 4) Build Regional Collaboration to Strengthen IT Education. Much of CITI's work was aimed at providing grants to train CIS faculty and improve curriculum, develop IT Across the Curriculum (ITAC) courses, and to convene conferences of educators and industry in partnerships across regions and the state.

2005 CITI issued grants focused on further developing ITAC programs by institutionalizing them and building partnerships between institutions. Though CIS education was not funded during this round of grants, the dialogue has continued through conferences and partnerships. CITI is no longer active, but its work was part of the genesis of both CAITE and BATEC (described below).

CAITE

Some of CITI's work resulted in the founding of CAITE, the Commonwealth Alliance for Information Technology Education, which has been funded largely through the National Science Foundation. CAITE's work primarily focused on effectuating a shift in historic underrepresentation in the Information Technology education and workforce. CAITE placed emphasis on "women and minorities in groups that are underrepresented in the Massachusetts innovation economy; that is, economically, academically, and socially disadvantaged residents."

CAITE successfully piloted outreach programs to support students from rural, suburban and urban areas. Through support from the National Science Foundation, CAITE worked to develop "clearer and more nurturing paths from high school, through community college and into four-year programs." Based at UMass Amherst, CAITE has served as an alliance between eight community colleges, two state universities and four UMass campuses, along with BATEC and several other organizations focused on increasing participation of women and others traditionally underrepresented in computer science and IT.

The efforts driven by the Department of Higher Education will dovetail and connect this work, as they are motivated by the same goals. In the words of Rick Adrion of UMass Amherst, "The Massachusetts economy has depended on keeping out-of-state students in the Commonwealth after graduation and attracting degree-holding immigrants, but these numbers are declining. That's why we decided to focus on resident students attending public institutions—they tend to stay in state in larger numbers after graduation."

CAITE built on partnerships with the Commonwealth Information Technology Initiative (CITI), BATEC, regional Louis Stokes Alliances for Minority Participation and Alliances for Graduate Education and the Professoriate (AGEP) programs, also funded by NSF, and other initiatives focused on information technology education and science, technology, engineering, and math (STEM) pipeline issues.

Much of CAITE's work has now shifted to a national focus, with ECEP (Expanding Computing Education Pathways), a new effort also funded by the National Science Foundation and in partnership with a sister organization, Georgia Computes. Although NSF funding has shifted to encompass national-level work, CAITE continues to make important strides, and DHE will collaborate with CAITE in these efforts. Currently, CAITE is working to develop a common understanding between the four UMass computer science programs, such that community college students might understand the most effective computer science transfer pathway.

BATEC

BATEC (Broadening Advanced Technological Education Connections) has also been a transformative force in the Massachusetts landscape in Computer Science and IT education at our public higher education institutions. BATEC is a National Center of Excellence in Computing and Information Technology, with headquarters at UMass Boston, and now with sites in Chicago, Las Vegas and San Francisco. BATEC's focus is in public education, centered on community colleges, and has been an important part of effective computer science and IT pathway development since its founding in 2003. BATEC has supported several Massachusetts community colleges in the development of stackable credentials from workforce certificates to Bachelor's degrees, allowing students to pursue education leading to viable career pathways while staying in the workforce.

For example, BATEC recently supported efforts at Middlesex Community College to revamp their computer science and IT curriculum, with particular emphasis in cyber security at a 2-year degree level and for 2-4 year transfer. BATEC has also served critical roles around its other priorities—connecting high school students, community college students and university students to internships, and supporting critical outreach efforts for students at the high school and community college level. Furthermore, BATEC has served an important role educating teachers at the K-12 level, building the critical pipeline of educators needed to excite the next generation of technology professionals. BATEC's research arm has provided essential analysis to help policymakers and educators understand the landscape of information technology and computing education as linked with their corresponding industries.

Massachusetts Technology Industry Groups and Companies

Technology companies, both individually and as represented by their industry associations, have consistently demonstrated an interest and willingness to be part of critical conversations with public policymakers. The industry has been and will continue to be an essential collaborative partner in the statewide effort proposed here. The Massachusetts Technology Leadership Council (MassTLC) has been a close partner with DHE in supporting the department's efforts to understand the technology gap from

the perspective of employers. MassTLC is the largest technology industry association in Massachusetts, with over 550 member companies that span the technology ecosystem, from small startups to the largest tech firms in Massachusetts, like Constant Contact and Google. MassTLC member companies also include large IT departments as well as the large number of firms who service tech companies in the commonwealth.

The Society for Information Management (SIM) is also an important partner in this effort. Representing CIOs and management of Information Technology Teams, SIM is a national organization, and Boston SIM is one of its largest and most active chapters. SIM members represent some of the largest IT teams in the state, at places like Boston Properties, John Hancock Financial Services and the City of Boston. SIM has been deeply connected with the effort to support increasing interest in technology and building the pipeline of young people pursuing careers in technology. SIM has consistently supported and hosted interns in the Tech Apprentice program, Year Up, and their own Future Potential in IT program. SIM has been an active partner with DHE in the effort to better understand the workforce needs of employers represented by their membership.

The Massachusetts Competitive Partnership represents some of the commonwealth's largest employers, including Suffolk Construction, Partners Healthcare, Staples, EMC, Raytheon, Vertex, TJX, State Street, Fidelity, and others. With a mission to "promote job stabilization and growth across the full spectrum of business, and within all geographic regions of the Commonwealth," MACP will be a critically important partner in the initiative described here. MACP companies will be able to provide important perspective on the shifting needs in their own workforce, and their efforts to promote "learn and earn" experiences for students at some of our public community colleges is just one of many ways that their work dovetails the efforts of this initiative.

The Massachusetts High Technology Council has also been an important association of some of the state's largest high tech companies, such as Boston Scientific, Dossault Systems, Hewlett Packard and Lockheed Martin. Mass High Tech is currently completing their own analysis of the talent development needs in Massachusetts, and that data will be integrated into the efforts described here.

State Government Collaboration

The necessary analysis and strategy implicated by this document will be necessarily completed in collaboration with executive branch agencies and colleagues. This initiative is intended to be focused on our public higher education institutions and should maintain fidelity to that focus. However, the effort to more completely understand dynamics influencing programs at those institutions implicate related efforts across a number of agencies and departments. This report recommends that the Technology Talent Initiative of the Department of Higher Education engage in collaboration with the Executive Offices of Education, Labor and Workforce Development, and Housing and Economic Development, the Departments of Elementary and Secondary Education and Early Education and Care, the Governor's STEM Advisory Council, the Massachusetts Technology Collaborative and the Commonwealth Corporation.

VI. Conclusion and Call to Action

The foregoing analysis illuminates the importance of focused and sustained effort and continuing collaboration among employers, industry groups, academic leaders and government officials to address technology talent needs. We know that our publicly educated workforce is imperative to the social and economic health of our economy, and that our technology fields are a large, growing and essential part of our future workforce. Our public mission demands that we effectively build interest of young people in some of the most compelling and rapidly changing fields of the future, determine the best way to support students who wish to pursue computer science and IT fields, and focus our strategy to support public computer science and IT departments at our public colleges and universities.

This report is intended to serve as a call to action for the Massachusetts public higher education community, and a catalyst for a longer term effort workforce planning effort, as convened by DHE. Initial efforts to understand the key issues that should serve as a focus for this effort have included research into the demand in the industry, inquiry with leaders from among employers of the tech workforce, and computer science and IT programs from among computer science and IT programs.

This initial analysis has highlighted some critical areas of review for the department over the next year, and some first order thinking regarding strategies to focus our efforts. Distilling this information and its impact on Massachusetts' public campuses, we find that critical areas of focus fall within three areas: program capacity, program alignment, and resource demands. These areas will provide the framework for statewide coordination and collaboration.

Program Capacity

Given the significant demand for an increase in the number of graduates necessary to meet workforce needs, the capacity for computer science and IT program growth is and will be a critical question.

Addressing issues of capacity will require thoughtfulness from a number of perspectives. Ongoing labor market analysis will help pinpoint major shifts in the technology industry, and can help drive an understanding of the gap between labor market demand and the output of graduates in relevant fields. Exploration of capacity concerns will also drive thinking around where opportunities may exist on many of our campuses.

The challenge of faculty hiring in this context must also be a critical focus in any conversation regarding program capacity. Because the computer science and IT job market itself is so lucrative, public institutions are finding it increasingly difficult to offer faculty opportunities with competitive salaries.

Addressing issues of program capacity will require the following action items:

- **Data analysis:** Many campus programs have grown rapidly in the last few years, and efforts aimed at meeting capacity of programs will require

understanding current campus capacity and to determine where expansion may or may not be possible.

- **Internships:** Employers are explicit about the necessity of real world experience as a prerequisite to hire in most technology jobs. Many key employers do host successful internship programs, and the Mass Tech Collaborative has hosted successful stipend support as well as a venue to link students with technology and IT employers. However, comprehensive internship support for students and employers continues to be a capacity/bandwidth challenge for many campuses. Statewide efforts should include a review of internship support and explore opportunities for aggregated resources to reduce the burden on each individual campus to broker relationships with employers separately.
- **Diversity:** A key issue for building pipeline capacity is and will continue to be ensuring the necessary exposure and support exist to foster interest, pursuit and completion of CS and IT degree programs for students of color and women.
- **K-12 Pipeline:** Success in building that interest will require complementary capacity at our public campuses, and this effort will therefore require a cohesive connection between K-12 CS/IT strategy and efforts within higher education.
- **Faculty:** As stated above, addressing capacity concerns will require addressing the challenges inherent in finding and retaining qualified computer science and IT faculty

Program Alignment

Statewide convening and collaboration will facilitate shared thinking among campus departments to address rapidly changing technology and shifting demands of students, employers, and regional economies. In preliminary conversations with campus faculty, it has become clear that while most campuses lead their own analysis of workforce trends in their area and engage local employers, there is always a benefit to more detailed data on the field's impact on program delivery.

DHE can also serve as a convener and liaison between campuses and the larger community of tech companies and IT employers. While nearly all campuses have been successful at brokering these relationships from among their partners, many have expressed a desire for a broader and deeper connection with companies and industry groups, which will be a primary focus of this effort.

More specifically, addressing matters of program alignment will require the following action items:

- **Data analysis:** Building on the analysis in this report and the data sources aggregated here, ongoing data analysis will be necessary to further determine detailed and shifting marketplace needs that may impact campus programs and capacity. Further effort will also benefit from analysis of regional labor market data as will impact various parts of the state in different ways.
- **K-12 Pipeline:** As discussed above, marketplace demands will require growth of interest in computer science and IT within students' k-12 years.
- **Student support:** a key indicator of success for students in CS and IT programs is ensuring support through the program and completion. Building on learning from the STEM Starter Academies and the Massachusetts participation in the Guided Pathways in STEM projects, this long term strategic effort will require

attention to the need for focused student support in CS and IT certificate and degree programs.

- **STEM Connections:** As articulated in this report, deep connection and cohesiveness with broader STEM strategies will be essential to CS/IT program support moving forward.

Resource Demands

Inevitably, any effort to focus on the expansion and enhancement of degree programs to meet the demand of the technology workforce will necessarily require thoughtful and creative focus on resource needs and strategic funding. Focused analysis of resource and funding needs will allow for strategic thinking about possible funding mechanisms that will be supported by DHE at a statewide level.

This analysis will explore needs for:

- State level resource support
- Federal and private grant alignment
- Analysis of capital and program resource demands on each campus

Next Steps

Pending approval by the Board of Higher Education, the Commissioner will appoint a task force of industry leaders, faculty, campus administrators and critical partners to explore next steps in response to the key issue areas identified here and develop a long term strategic technology workforce plan.

This effort will follow the following timeline:

April 2014: First small working group convening to develop top priorities and help shape future process moving forward.

Spring/Summer 2014: Appointment of Advisory Committee, to include representatives from:

- Executive offices of Education, Labor and Workforce Development, and Housing and Economic Development
- The MA Legislature Technology Caucus
- Department of Elementary and Secondary Education
- Department of Early Education and Care
- Tech sector industry groups
- Industry groups representing IT employers
- All public campus segments:
 - Community colleges
 - State universities
 - UMass campuses
- BATEC
- CAITE/ECEP
- Office of the Commonwealth CIO
- One private university representative

June/July 2014: Working groups formed to address specific domains:

- Capacity analysis
- Community College CS Transfer
- Diversity in CS/IT
- Industry collaboration
- Internship strategy
- Priority/growth sectors and curriculum alignment
- Student support
- K-12 and STEM Collaboration
- Resource analysis

Fall 2014: Large scale convening of representatives from CS/IT programs at each of the 24 public campuses

Winter 2014: Aggregation of information from each working group, drafting of long term CS/IT Strategy

Spring 2014: Delivery of long term technology workforce strategy