Information & Communication Technology: Shared Prosperity in the Digital Age

SkillWorks℠

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JPMorgan Chase & Co.

EARI

Acknowledgements

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Lastly, SkillWorks would like to thank all of our workforce and education partners that are working closely with us to develop a strong system of training for jobs in IT/Tech that reflect our academic, technical, cultural, and social qualities.

About SkillWorks

Launched in 2003, SkillWorks is a $30 million public/private partnership between The Boston Foundation, the City of Boston, and local, national, and corporate philanthropy designed to meet worker and business needs while developing pathways out of poverty in the face of overwhelming evidence that a large percentage of our workforce is unprepared for the available and growing jobs in our economy. As a workforce funder collaborative, SkillWorks invests in employer-driven, sector-based training and placement strategies to help low-skill, low-and moderate-income job seekers move to family-sustaining jobs, and help employers find and retain skilled employees. SkillWorks is a nationally recognized workforce development intermediary and is the model for the National Fund for Workforce Solutions. Since its inception, SkillWorks has helped over 5,500 job seekers and incumbent workers progress on a path to self-sufficiency, served hundreds of employers in healthcare, hospitality, construction and financial services sectors, increased the number and capacity of sector-based workforce partnerships implementing innovative training and placement strategies, and advocated successfully for more than $100 million in state funding for key workforce priorities. SkillWorks commissioned the Economic Advancement Research Institute to conduct this research as part of a strategic planning effort to expand its sector-driven portfolio into the IT/Tech industry. Similar to its operational support of the Boston Healthcare Careers Consortium that centrally convenes healthcare employers to voice workforce needs and opportunities, SkillWorks anticipates replicating the healthcare model for the IT/Technology sector in close partnership with the Boston Private Industry Council, the City of Boston, industry leaders in the region, community based organizations, post-secondary education and workforce training providers in Greater Boston.

About EARI

The Economic Advancement Research Institute (EARI) is a Massachusetts 501(c)(3) nonprofit organization focused on issues and challenges related to economic mobility, sustainability and vitality—all critical to restoring America's competitiveness. Addressing these challenges requires the ability of regional economies to thrive. Connecting regional assets to create a competitive economic environment has to be driven by empirical research and data that informs and transforms systemic policies that are too focused on short-term political ideology. EARI's approach to nuanced research and policy provides actionable recommendations to overcome short-term political ideology and support a successful regional framework.

Our nonprofit institute delivers policy reform recommendations, new frameworks and actionable guidance through applied economic research that identifies pathways between talent development and workforce needs, and empowers regions to move towards full employment with expanded opportunities for job seekers, entrepreneurs and the business community.

Executive Summary

Massachusetts is at the forefront of the digital economy. The state is home to a world-class Information and Communication Technology (ICT) sector, headlined by software and enterprise solutions as well as big data and technology-intensive industries such as financial services, clean energy, healthcare, and biotechnology. Altogether, Massachusetts supports about 156,000 computer and mathematics related jobs; these workers—largely located in the Greater Boston Area—represent four percent of the state's workforce. With strong employment, the sector hints towards yet more growth across these sustainable, high-wage occupations.

In fact, each of the 20 computer and mathematical occupations is more highly concentrated in Massachusetts than in the United States, and seven of these are over 50% more concentrated in the state compared to the national average. With the highest growth since 2010, Computer Programmers, Applications Software Developers, and Computer Systems Analysts have increased total employment by three to four percent over five years; these three occupations now support almost 63,000 individuals across the state. However, economic projections indicate that Statisticians, Operations Research Analysts, and Web Developers will be in higher demand over the next five years—a three percent annual growth rate through 2020.

While labor market data illustrates a high concentration of sustainable ICT employment opportunity in Massachusetts, they also suggest misaligned educational requirements, insufficient critical thinking, problem-solving, and analytical skills, and lack of diversity. These issues have resulted in talent shortages that could limit future economic growth in the region.

College as a Proxy

As most ICT employers require or prefer a college degree, the workforce is largely comprised of college-educated individuals. However, about half of those degrees are in subject areas unrelated to ICT technologies. Though ICT employers note that college is important for knowledge, communication, and teamwork skills, it is not considered to be an important factor in developing other non-technical skills, such as work ethic, dependability, or critical thinking. In fact, these skills were the most reported deficiency among non-entry-level job applicants—nearly one in four employers state that their non-entry-level applicants lacked these skills.

These findings suggest that while some employers report that their ICT positions require skills and knowledge attained in college (e.g., software engineers, application systems managers, etc.), many are using college as a proxy for other traits. When pressed on those advantages, however, employers are unable to identify much beyond teamwork and communication. In addition, despite hiring nearly exclusively from the college-graduate pool, a stunningly large segment of employers report significant skill gaps for non-technical skills ranging from problem-solving and data analysis to work ethic. Given the cost of a four-year degree, this appears an expensive and incomplete remedy to solving such skill gaps.

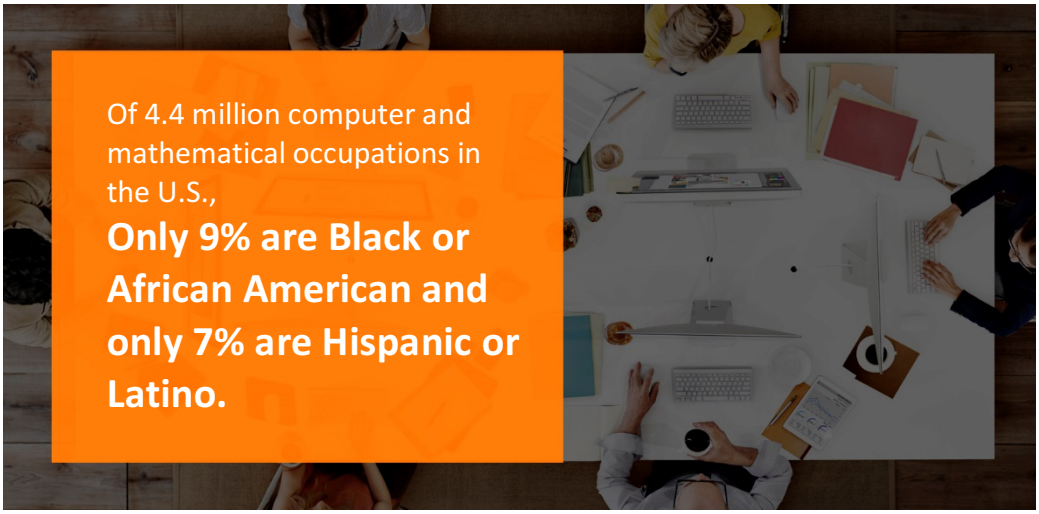
Greater focus on critical thinking and problem-solving, in particular, may provide an immediate opportunity to improve the looming talent shortage and ease difficulty among employers.

In addition to the higher cost associated with hiring college-educated workers for positions that do not require college-level technical skills**,** limiting the applicant pool only to degree holders creates talent bottlenecks. While demand growth has certainly contributed to the difficulty employers face in finding qualified talent, more than half of the labor pool does not have a degree, further compounding the problem. As projected growth continues to incline and unemployment drops, hiring difficulty is likely to increase as well.

At the same time, large swaths of the population—as seen in ICT employment distribution across neighborhoods in the City of Boston—are not directly benefiting from this important occupational cluster. Communities with fewer college graduates are underrepresented, perpetuating a cycle that prevents economic mobility as individuals face few opportunities to break into sustainable, high-wage careers. It is imperative that training providers, companies, educators and the workforce development community create programs and partnerships that transform a largely unconnected talent pool into the professional, career-focused, problem-solvers that the business community strongly demands.

Diversity

Across the nation, the ICT workforce suffers from a lack of diversity. In the 4.4 million computer and mathematical occupations in the United States, only nine percent of the workers are Black or African American and only seven percent are Hispanic or Latino. These percentages are smaller for management occupations—six percent of computer and information systems managers are African American and five percent are Hispanic or Latino.[1] Indeed, the majority of ICT workers—especially those in high-wage positions—are white men with at least a four-year degree. The



[1] Bureau of Labor Statistics, Labor Force Statistics from the Current Population Survey, Employment persons by detailed occupation, sex, race, and Hispanic or Latino ethnicity; Marcus, Bonnie. *The Lack of Diversity in Tech is a Cultural Issue.* Forbes, April 2015

research shows that both women and ethnic or racial minorities are underrepresented, and those with the same or more education and experience are not only earning a fraction of their male, non-minority counterparts but are also less likely to report meaningful career advancement. Supply-side data indicates that more male ICT workers have no degree compared to women, yet appear to be more likely to not only land a job, but also achieve higher wages. Similarly, fewer minority workers in ICT-related occupations report no degree compared to non-minorities, but four in ten minorities agree that they have not advanced as quickly in their career as they would like. Expanding opportunities for women and ethnic or racial minorities is an economic imperative. With changing demographics, global competition, and limited talent supply, businesses and training programs will seek new sources of talent.

Mentorship, professional networking, and other career navigation activities, such as performing self-assessment, relationship management, and organizational reading, were reported to be especially important to women and minorities. However, these are often not included as formal components of a training program. Given the rapidly emerging and changing technology landscape, many ICT jobs exist in an environment of creative destruction, meaning that platforms, programming languages, and other technical skills related to the job quickly become obsolete. Successful ICT professionals note that self-evaluation and self-guided learning as well as professional network management have supported career navigation and advancement. These characteristics are learned and practiced behaviors – and while these are traditionally often acquired at home, at a university, or on the job, the research suggests that they can be taught and practiced within training programs – and remain important for a lifetime.

Conclusions and Recommendations

The Information and Communication Technology workforce is robust in Massachusetts, with above average representation across each of the 20 detailed computer and mathematical occupations. Though the occupational cluster is supported by optimistic growth projections—particularly from employers—their optimism is tempered by significant hiring difficulty and potential talent shortages that have left the business community with a lack of qualified applicants to fill their new and open positions.

ICT employers favor a college-educated pool of applicants, not only for the industry-specific skills gained through coursework, but for higher order, non-technical skills. Nevertheless, employers report that applicants are not quite meeting their requirements for these non-technical skills. Given that the degree appears to be a proxy for such skills—as few are actually in ICT-related subject areas—it seems that these can be learned, either through ICT-specific or other workforce development training as well as mentorship and career navigation programs. Workforce development institutions are pivotal to the development of training modules that incorporate critical thinking and problem-solving skills as well as industry partnerships that foster mentorship and professional networking opportunities between current ICT professionals and the next generation of workers. A pathway between the sector's current and potential workforce will also provide job-seekers with an avenue for both personal growth and talent promotion.

Though employers are cognizant of a skill gap, they may be unaware of a largely untapped talent pool within underrepresented demographics—minority populations that, as of yet, are lacking opportunity and access to sustainable ICT careers. This disconnect requires a solution to address both supply and demand; career exposure and experience programs support diversity and engage the business community in exploring non-traditional hiring sources and internship programs. Ultimately, entry-level new hires will likely have to learn additional technical skills via on-the-job training, regardless of educational background. Workforce development programs must equip minority populations, particularly those from low-income neighborhoods, with the necessary industry-specific technical and non-technical skills, as well as career navigation exposure and training that are required for ICT occupations. Opportunity lies in stakeholder partnerships that foster improved communication and career pathways that will expose hidden talent populations to employers. These solutions will support not only the state's burgeoning ICT industry, but also the next generation of successful inventors, engineers, and mathematicians.

Specifically, the findings support the following recommendations:

- **Develop career exposure and experience programs that focus on diversity**
- **Integrate problem solving and critical thinking into all ICT training**
- **Provide expanded networking and mentorship opportunities**
- **Work with job-seekers to showcase their talent**
- **Engage employers to explore non-traditional hiring sources and internship opportunities**

Introduction

Information and Communication Technologies (ICT) include a wide array of products and services, including computer hardware, software and applications, networks, telecommunications, and the internet. These technologies are emerging, evolving, and converging at a rapid pace—skills, businesses, technologies, and workers compete in a climate of creative destruction.

Given the pace of change, ICT workers must continually adapt to market forces to update their knowledge and skills. Those who successfully navigate both the technical and non-technical employment obstacles of this high-tech landscape are rewarded with high wages and job satisfaction.

Massachusetts is a global leader in ICT. Boasting a highly educated workforce and historic industry strength, as well as data intensive industries such as financial services and life sciences, the Commonwealth has abundant opportunities across a vast spectrum of ICT job roles—from help desk to CIO.

ICT employers have markedly homogenous talent pipelines.[2] The lack of diversity in the tech workforce may be limiting firms' ability to grow, while making this high growth, high wage cluster more accessible to the economically disconnected could have a profound economic impact to individuals and communities throughout Greater Boston and beyond.

Research indicates that career navigation skills are critical for success in ICT, but activities that hone them, such as networking, mentorship, self-awareness, and organizational reading, are seldom formally

[2] *See generally*, http://www.usatoday.com/story/tech/2014/06/26/silicon-valley-tech-diversity-white-asian-black-hispanic-google-facebook-yahoo/11372421/.

included in traditional post-secondary or university education. While these skills are clearly important for all job-seekers, they are especially critical for underrepresented populations from communities that are economically disconnected because such individuals tend to have a less robust safety net to fall back on should their career progression become stunted.

At the same time, many programs that serve disconnected youth and adults tend to focus on enrollees' deficiencies, in an attempt to highlight the importance of particular skills and characteristics. Because student expectations have been shown to be the most important indicator of success in school[3], it is possible that these well-meaning programs, by focusing heavily on "improving deficiencies," are negatively impacting enrollees self-esteem.

The Massachusetts economy – particularly in Greater Boston – is producing many high skilled, high wage jobs, but employers report significant difficulty finding workers that meet their needs. At the same time, ICT jobs have less diversity, which limits economic mobility and is potentially leading to talent bottlenecks. This report includes a summary of data from the Bureau of Labor Statistics and Census Bureau, a comprehensive survey of more than 300 employers across the Commonwealth, quantitative and qualitative assessments and ethnography of current ICT workers in Massachusetts, and conclusions and recommendations from the findings.

[3] *See generally*, Hattie, J., Teachers Make a Difference; What is the research evidence?, October 2003, available at: http://www.decd.sa.gov.au/limestonecoast/files/pages/new%20page/PLC/teachers_make_a_difference.pdf.

Information and Communication Technologies: Labor Market Demand

Occupational Overview

The Bureau of Labor Statistics and Census Bureau collect detailed information about computer-related occupations, providing consistent and highly accurate data on the ICT workforce.[4] With about 156,000 jobs, Computer and Mathematical Occupations support approximately four percent of the state's workforce and have grown by about three percent since 2010.[5] The chart below illustrates the detailed computer and mathematical occupations that are employed in Massachusetts.[6]

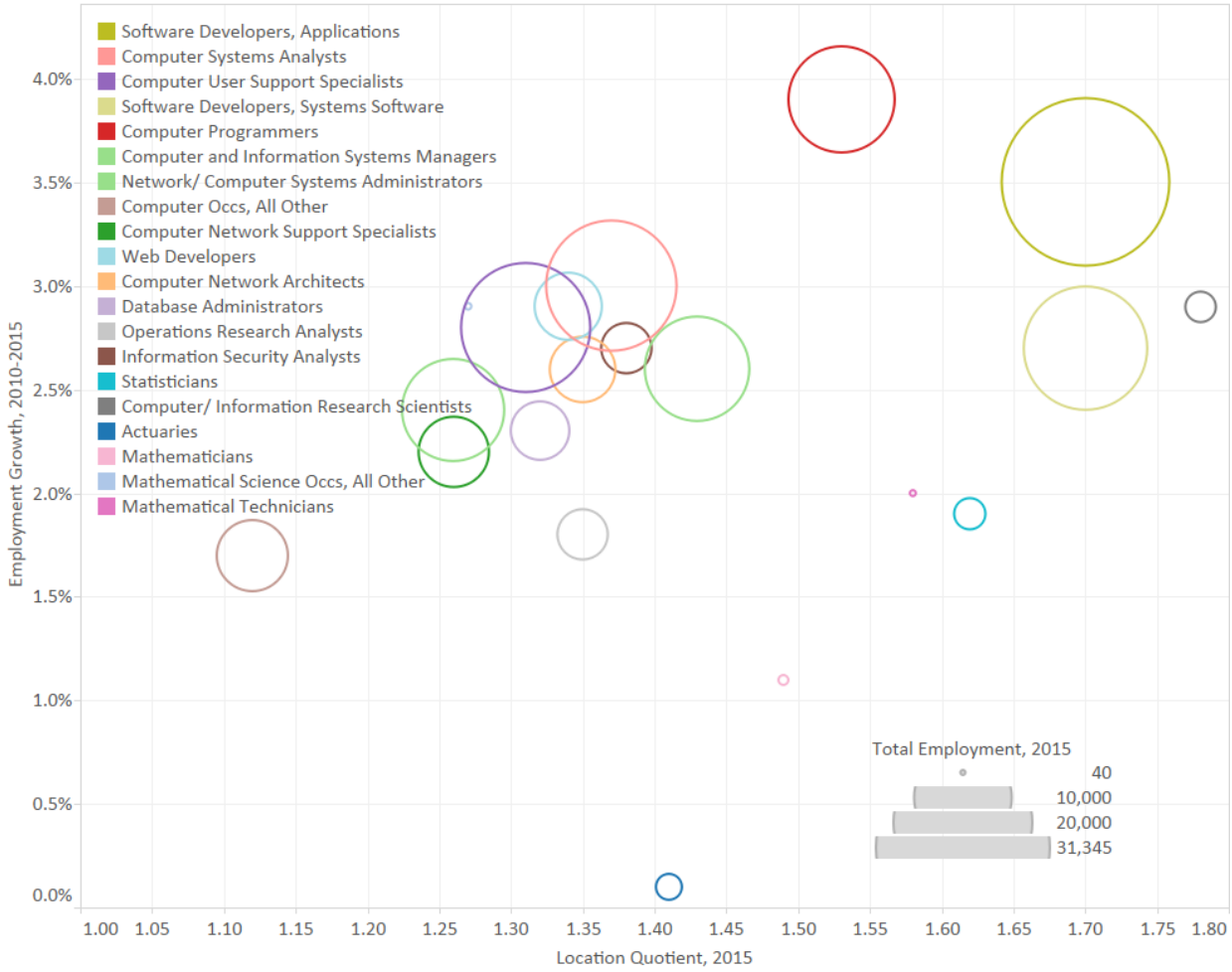
Each of the 20 detailed ICT occupations found in Massachusetts exhibits a higher than average concentration compared to the United States; ranging from 12% to 78% more concentrated in the state than the national average, and seven of the 20 occupations are over 50% more concentrated in Massachusetts than the national average. Computer and Information Research Scientists have the highest concentration, followed by Applications and Systems Software Developers. These two latter occupations are also among the highest paid, earning over between $110,000 and $115,000 per year. In terms of size, Applications Software Developers are the largest subgroup of ICT occupations—almost 22% of the Computer and Mathematical workforce in Massachusetts—followed by Computer Systems Analysts (13%), Computer User Support Specialists (13%) and Systems Software Developers (12%).

[4] The Bureau of Labor Statistics and other Federal statistical agencies rely on a Standard Occupational Classification (SOC) system for both data collection and analysis. This SOC system classifies workers into one of 840 detailed occupational categories based on their occupational definitions. The system functions as a hierarchy, from major (23 occupations) and minor (97 occupations) groups to broad (461 occupations) and detailed (840 occupations) delineations. The detailed occupations are encompassed within the larger groups as they share similar job duties, skills, education, and training. For the purposes of this study, secondary data regarding Information and Communication Technology occupations are defined using the Computer and Mathematical Occupations major SOC code. The following analyses are based on secondary data from JobsEQ 2015Q4—unless otherwise noted—using the SOC code 15-0000 (computer and mathematical occupations) and its component minor, broad, and detailed occupational groups.

[5] Total employment refers to the total number of Computer and Mathematical Occupations in the state regardless of whether or not these workers reside in Massachusetts.

[6] The location quotient quantifies how concentrated a particular occupation is relative to the national average. Anything above 1 indicates that this occupation is more highly concentrated in Massachusetts compared to the rest of the United States. The size of each bubble denotes the total employment relative to each occupation, while the x-axis displays the location quotient and the y-axis notes employment growth between the fourth quarter of 2010 and the fourth quarter of 2015.

Figure 1. Computer and Mathematical Occupations Matrix



Computer Programmers, Applications Software Developers, and Computer Systems Analysts have experienced the highest growth since 2010; these occupations have grown between three to four percent in the last five years and employ almost 63,000 individuals across the state. However, at about three percent annual growth, economic projections indicate that Statisticians, Operations Research Analysts, and Web Developers will be in higher demand over the next five years. The overall occupational segment for Computer and Mathematics is expected to add just over 10,000 new jobs over the next five years for an annual growth rate of 1.4%—or a total of seven percent in five years—but surveyed employers are more optimistic as they project employment to climb by almost nine percent over the coming 12 months. More recent, positive economic trends (including the relocation of a major ICT employer to the city) are likely driving this greater optimism.

The top three industries in Massachusetts that employ Computer and Mathematical Occupations are Computer Systems Design and related services (31%), Software Publishers (11%), and the Management

of Companies and Enterprises (5%). There are few ICT workers found in the data processing and hosting (2%) or computer and peripheral equipment manufacturing (3%) industries.

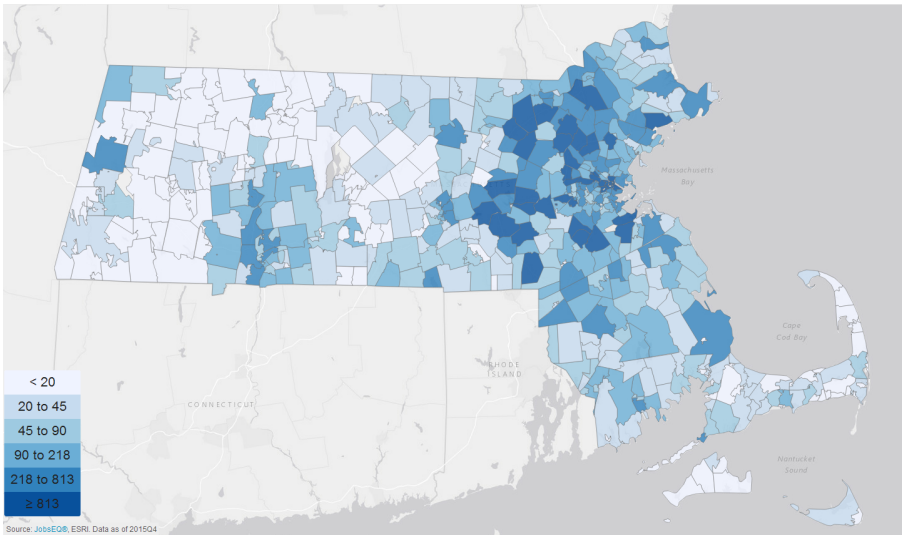
Geographic Characteristics of Computer and Mathematical Occupations

Computer and Mathematical Occupations are most highly concentrated in Greater Boston[7], and most particularly in Middlesex and Suffolk Counties. Not surprisingly, the concentration of ICT workers diminishes further west from larger cities and the state's capital. The Boston MSA accounts for almost eight in ten ICT jobs across the state, and Middlesex County alone represents almost half of ICT jobs, followed by Suffolk with about one in six ICT workers.

The state appears to be a net importer of talent with regards to IT employment. Overall, Massachusetts imports about five percent of its ICT workforce from outside the state; of the roughly 144,000 Computer and Mathematical Occupations in the state, about 95% of these workers actually live in Massachusetts. There is quite a bit of commuting within the state's regions as well, as ICT workers that reside in the Worcester, Springfield, and Providence MSAs commute out of the region and into Suffolk and Middlesex County, and perhaps even crossing the border into some neighboring states.

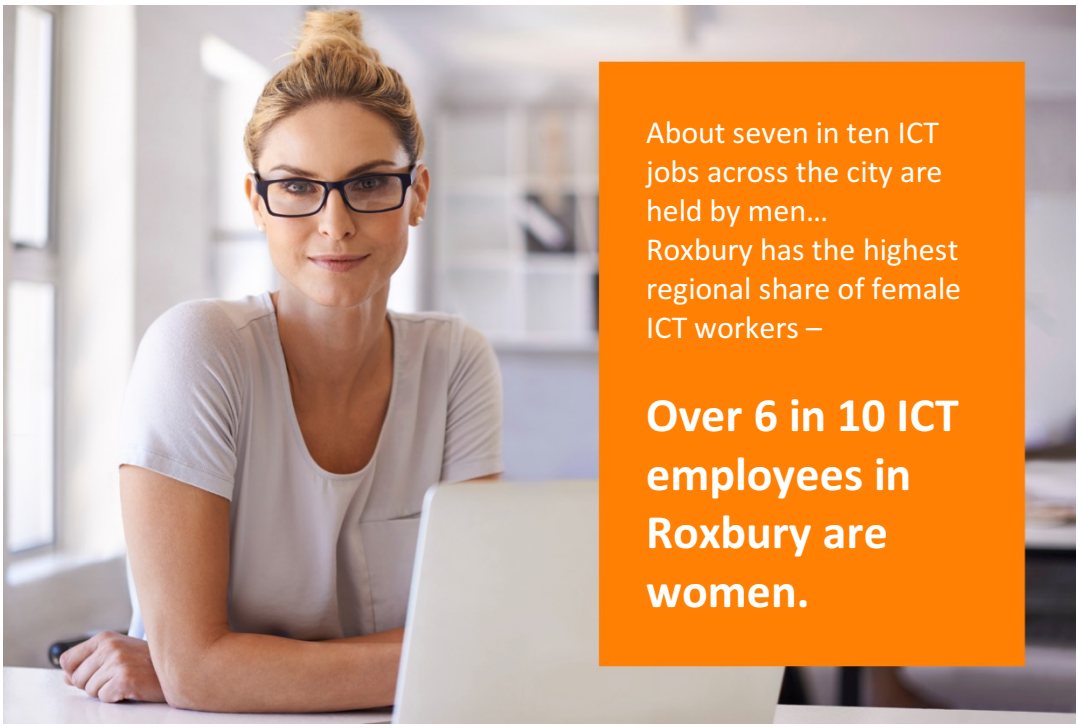
The Boston-Cambridge-Newton MSA supports higher-than-average wages for Computer and Mathematical Occupations. The mean annual wage for ICT occupations is about $1,000 greater in the Boston MSA compared to the statewide average. This region provides a much higher wage for its ICT workers compared to both Worcester County and the Springfield MSA—about 6% greater than Worcester and 14% greater than Springfield.

Figure 2. Computer and Mathematical Occupations, Geographic Distribution by *Place of Work*



[7] Defined as the Boston-Cambridge-Newton Metropolitan Statistical Area (MSA)

The proportion of Computer and Mathematical workers that reside in the City of Boston is identical to the state's overall proportion of ICT employment. Computer and Mathematical occupations represent just over four percent of all workers that live in the City. Brighton is home to the highest share of ICT workers—about one in six—followed by Jamaica Plain (9.4%) and Dorchester (8.8%). Less than one percent of residents in Harbor Islands, LMA, Mattapan, South Boston Waterfront, and the West End are working in ICT occupations. Mission Hill, Brighton, and the North End have the highest proportion of Computer and Mathematical workers by region—ICT workers comprise about eight percent of workers that reside in each of these neighborhoods.[8]

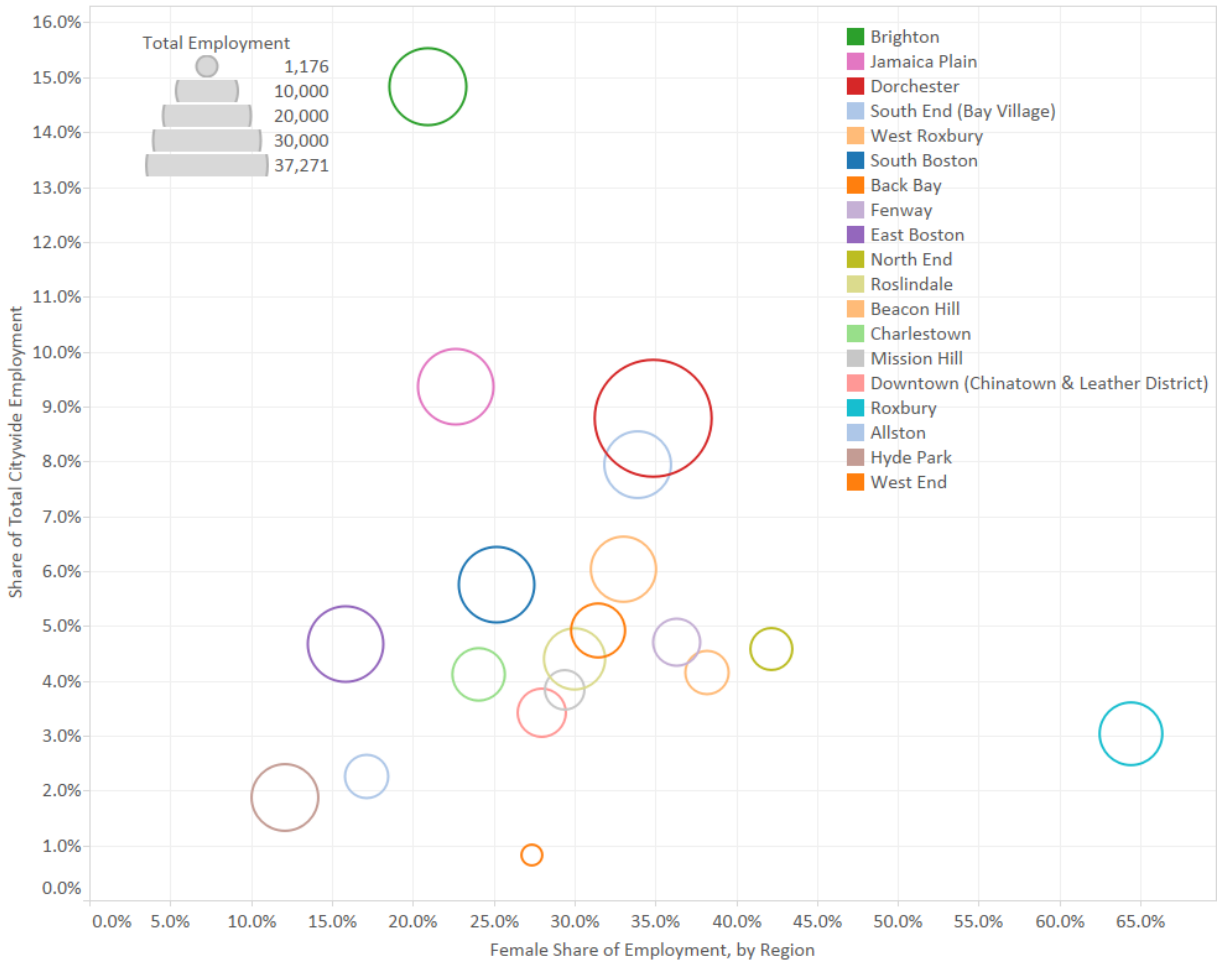


About seven in ten ICT jobs across the city are held by men, but there are some neighborhoods that support a very high proportion of female ICT employees. Though it only accounts for three percent of citywide Computer and Mathematical employment, Roxbury has the highest regional share of female ICT workers—over six in ten ICT employees in Roxbury are women.[9]

The chart on the following page illustrates overall Computer and Mathematical Occupations within each neighborhood—defined by census tract—for the City of Boston. The size of each circle denotes total employment for all occupations, while the x-axis illustrates the percent share of women in each neighborhood's ICT employment total and the y-axis notes the regional share of total citywide ICT workers.

[8] American Community Survey, 2013 5-year estimates by Census Tract
[9] *Id.*

Figure 3. Computer and Mathematical Occupations Matrix, by Census Tract[10]



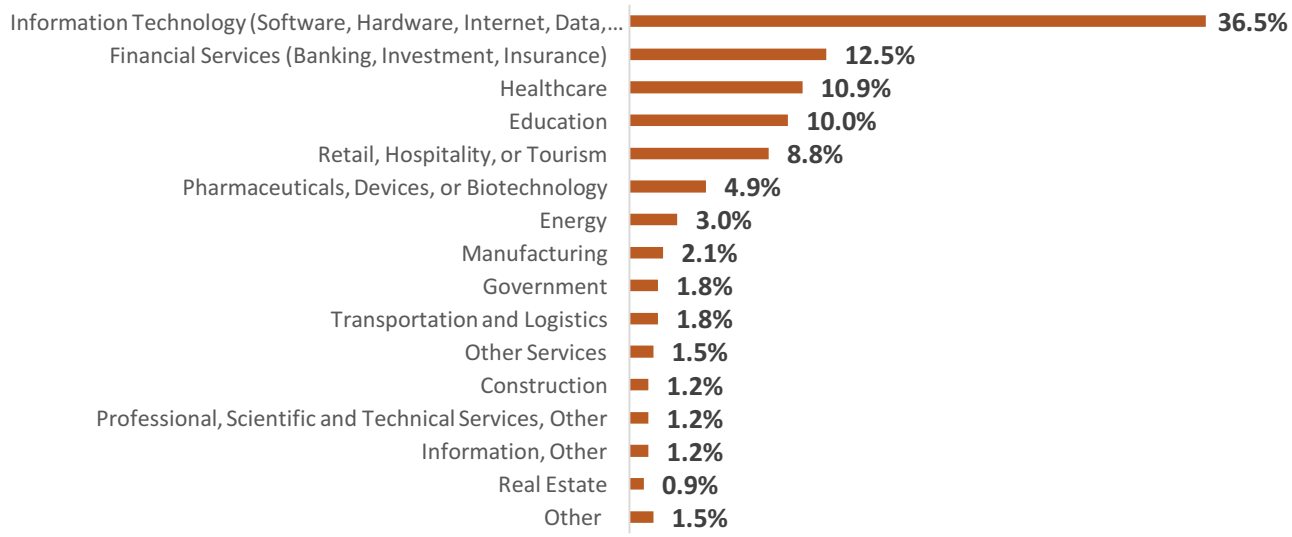
Employer Survey Data

To better understand the demand side of the Information and Communication Technology labor market, BW Research recruited a representative sample of 330 employers that employ ICT workers—including developers and implementers—to participate in a survey that quantifies firm projected growth, education and training requirements for IT new hires, workforce demographics, and other employer sentiments regarding the adequacy with which entry and non-entry level ICT staff are prepared for work. The following section details these results.

[10] Please note that LMA, Harbor Islands, Mattapan, and South Boston Waterfront are excluded from this visual because they represent under 0.5% of total Computer and Mathematical Occupations in the City of Boston.

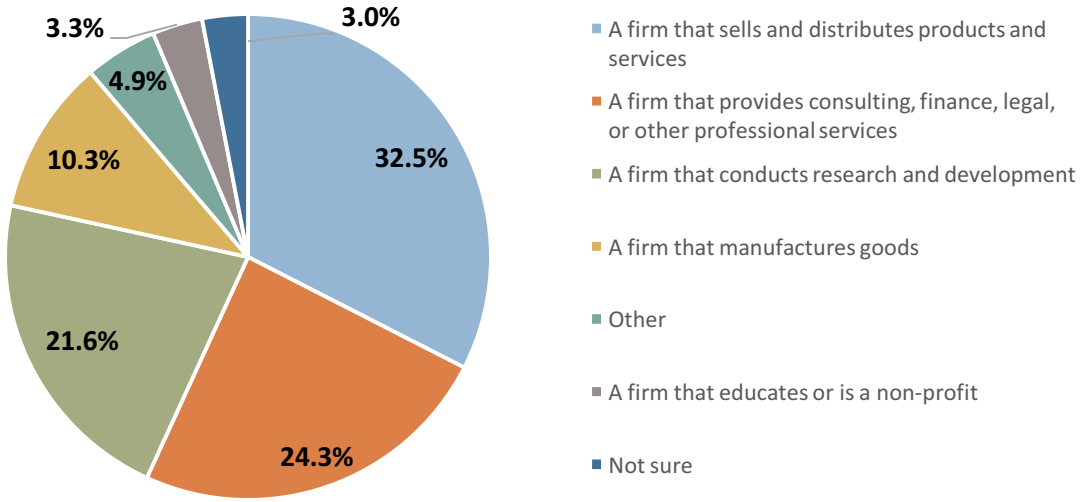
The majority of surveyed firms are in the information technology, financial, or healthcare industry. Together, these three industries represent six in ten firms. Almost 40% of firms—the largest segment of responses—are in the information technology industry.

Figure 4. Industry



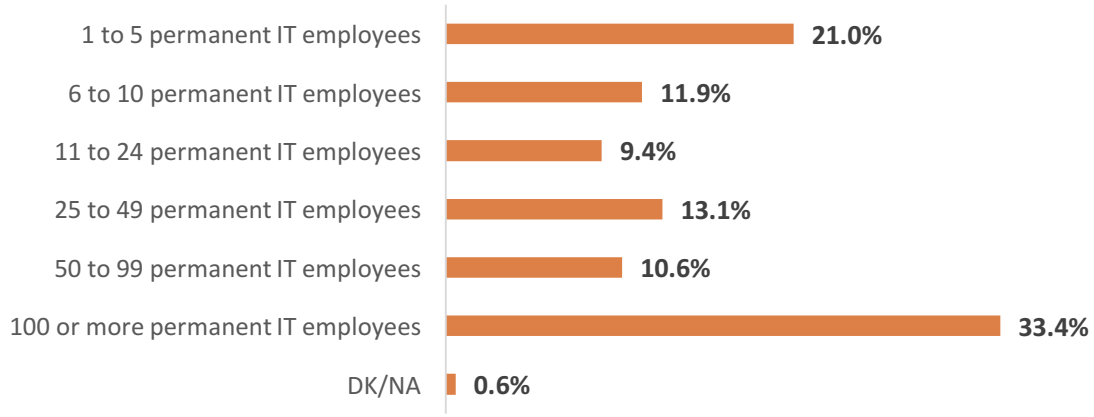
Information technology employment is found across a range of value chain activities. About a third of firms are primarily involved in sales and distribution, while another quarter provide professional service support such as consulting, finance, or legal services. Just over two in ten firms are involved in research and development activities, and ten percent of firms manufacture goods.

Figure 5. Value Chain



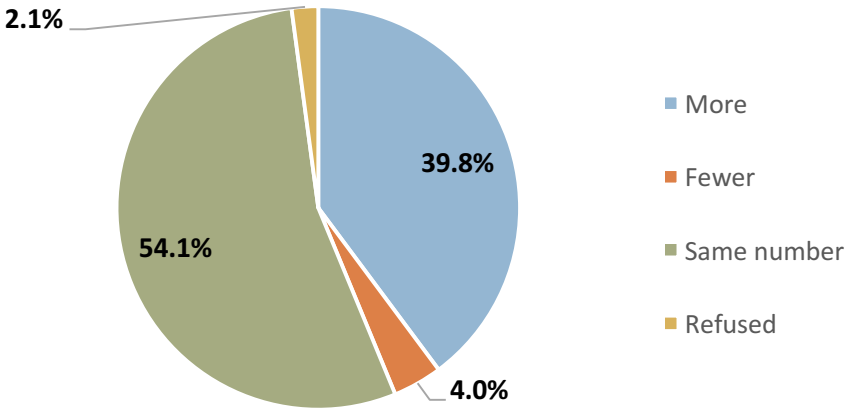
Information technology staffing ranges from one to more than 100 IT workers across surveyed firms. Just over a third of employers report 100 or more permanent ICT employees, but another 20% of firms report only one to five permanent ICT workers. The median number of ICT workers is 36.

Figure 6. Information Technology Staff Size



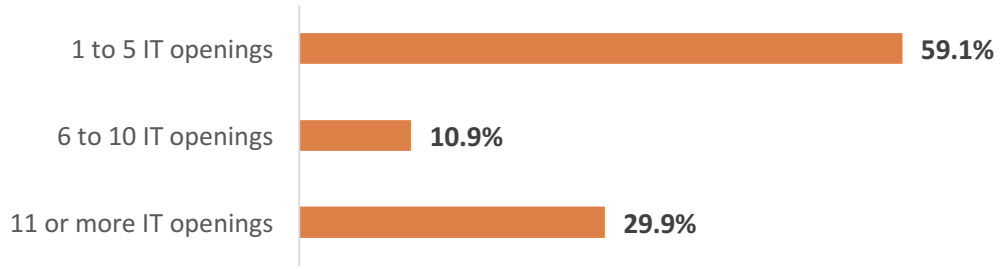
Projected growth for IT employment is six percent higher than overall firm growth. About four in ten employers expect to hire more information technology workers over 2016; these firms project almost nine percent growth (8.5%) in information technology employment over the next 12 months, compared to just over two percent projected (2.4%) overall firm employment growth for all workers.

Figure 7. Projected Information Technology Employment (2016 Projected)



The majority of firms report one to five current ICT employment opportunities at their locations. Of the firms that reported that they are currently trying to fill positions for ICT workers, over half note one to five open positions. Employers were not asked how long these positions have been open, but reported that managers, engineers, and developers are the most difficult to fill.

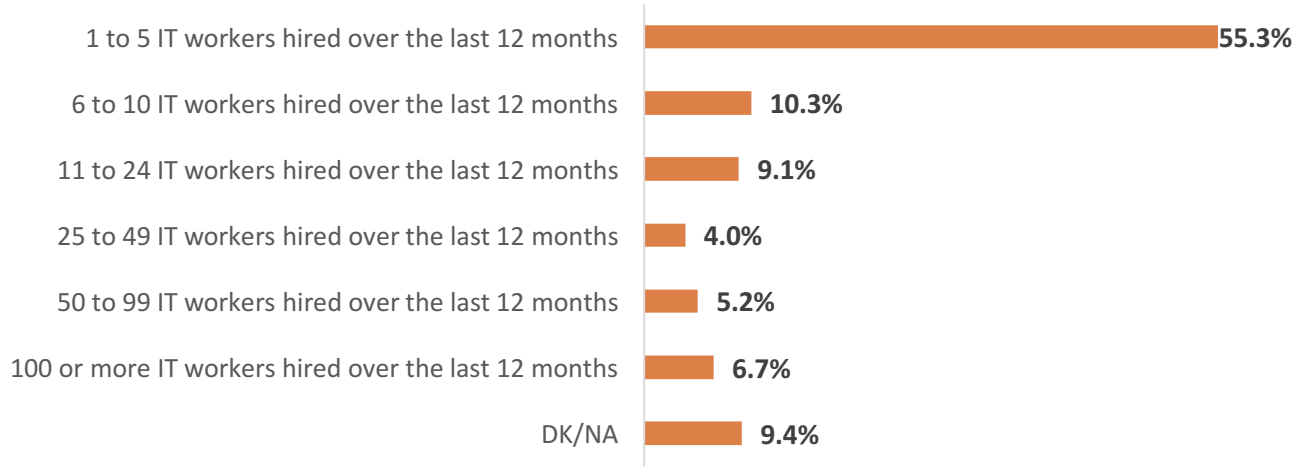
Figure 8. Number of Open Information Technology Positions



Most firms have hired one to five ICT workers over the last 12 months, and the majority were for positions that required relevant work experience. Fifty-five percent of employers report that they have hired one to five information technology specialists over 2015, and just under six in ten (58%) of these new hires required previous work experience related to the position. Forty-three percent of recent ICT hires required a Bachelor's degree or beyond, and 27% only required an Associate's degree or certificate from an accredited college.

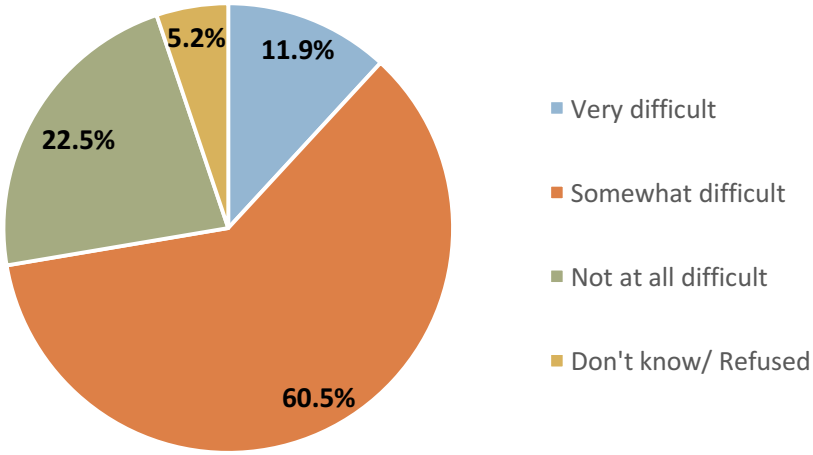
Thirty-one percent of ICT workers hired over the last 12 months are women, and just over a quarter (26%) are ethnic or racial minorities. Eighteen percent of recent ICT hires are veterans of the U.S. Armed Forces and 17% of IT new hires are over the age of 55.

Figure 9. New Information Technology Employees (2015)



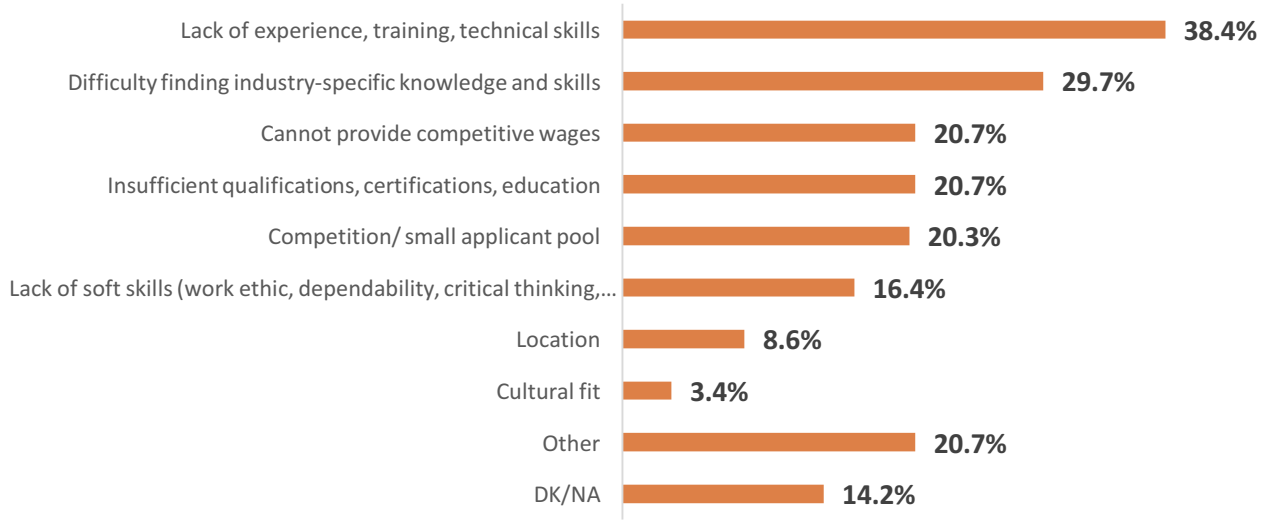
Employers report difficulty finding qualified candidates to fill their information technology positions. Just under three-quarters of firms report hiring difficulty in filling their open ICT positions over the last 12 months.

Figure 10. Hiring Difficulty



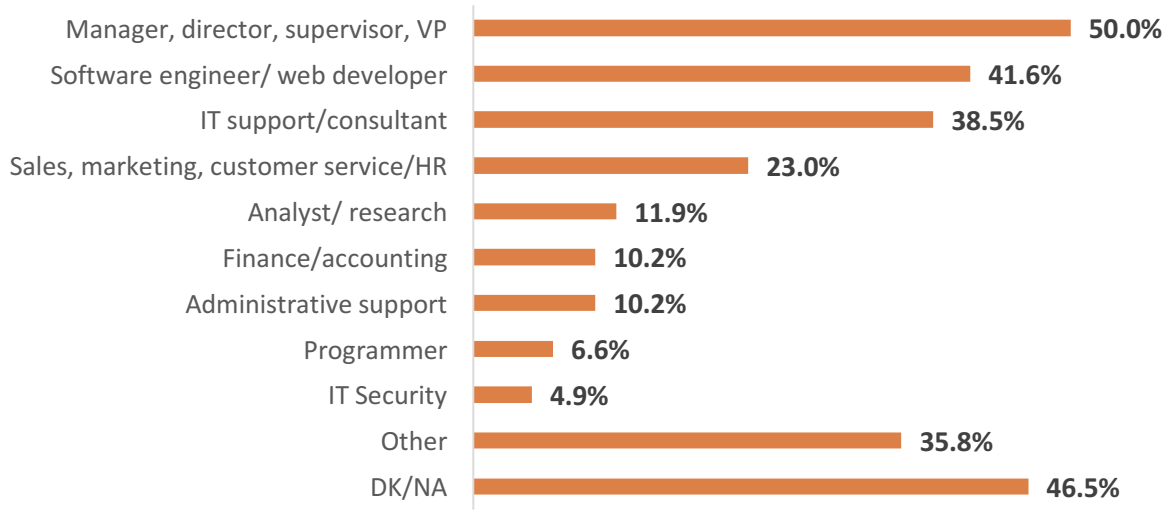
The most reported reasons for hiring difficulty were lack of experience, training, or technical skills. Almost four in ten firms mentioned this when asked what the two most significant reasons are for hiring difficulty. Another 30% of employers report difficulty finding industry-specific knowledge and skills, and about two in ten firms each reported that they cannot provide competitive wage, their applicants had insufficient qualifications, certifications, or education, or there is too much competition and a small applicant pool.

Figure 11. Reasons for Hiring Difficulty



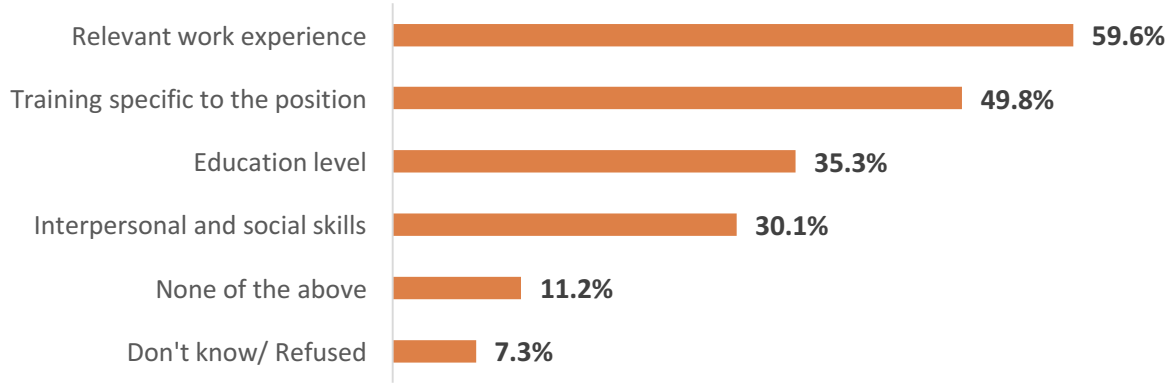
Firms report difficulty hiring for a number of positions from managers to administrative support. The most difficult ICT occupation to fill is in management; half of firms report qualified managers, directors, or supervisors are difficult to find, followed by software engineers or web developers and ICT support.

Figure 12. Most Difficult Positions to Hire



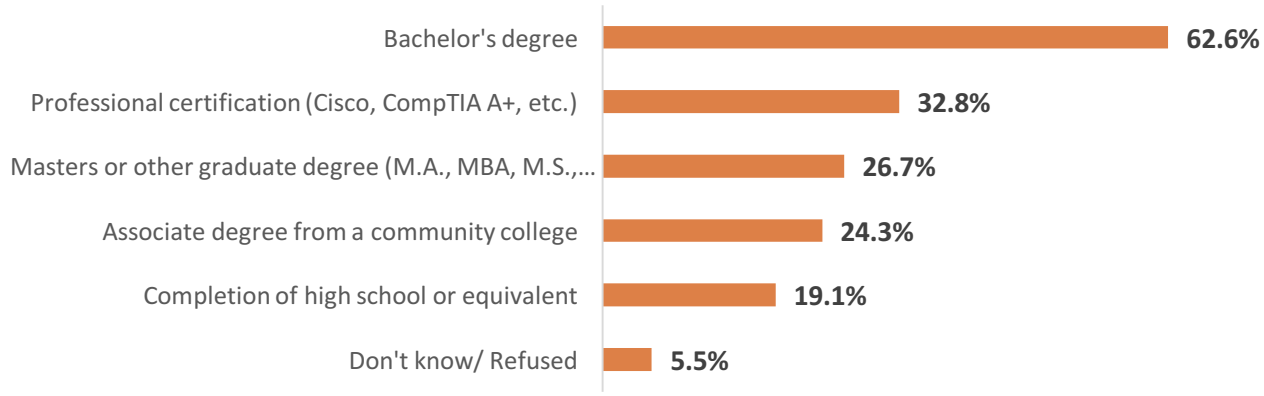
Firms also report that applicants do not meet their hiring standards for work experience, position-specific training, education, and non-technical skills. Half or more note difficulty finding qualified ICT applicants who meet hiring standards when it comes to relevant work experience and training specific to the position. About a third also note that applicants over the last 12 months did not meeting the firm's educational and soft skill requirements. Given the number of firms that report lack of interpersonal and social skills, together with reported difficulty finding workers with the right soft skills, suggests that there is a communication, problem-solving, and teamwork skill gap between what employers seek and what training programs produce.

Figure 13. Hiring Standards



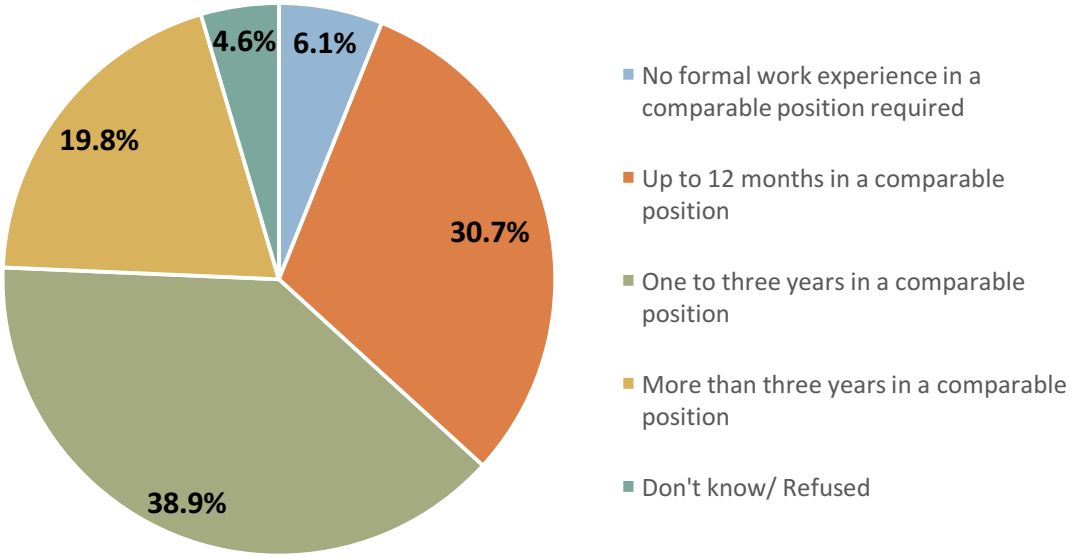
The majority of ICT positions typically require higher education. Over six in ten employers note that a Bachelor's degree is typically required of new information technology workers, and another third report that professional certifications are also typically required. Just over a quarter of firms expect some type of graduate degree.

Figure 14. Typical Education Requirements



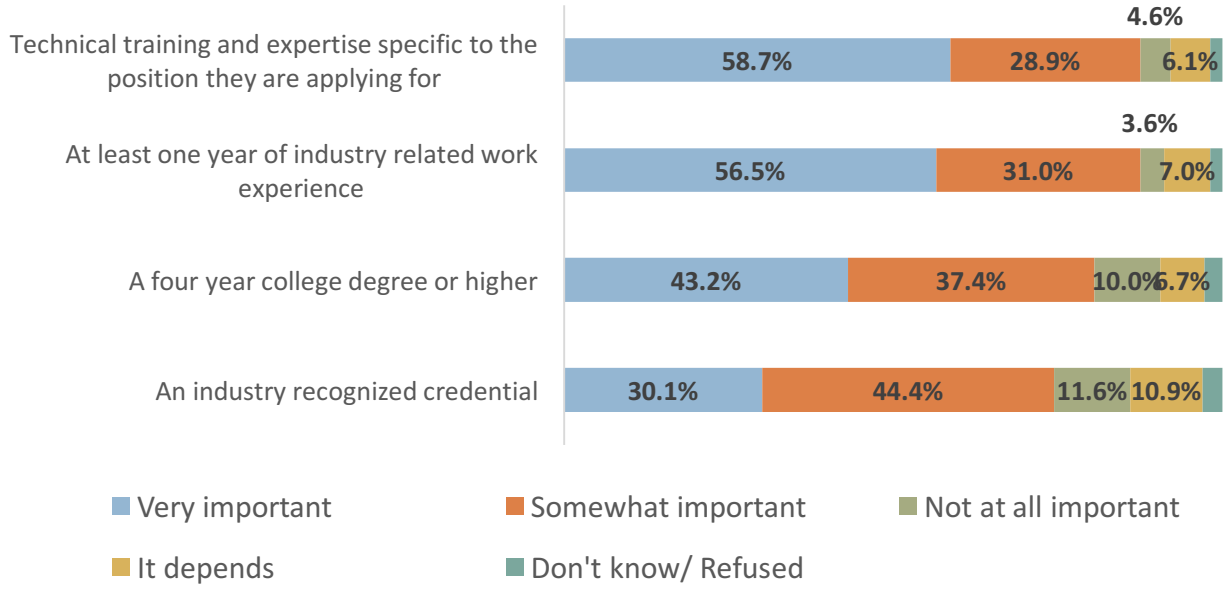
Most firms expect at least a year of work experience in a comparable position. Only six percent of respondents report that no formal work experience is required, but 89% note that at least a year to more than three years in a comparable position is typically required of their ICT applicants. Almost four in ten employers would like their ICT employees to have worked one to three years in a comparable position.

Figure 15. Typical Expected Work Experience



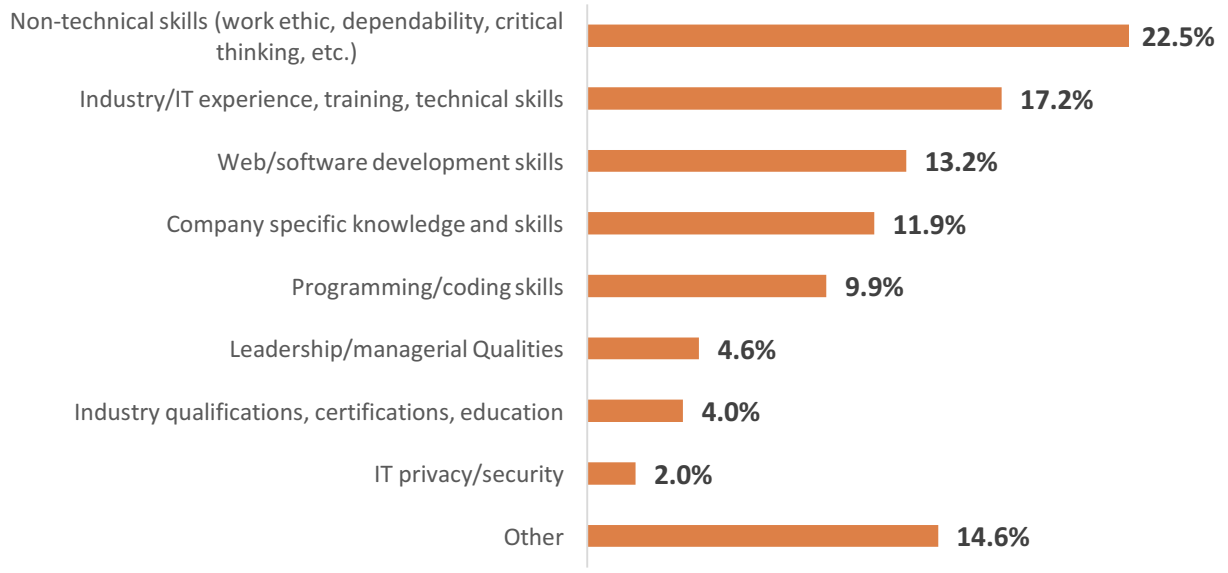
At least three-quarters of employers find technical training, relevant work experience, a four year college degree, and an industry-recognized credential as either very or somewhat important. The most important considerations for new candidates are occupation-specific technical training and at least one year of industry-related work experience; each of these qualities are rated important (very and somewhat) by almost nine in ten firms.

Figure 16. Importance of Training and Credentials



Employers report that non-technical skills are most difficult to find among non-entry level workers. Just under a quarter of firms find that work ethic, dependability, critical thinking, and other soft skills are most lacking in their non-entry level workers, followed by industry experience, training, or technical skills.

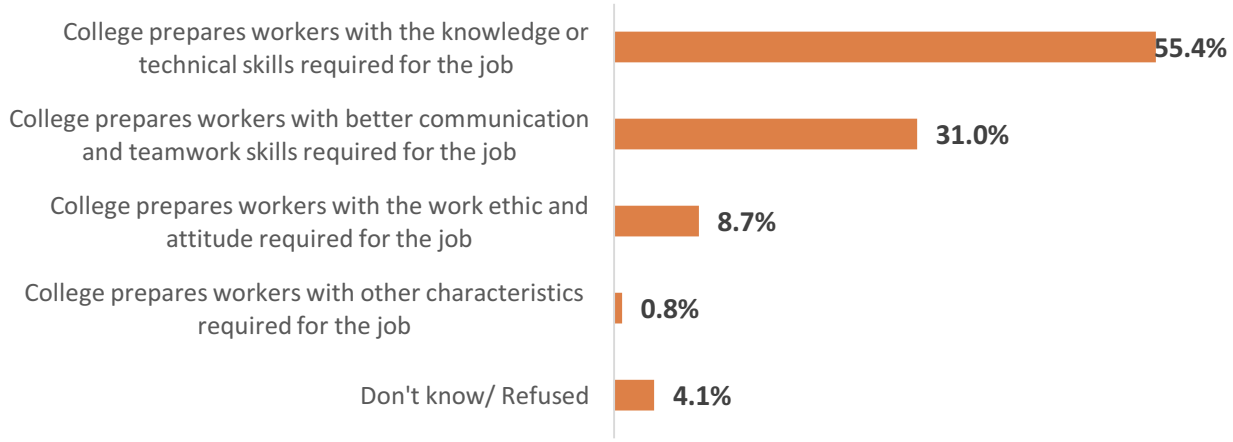
Figure 17. Skill Gap for Non-Entry Level Workers



Firms note that a college education lacks the ability to instill the soft skills—such as good work ethics—required for employment. Over half of employers find that college successfully prepares

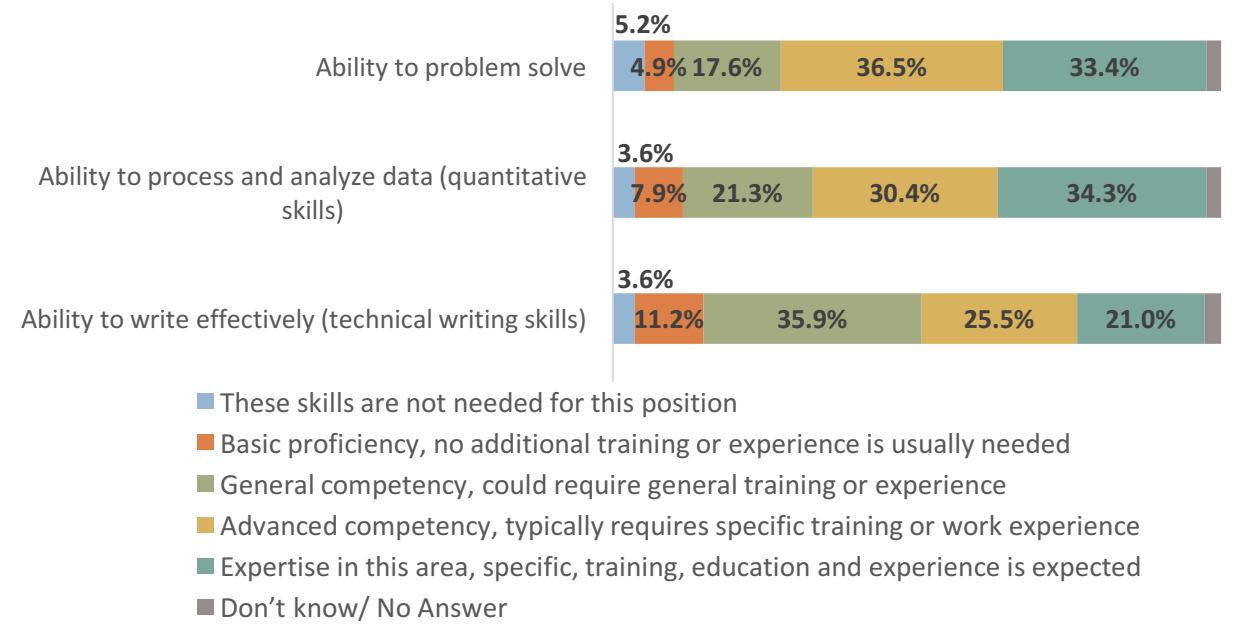
individuals with the knowledge and technical skills required, but less than ten percent believe that college successfully instills proper work ethics.

Figure 18. College Preparation



The ability to problem solve is a very important technical skill for ICT occupations. Seven in ten employers report that they require either advanced competency or expertise in this area for either new hires or current open positions. Quantitative skills, such as the ability to process and analyze data are also important; 65% of firms expect ICT workers to have either advanced competency of expertise in this area, followed by the ability to write effectively (47%).

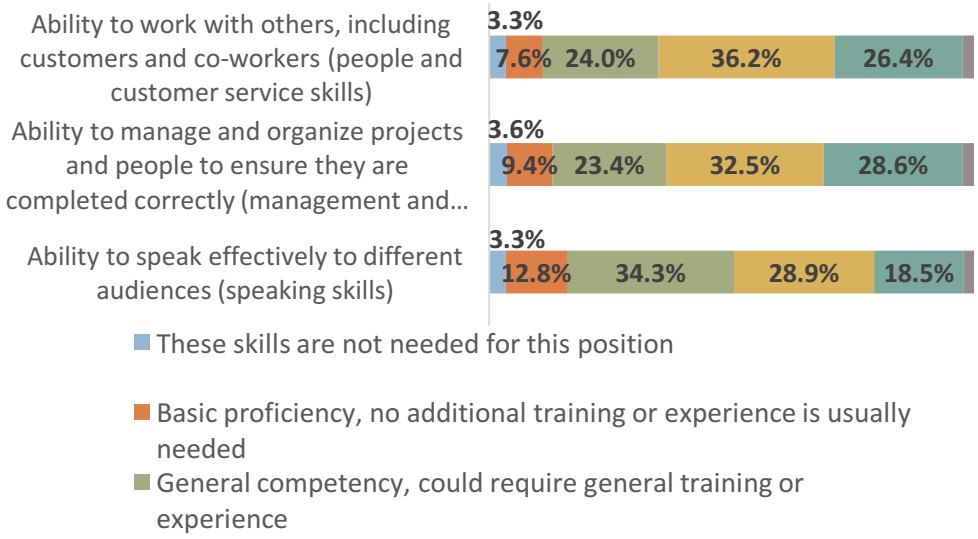
Figure 19. Important Technical Skills



Employers also expect their ICT specialists to possess customer service, organizational, and speaking skills. The ability to work with others is the most important non-technical skill for firms; just under two

thirds of firms expect that their ICT employees will have advanced competency or expertise in this area, followed by management and organizational skills (61%) and effective verbal communication (47%).

Figure 20. Important Non-Technical Skills



Information and Communication Technologies: The Talent Supply

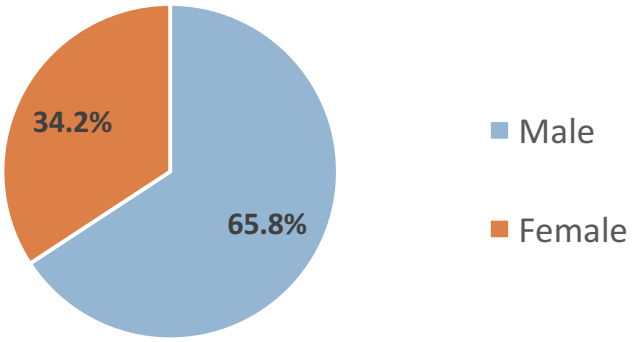
In addition to surveying ICT employers across Massachusetts, BW Research also recruited just over 100 ICT workers from across the state to provide insight into the supply side of the ICT industry. These individuals participated in a survey to provide deeper understanding on successful career strategies within technology-related fields. Questions covered individual pathways to career advancement, barriers, and potential solutions to move forward in ICT occupations, as well as the importance of various technical and non-technical skills for success in the industry.

Following this career navigation survey, participants agreed to take additional personality and skill assessments. The Woofound assessment by Traitify asks individuals to identify with different activities, crafts, or situations and then assigns a percentage to various personality traits—visionary, planner, analyzer, action-taker, naturalist, inventor, or mentor—and the best work environments for these participants. Respondents also took the Strengthsquest assessment which provides qualitative data on the top five strengths of IT workers who participated. Finally, a subset of respondents also agreed to take a longer, more rigorous exam known as CTECS. This exam tests workplace readiness skills related to the ICT industry in three categories—personal qualities and people skills, professional knowledge and skills, and technology knowledge and skills. Individuals received a percentage score depending on their proficiencies, and each major skill is broken-down into skill subsets, such as positive work ethic, integrity, critical thinking and problem solving, or internet use and security.

Demographics and Background

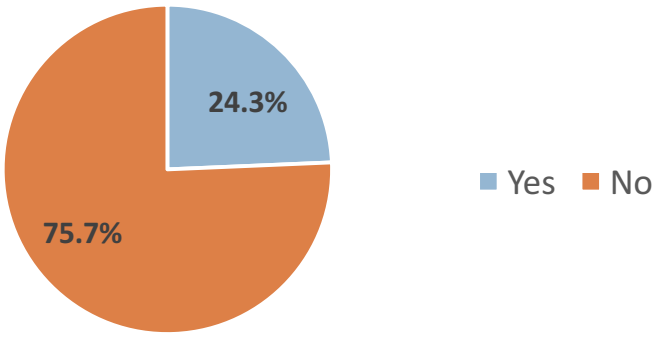
The majority of ICT workers are male. About two thirds of information technology professionals are male, and just over a third are female. This compares to 51% of men in the overall statewide workforce and 49% women.[11]

Figure 21. Gender



Few ICT employees identify themselves as racial or ethnic minorities. The majority—just over three-quarters—of surveyed information technology workers did not identify themselves as racial or ethnic minorities. This is similar to the overall population in Massachusetts, which reports about 26% racial or ethnic minorities.[12]

Figure 22. Racial or Ethnic Minority

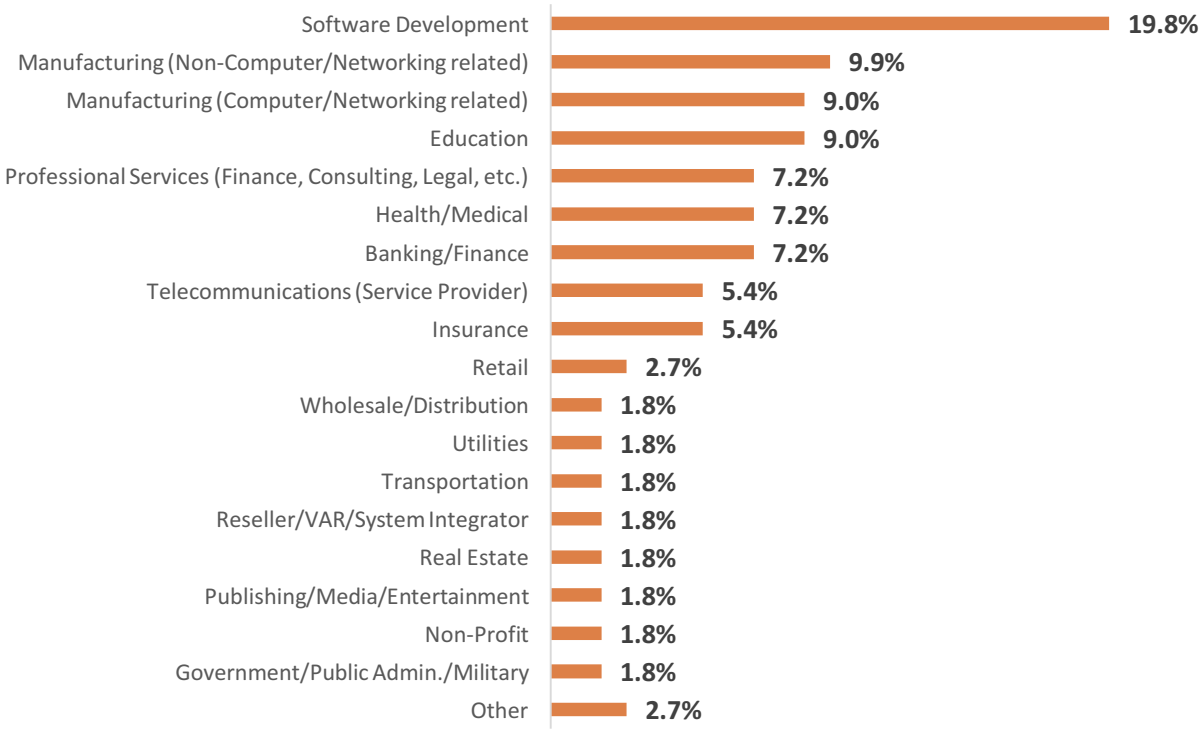


[11] American Community Survey 2014 1-Year Estimate; Sex by Occupation for the Civilian Employment Population 16 Years and Over

[12] American Community Survey 2010-2014 5-Year Estimate; ACS Demographic and Housing Estimates

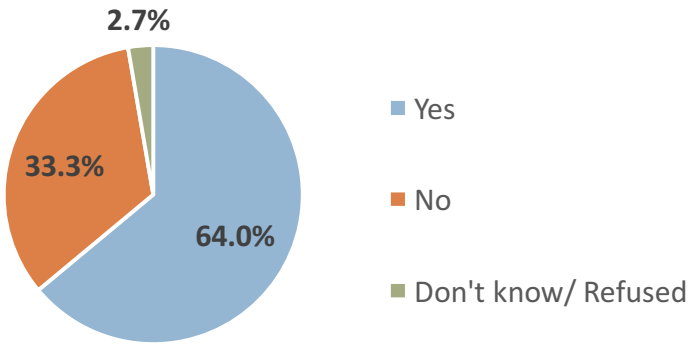
Information Technology workers are found across a very diverse spread of industries. Two in ten respondents note that their firm is in the software development industry; this was the largest chunk of responses. An additional two in ten report they are in manufacturing, both computer and non-computer or networking-related, but the rest of workers are spread across education, professional service, healthcare, finance, insurance, retail, and other industries.

Figure 23. Industry



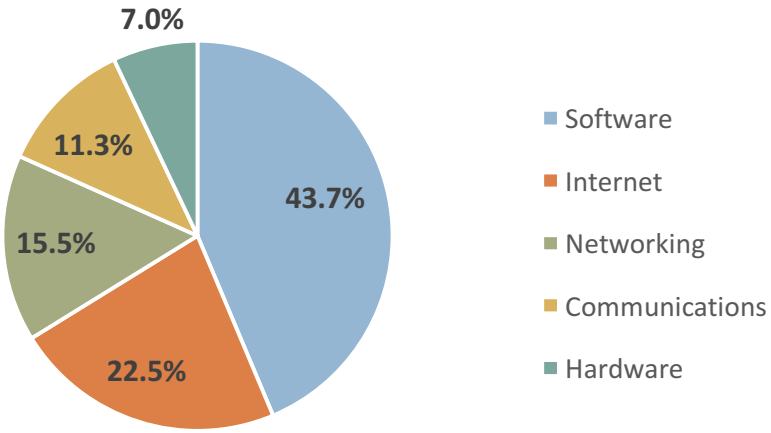
However, in an aided question, **the majority of workers report that they are also in the broadly defined information communication technology sector.** Only a third of firms replied that their companies are not in the ICT sector.

Figure 24. Information Communication Technology Sector



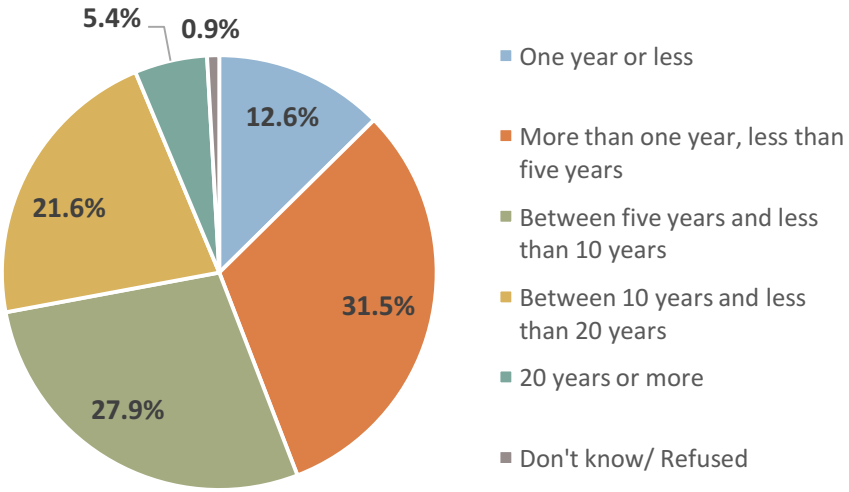
Of workers that report they are in the information communication technology sector, **just under half note they are most closely connected to the software industry.** Forty-four percent of workers support software, and about a quarter work in the internet industry, followed by networking with about one-sixth of respondents.

Figure 25. Information Communication Technologies Breakdown



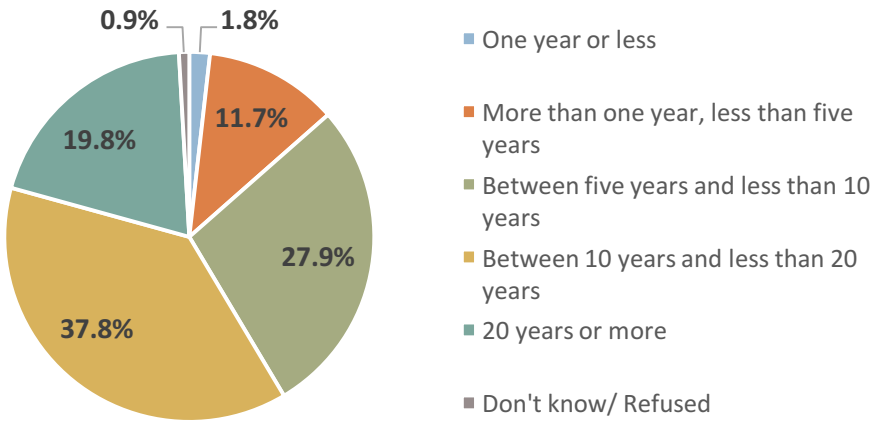
ICT employees across Massachusetts have varied experience in the sector. Almost half of respondents note they have worked in their current position between five to 20 years—the largest chunk of responses is five to ten years. Just over five percent of workers report they have been working for 20 years or more, and 13% note they have been at this job for less than one year.

Figure 26. Years in Current Position



Men and individuals with a Master's degree or greater are more likely to have longer experience in a technology-related field compared to women or those with a Bachelor's degree or less.

Figure 27. Years in Technology-Related Field



Careers, Education, and Training

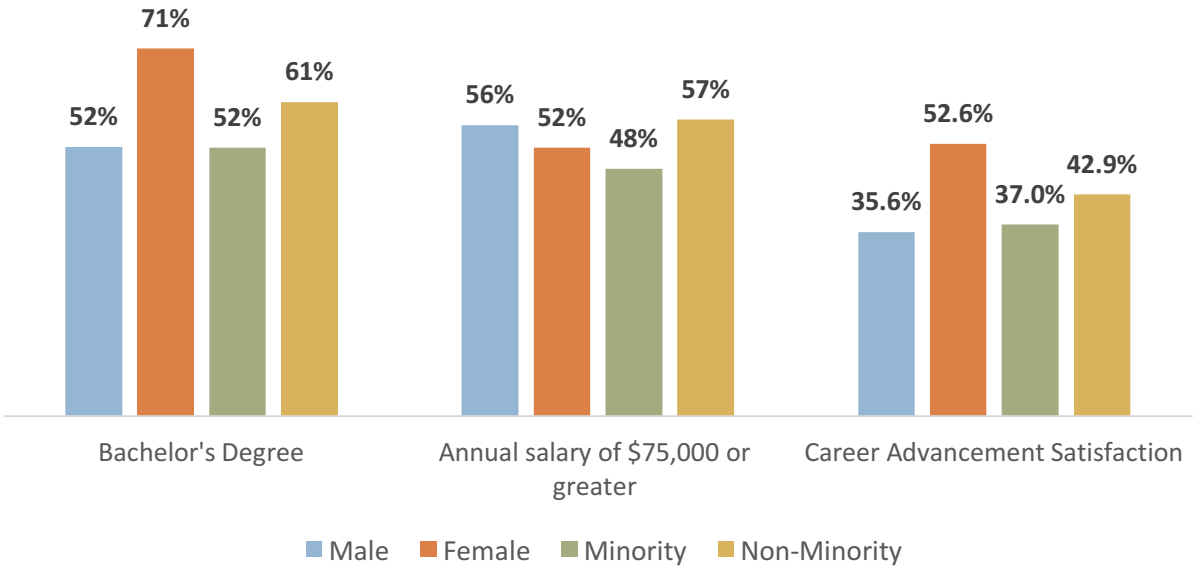
Demographic Assessment

The following are some key findings regarding demographic differences within the Information Communication Technology workforce in Massachusetts:

There is a slight difference between men and women across experience, educational attainment, and annual salary. Men are slightly more likely to have spent ten years or more in a technology-related field than women, but they are also more likely to have no degree; eight percent of men reported they have no degree compared to none of the surveyed women. Though there is a slightly higher percentage of men that have achieved a Master's degree or beyond (29% vs. 21%), there are significantly more women who have completed their Bachelor's degree (71% vs. 52%). With regards to wages, women make slightly less than their male counterparts; just over half of female IT workers (52%) report they earn $75,000 or more per year compared to 56% percent of men.

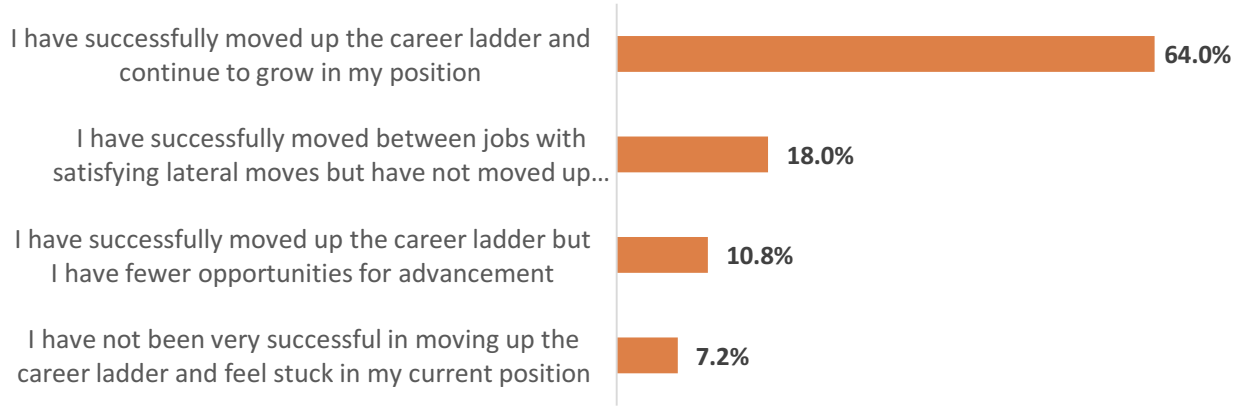
Though minorities tend to have as much education and experience, they report both lower wages and satisfaction with career advancement. Eighty-two percent of minorities have a Bachelor's degree or greater; three in ten note that they have completed their Master's degree or beyond—compared to a quarter of non-minorities—and fewer report having no degree compared to non-minority IT workers. Minorities are more likely to report that they have been working in their current position for over ten years, but only 37% of minorities agree that they have advanced as quickly in their career as they would like, compared to 43% of non-minorities. Minority IT workers are also less likely to make above $75,000 compared to their non-minority counterparts.

Figure 28. Demographic Comparisons by Education, Salary, and Career Advancement



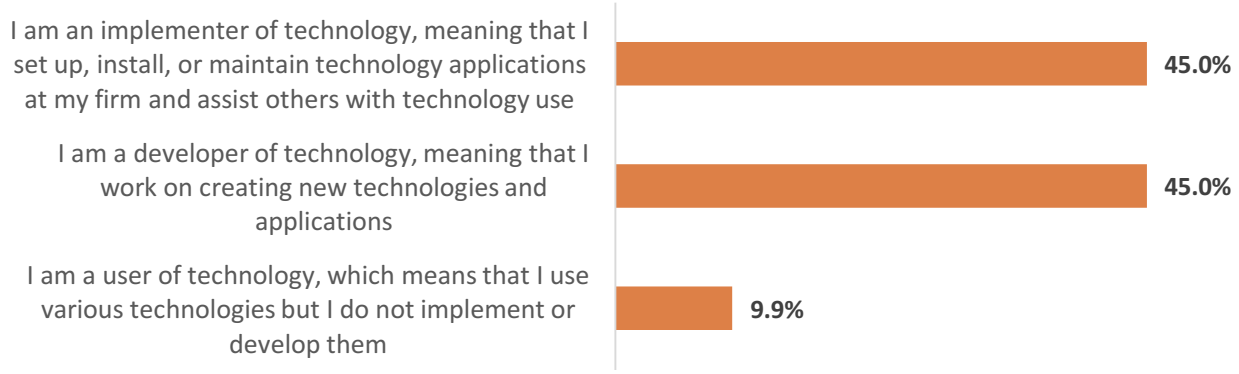
The majority of employees note that they have not only moved up the career ladder, but also continue to grow in their position. Just over two-thirds of surveyed information technology workers report this, and 11% note they have moved up the career ladder but now have fewer opportunities for advancement. Seven percent of respondents feel they are stuck in their current position.

Figure 29. Career in Technology



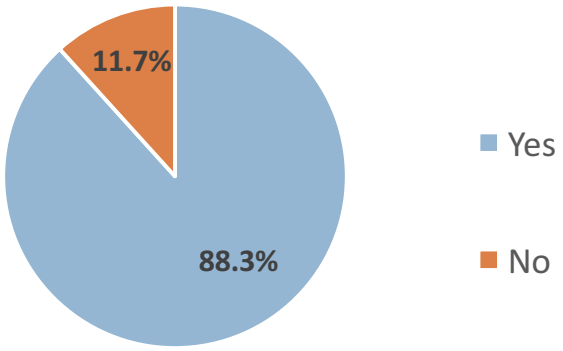
The majority of information technology professionals are either technology implementers or developers. Forty-five percent of respondents note that they install or maintain technology applications at their firm, assisting others with technology use, and another 45% work to create new technologies and applications. Only ten percent of respondents report that they only use the technologies that are provided.

Figure 30. Use of Technology in Current Position



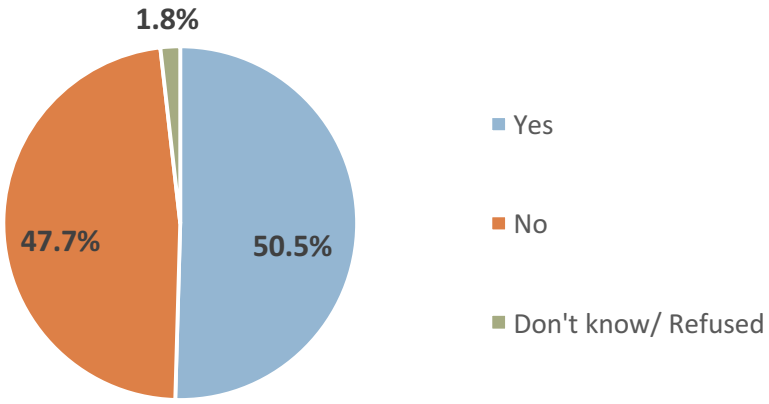
The majority of information technology professionals have received formal education or training; 88% of respondents report they have in fact received formal education or training on the use, implementation, or development or technologies.

Figure 31. Formal Education for Technology



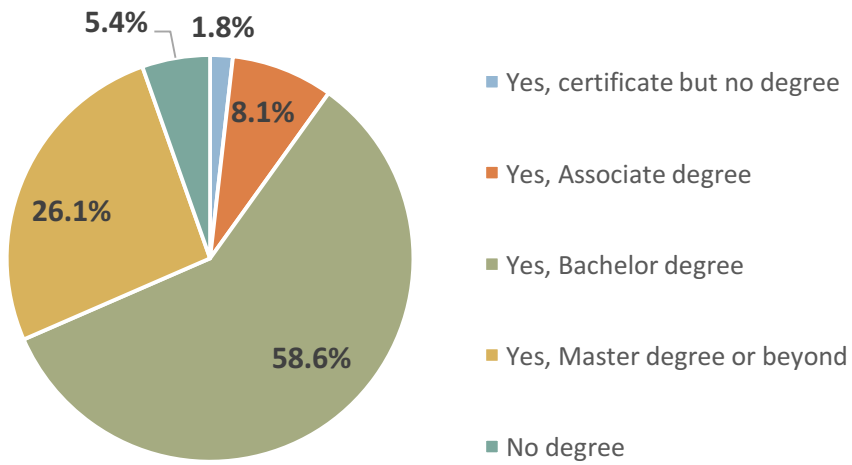
However, fewer have technological certifications. About half of survey respondents have certifications—such as CompTIA, Microsoft, Cisco, or Java—while the other half do not have such certifications.

Figure 32. Certifications



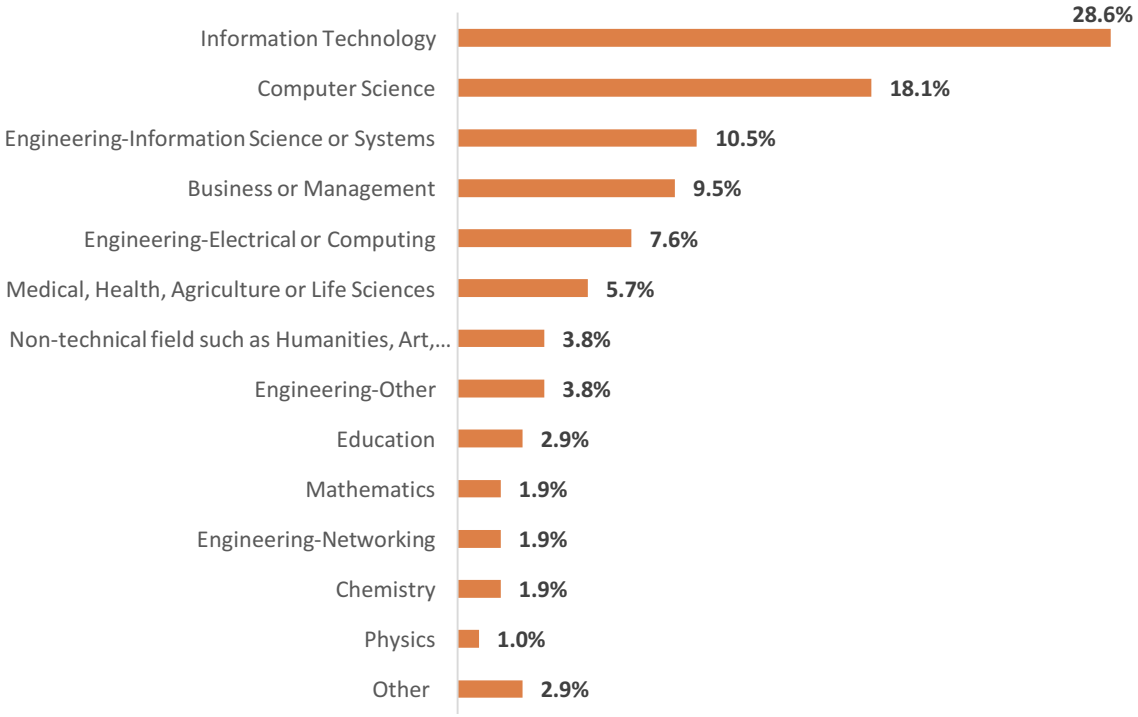
The majority of information technology professionals have completed higher education. About 85% of respondents note they have either a Bachelor's degree, Master's degree, or beyond; 59% of IT workers have a Bachelor's degree—this is the largest chunk of responses. Few individuals report that they have no degree; men and non-minorities are more likely to fall into this category than women and minorities.

Figure 33. College Certificate or Degree



About six in ten information technology professionals received their degree in a related field. Fifty-seven percent of individuals report that they studied either Information Technology, Computer Science, or Engineering for Information Science or Systems.

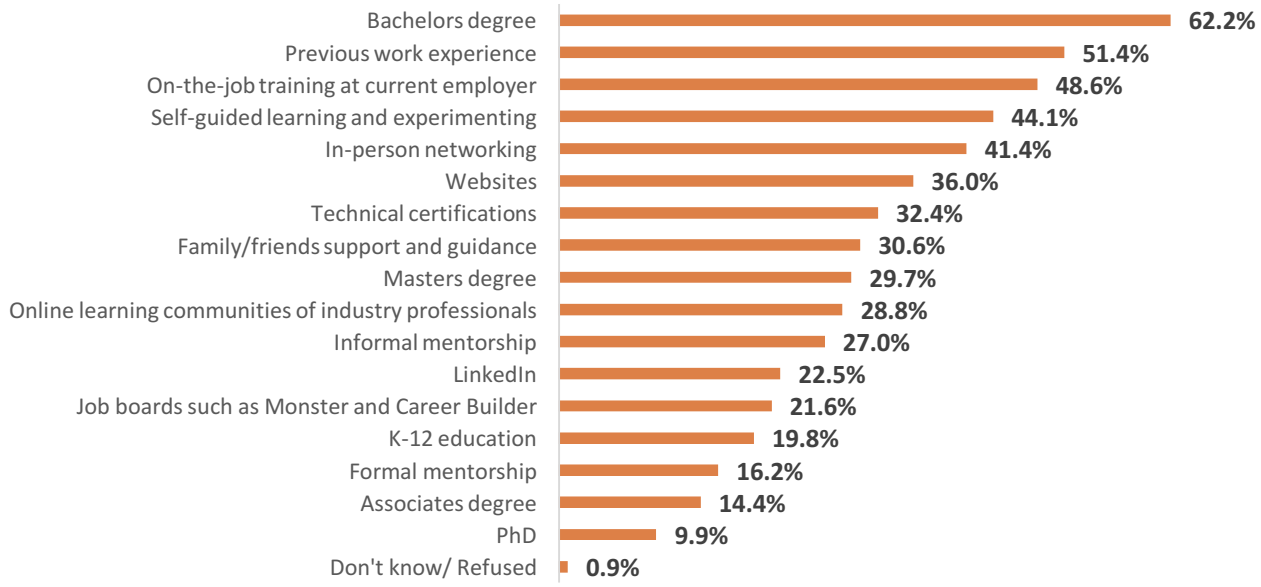
Figure 34. Primary Field of Study



Keys to Success

Higher education, work experience, and on-the-job training are most important for successful career navigation. About half or more of surveyed information technology professionals note that a Bachelor's degree, previous work experience, and on-the-job training have been most important in successfully advancing their career to new jobs with increased pay and responsibilities. Self-guided learning and experimenting is also rated highly important by 44% of respondents.

Figure 35. Resources for Successful Career Navigation

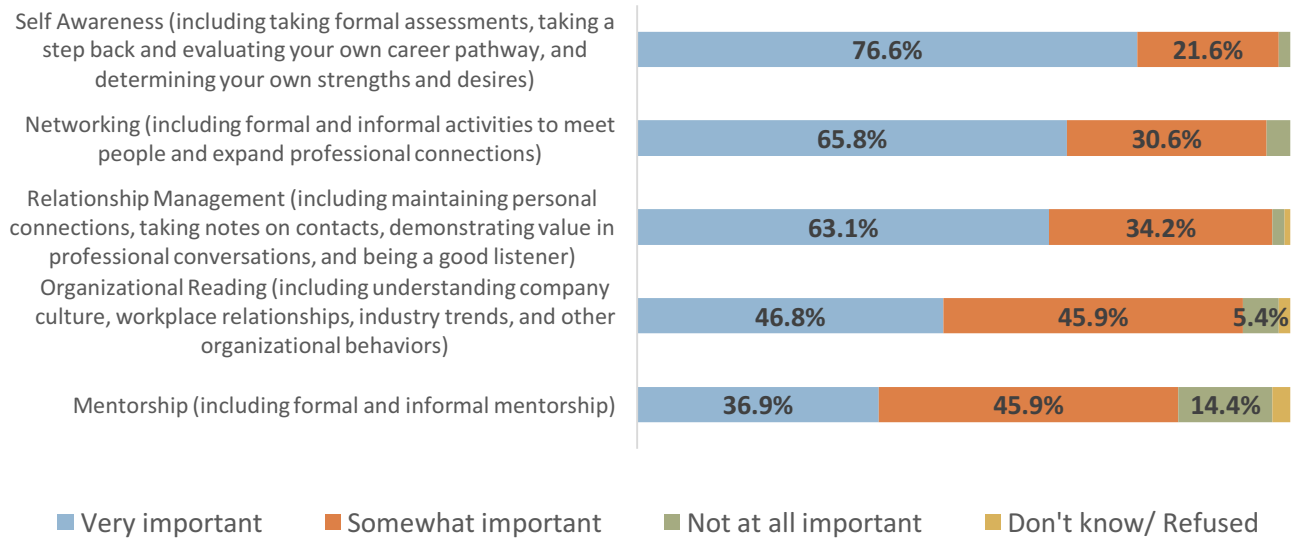


Self-awareness, networking, and relationship management are rated very important for career advancement by over half of IT professionals. In fact, self-awareness—formal assessments, understanding strengths and desires, or career pathway evaluation—is considered important (very and somewhat) by nearly all survey respondents, and very important by just over three-quarters; this skill is the most highly rated in importance for career advancement. Networking, or formal and informal activities to meet people and expand professional connections, was also rated important by nearly all respondents, followed by relationship management—maintenance of personal connections, value demonstration in professional conversations, remembering contacts, and being a good listener.

Respondents note that they spend the most time each month developing, practicing, or conducting relationship management—an average of 15 hours and a median of 10—followed by organizational reading, networking, mentorship, and self-awareness.

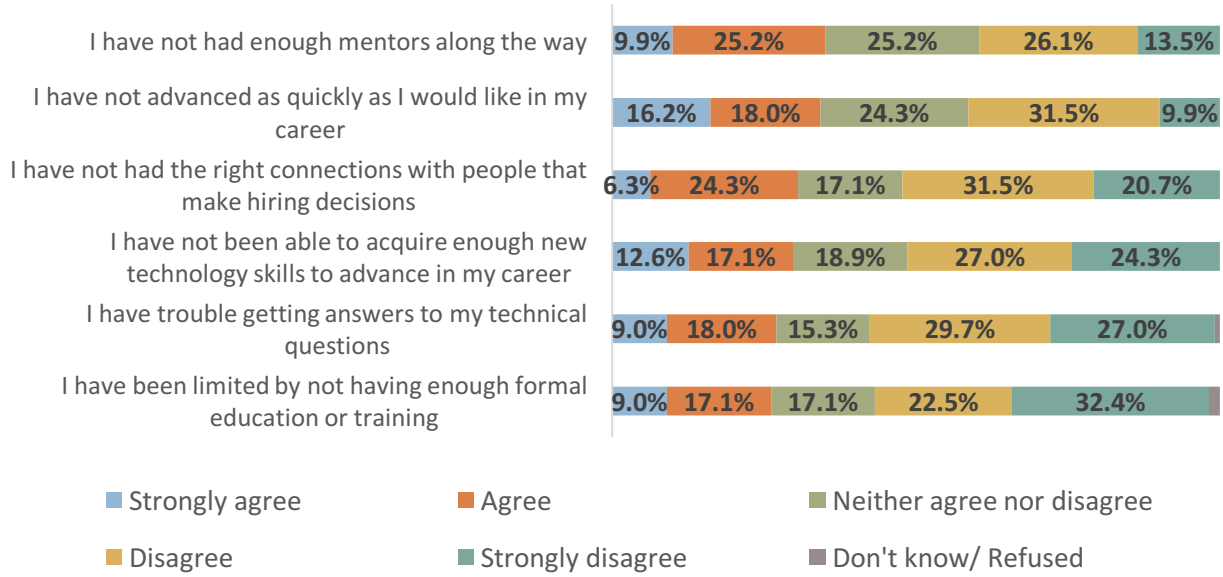
Individuals who self-reported as minorities are more likely to find mentorship very and somewhat important compared to those who identify as non-minorities.

Figure 36. Importance of Career Advancement Activities



Lack of sufficient mentorship is perceived as the greatest obstacle to career development. Lack of mentorship during their career received the highest agreement (strongly and agree) from information technology professionals, followed by feeling they have not advanced as quickly as they would like, and not having the right connections with people that make hiring decisions.

Figure 37. Career Obstacles

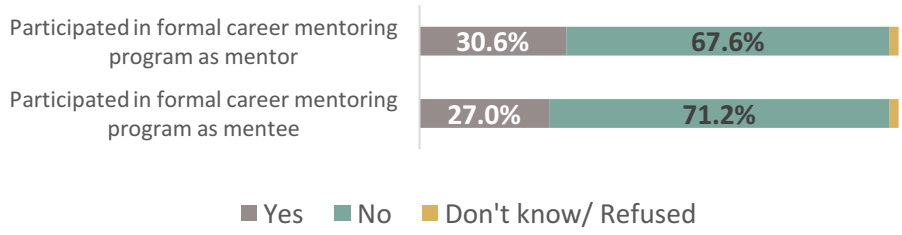


Few individuals have participated in formal career mentoring programs as either a mentor or a mentee. Only about three in ten individuals report that they have either received mentorship or provided mentorship in a formal career mentoring program. Men are more likely to participate as either

a mentor or mentee compared to women, as are minorities and individuals with a Master's degree or more.

In fact, few firms actually offer mentorship programs. Just under a third of firms report that they have some type of formal mentorship program, but 68% of firms do not.

Figure 38. Mentorship Program



Skill and Competency Profiles

Information technology professionals were most highly rated as planners, analyzers, and action-takers. Surveyed IT workers that participated in the Woofound personality test were more likely to score higher for their personality traits as planners, analyzers, and action-takers. Planners are most often found in office settings; they enjoy detail-oriented work, such as data analysis, and are methodical and precise. Analyzers are inquisitive in nature and excel at finding information and identifying solutions. Action-takers enjoy manual or physical tasks, using machinery or technology to complete projects; they are practical, systematic, and applied—drawn to jobs that involve a specific skill-set and concrete task.

Of these top three personality traits, the most correlated are analyzers and action-takers—the higher an individual scores in the analyzer category, the more likely they are to be an action-taker as well. This is particularly true for men as well as those individuals that are employed in the manufacturing or software development industries.[13]

[13] The overall R-squared value is .65; R-squared for men only is .86; R-squared for manufacturing is .99; and R-squared for software development is .94.

Table 1. Personality Traits, Average Scores

Personality Trait	Average Score
Planner	71.6%
Analyzer	70.6%
Action-Taker	64.3%
Visionary	63.1%
Mentor	58.0%
Naturalist	51.2%
Inventor	50.4%

More than a quarter of information technology employees work best in a structured environment with clear goals and tangible results that still manages to foster autonomy and encourage investigation. Almost half of respondents work best in an environment that fosters autonomy, and another four in ten work best in an environment that is routine-oriented and structured yet still encourages investigation; three in ten individuals work best in an environment that offers tangible results and clearly outlines goals to be accomplished.

Table 2. Top Five Best Work Environments

Work Environment	Percent of Cases
Fosters autonomy	48%
Is routine-oriented and structured	41%
Encourages investigation	38%
Offers tangible results	28%
Outlines clear goals to be accomplished	28%

Information technology workers exhibit the greatest strengths in their input, learning, and strategic skills. About three in ten individuals were found to have input, learner, and strategic strengths, and just under a quarter also demonstrate achiever, deliberative, harmony, ideation, analytical, relator, and responsibility strengths.

Table 3. Top Ten Strengths

Strength	Percent of Cases
Input	31%
Learner	28%
Strategic	28%
Achiever	24%
Deliberative	24%
Harmony	24%
Ideation	24%
Analytical	21%
Relator	21%
Responsibility	21%

Of the three major workplace readiness skills for the Commonwealth—personal qualities and people skills, professional knowledge and skills, and technology knowledge and skills—**information technology workers received the lowest average score in their professional knowledge and skills,** particularly in critical thinking and problem solving—their ability to analyze and resolve problems that arise in completing assigned tasks. Not surprisingly, these individuals scored highest in their technology knowledge and skills, especially for the information technology subset, or their ability to use computers, file management techniques, and software programs effectively. In fact, individuals performed at or above 86% in all four of the information technology skill subcategories, which is above the national or state average on these four IT skills.

Table 4. Workplace Readiness Skills, Average Scores

Workplace Readiness Skills for the Commonwealth	Average Score
Personal Qualities and People Skills	**82.6%**
Positive Work Ethic: Comes to on time, willing to take direction, motivated to accomplish the task at hand	73.7%
Integrity: Abides by workplace policies and laws and demonstrates honesty and reliability	92.6%
Teamwork: Contributes to the success of the team, assists others, and requests help when needed	87.4%
Self-representation: Dresses appropriately and uses language and manners suitable for the workplace	71.1%
Diversity Awareness: Works well with all customers and coworkers	89.5%
Conflict Resolution: Negotiates diplomatic solutions to interpersonal and workplace issues	84.2%
Creativity and Resourcefulness: Contributes new ideas and works with initiative	75.8%
Professional Knowledge and Skills	**79.2%**
Speaking And Listening: Follows directions and communicates effectively with customers and employees	86.3%
Reading And Writing: Reads and interprets workplace documents and writes clearly	75.8%
Critical Thinking And Problem Solving: Analyzes and resolves problems that arise in completing assigned tasks	64.5%
Health And Safety: Follows safety guidelines and manages personal health	73.7%
Organizations, Systems, And Climates: Identifies big picture issues and role in fulfilling workplace mission	86.3%
Lifelong Learning: Continually acquires new industry-related information and improves professional skills	81.1%
Job Acquisition And Advancement: Prepares to apply for a job and to seek promotion	82.1%
Time, Task, And Resource Management: Organizes and implements a productive plan of work	78.9%
Mathematics: Uses mathematical reasoning to accomplish tasks	71.6%
Customer Service: Identifies/addresses all customer needs; helpful, courteous, and knowledgeable service	88.4%
Technology Knowledge and Skills	**89.5%**
Job-Specific Technologies: Selects and safely uses tech resources to productively accomplish responsibilities	89.5%
Information Technology: Uses computers, file management techniques, and software/programs effectively	92.6%
Internet Use And Security: Uses the Internet appropriately for work	85.5%
Telecommunications: Selects and uses appropriate devices, services, and applications	89.5%

Key Findings and Recommendations

Employers report hiring difficulty, as applicants fail to meet their standards. Almost three-quarters of firms report that they have had difficulty finding qualified IT workers in the last 12 months, and about half of these employers note that IT applicants fail to meet their hiring standards in terms of relevant work experience and occupation-specific training. A significant number—about three in ten—also mention that potential new hires do not meet their standards for interpersonal and social skills.

Higher education and work experience is very important at information technology firms. The majority of employers require a Bachelor's degree, and about three in ten each require additional certifications or a Master's degree. Four in ten firms expect their IT applicants to have one to three years of experience in a comparable position, and another 20% would like their new hires to have over three years of experience. **Not surprisingly, the majority of surveyed IT workers have completed higher education in some technology-related field.** In fact, at least half of information technology professionals report that higher education, experience, and on-the-job training have been important for successfully advancing their career.

However, employers also expect IT new hires to be proficient at both technical and non-technical skills. Over half of firms report that their information technology new hires must have either advanced competency or total expertise in problem-solving, data analysis and processing, people and customer service, and management or organizational skills. Just under half also expect advanced competency or expertise in effective writing and communication skills. **Indeed, current information technology workers are also cognizant of the importance of soft skills.** Just under half note that self-guided learning and experimenting have been important in successful career navigation and advancement. In fact, self-awareness was rated very important by just over three-quarters of IT professionals, and nearly all find this skill either very or somewhat important.

Despite this, employers find that non-entry level job applicants are most lacking in their non-technical skills. According to surveyed information technology employers, non-technical skills, such as work ethic, dependability, or critical thinking, are most difficult to find among their non-entry level job applicants.

Moreover, very few firms find that college prepares individuals with all of the soft skills needed for career success. Of employers that have hired a new IT worker with a Bachelor's degree over the last 12 months, the majority agree that college prepares individuals with the knowledge and technical skills required for a job. However, few report that college prepares workers with the proper work ethic and attitude.

Information technology professionals note that a lack of mentorship has created obstacles in career advancement. Just over a third of IT employees agree that they have had insufficient mentors along their career pathway. Only one in three surveyed firms offer mentorship programs, and less than three

in ten surveyed employees report that they have participated in a formal career mentoring program as a mentee; just over three in ten report that they have participated as a mentor.

Though Massachusetts exhibits above average strength in both occupational concentration and growth potential, employers still note difficulty finding qualified applicants to fill these open positions. Just under half of recent ICT new hires required a Bachelor's degree or more and about six in ten required previous work experience. But while higher education and work experience are very important to employers, only about half of information technology professionals received their degree in a related field. This suggests that employers are using college degrees as a proxy for critical thinking and other related skills, as opposed to the industry-specific technical skills gained during coursework. However, few employers believe that college adequately instills other non-technical skills such as communication, teamwork, and work ethic. This seems particularly true for high-level management positions, where the ability to communicate effectively and work with others becomes increasingly important as individuals advance in their careers. Indeed, employers note that not only are they having the most difficulty finding managers, directors, and supervisors, but also that these non-entry level applicants are most deficient in soft skills.

Many information technology professionals comment on the importance of self-driven non-technical skills in addition to mentoring programs for career advancement, but unfortunately few such programs exist. Entry-level new hires are likely to gain the necessary technical skills from both education and on-the-job training, but there may be more opportunity for company-driven mentorship programs that foster personal growth and ultimately career advancement. Furthermore, the industry's lack of diversity may indicate yet more opportunity in terms of untapped talent potential across these demographic minorities. Expanding the talent pool to underrepresented communities with training, career navigation, and mentorship support could drive growth in these high-demand soft skills, alleviate the talent shortage, and foster economic growth by placing individuals into long-term, sustainable career pathways. Specifically, we recommend the following actions to expand ICT employment opportunities and support the local economy:

1. **Develop career exposure and experience programs that focus on diversity**. Employers report a desire for a more diverse workforce, but women and racial or ethnic minorities remain underrepresented. However, ignoring current demographics within the ICT workforce and providing less exposure to underrepresented communities may lead women and people of color to exclude themselves from the field. Left on its own, lack of diversity can have a spiraling effect, as networks, mentors, and opportunities remain segregated. It is critical, therefore, to engage in intentional dialogue about race, ethnicity, and gender in ICT.

2. **Integrate problem solving and critical thinking into all ICT training.** The Bachelor's Degree has become a proxy for many employers. A college degree certainly provides the necessary knowledge and skills for some ICT jobs, but too often, employers will only hire candidates with a degree because they desire the problem-solving, analytical, and critical thinking skills often associated with college. Not only is this an expensive solution (college degree holders have

higher pay), the research suggests that most college programs do not improve critical thinking and problem-solving without intentional design to do so. Noncredit coursework that includes critical thinking modules (such as NSF-funded CAT Apps[14]) can bridge the gap at a fraction of the cost.

3. **Provide expanded networking and mentorship opportunities**. Particularly for underrepresented populations, mentorship is reported as a critical success factor. However, just under one third of ICT employers report that their company has a formal mentorship program. Developing formal mentorship and networking programs provides several tangible benefits. First, it helps individuals mitigate some of the risks of their career development by following the advice and pathways of their mentors. In addition, it leads to more dialogue about career navigation strategies for non-traditional (e.g., college educated) pathways. Finally, diverse career networks and mentorship programs help to break the spiral bred by lack of diversity, and help to break silos in hiring and advancement.

4. **Work with job-seekers to showcase their talent**. Job seekers—particularly those who have lacked mentorship and professional ICT networks—must focus their job search and marketing efforts on the value they can bring to an organization. This includes helping job applicants to recognize companies' place in the market, highlighting how they can make the organizations more effective, and position themselves as good communicators and team players, problem-solvers, and how they integrate their technical and non-technical skills to maximum effect.

5. **Engage employers to explore non-traditional hiring sources and internship opportunities**. While most of the recommendations in this report have been focused on job seekers and the training community, employers that continue to draw from their traditional sources (e.g., degree programs, non-diverse candidate pools, etc.) will have fewer candidates to draw from and may miss out on more targeted and effective programs. There is always perceived risk to change, but with increasing numbers of unfilled, open positions, greater difficulty hiring, and increased competition for talent, expanding the talent pool is becoming an economic imperative. SkillWorks and its partners and stakeholders can play a critical role in engaging with employers and developing program that prepare job-seekers and reduce risk for employers.

[14] *See* https://www.tntech.edu/cat/cat-applications-in-the-discipline

Methodology

The Economic Advancement Research Institute (EARI) partnered with Skillworks to design and implement a research plan in order to understand the demand and supply side of the Information and Communications Technology (ICT) industry sector in Massachusetts. Along with the initial secondary data analysis for industry and occupations, the research plan was split into three additional phases.

The **first phase** of research covered the demand side of ICT, including detailed analysis of existing public and private resources as well as a survey administered to a random sample of approximately 4,300 business establishments in Massachusetts. The sample included establishments that are strictly ICT (1,800), are involved in industries that utilize technology at a high rate and employ workers with tech credentials (1,500), and companies that are classified as low tech and typically have tech support on staff or outsource such tech workers (1,000). This sample was reinforced with internet panels across the same industry groups in the Commonwealth. For confirmation, the surveyed establishments had to meet the following criteria;

- Business location in Massachusetts
- Business employs information technology workers classified as support workers (such as help desk) or workers classified as developers, including software, database, and web developers.

The survey effort was conducted over the phone and online with 329 firms completing a survey.

The **second phase** of the research targeted the ICT workforce and sought to gain further information on activities at firms that employ these workers, educational attainment, salary, pathways, etc. The respondents were culled from an internet panel of ICT workers in Massachusetts and those that completed were offered a gift card incentive. Respondents were also asked to provide their personal email address so that they could be invited to three separate assessments upon completion of the survey. A total of 111 ICT workers in the Commonwealth participated in the survey effort and provided contact information to be used for the third phase of the research.

The **third phase** of the research was an extension of the supply side focus of phase two. Each of the 111 respondents were invited to take three separate assessments to further expand on the data already gathered previously and to round out the workforce profile of ICT workers in Massachusetts. Participants were offered an additional gift card incentive that was distributed upon the completion of all three assessments. The following assessments were administered;

- **Woofound Personality Assessment** – survey respondents were sent an email and asked to register an account with Woofound at https://swn.woofound.me/sessions/new. From there, a series of work activities and personality questions were administered. The assessment took an average of five minutes to complete. Each participant was provided a customized personality assessment that also included favored work environments and occupational recommendations. This data was gathered by the research team and analyzed to determine a combined personality profile for ICT workers.

- **StrengthsQuest StrengthsFinder Online Assessment –** this assessment was administered to survey respondents from phase 2 that also completed the first additional assessment (Woofound Personality Assessment). Each participant was provided a unique access code and asked to register at https://www.strengthsquest.com/register/default.aspx. The online assessment took approximately 30 minutes to complete. Respondents were provided with a report that listed their top five talent themes or strengths and offered suggestions for their application to academic, career and leadership development. This data was gathered by the research team and analyzed to determine a combined talent or strengths profile for ICT workers.

- **Career and Technical Education Consortium of States (CTECS) Workplace Readiness Skills for the Commonwealth Assessment** – This final assessment was administered to survey respondents from phase 2 that completed the first two additional assessments of phase 3 (Woofound Personality Assessment and StrengthsQuest StrengthsFinder Online Assessment). Each participant was sent an invitation from CTECS to take the assessment. The online assessment consisted of 100 multiple choice questions and offered a one-hour window for completion. Each respondent to the CTECS assessment was offered an official certificate if they achieved an overall passing score of 75% or higher. The assessment offered disaggregated scores within the following assessment themes;
    - Personal Qualities and People Skills
    - Professional Knowledge and Skills
    - Technology Knowledge and Skills

  This data was gathered by the research team and analyzed to determine a combined workplace readiness skill profile for ICT workers.