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Viewpoint
The 2021 Software Developer Shortage Is Coming

Companies must address the difficulty of hiring and retaining high-skilled employees from an increasingly smaller labor supply.

IMAGE BY DMITRY KOVALCHUK

While global economies of all scales have been severely impacted by the COVID-19 global pandemic, information technology (IT) companies have managed to survive much of the economic downturn. This is due in large part to their past success in distributed IT development, remote IT operations, and remote maintenance. IT companies have required their staff to essentially do at home what they had been doing in the office years before. Moreover, to meet the constraints of working from home, the demand for IT services has increased across many other market sectors, including retail, entertainment, education, and healthcare, leading to a more profitable IT market.

Tightening in the Upstream IT Labor Supply

While this news is largely positive for IT companies, the pandemic is also taking its toll on the upstream supply of IT labor, and software developers in particular. These effects could constrain hiring and innovation over the next two to three years. Due in part to travel embargos, limited access to educational loans, and delays in student visa processing, U.S. colleges and universities are observing significant declines in graduate-level enrollments in computer and information science this year. These declines are translating into one-year enrollment deferrals, meaning a temporary, but significant reduction in expected 2021 graduation rates.

Two years ago, in 2019, U.S. colleges and universities awarded more than 136,000 bachelor's, master's, and Ph.D. degrees in computer and information science (CIS).[6] Among which, 35,200 of these degrees were awarded to nonresident aliens, among whom 27,200 or 77% earned either a master's or doctoral degree, placing these graduates in a higher skilled technology category. Recently, the American Council on Education (ACE) reported a 43% decline in pandemic-era enrollments for international students based on recent surveys.[5] This decline will reduce CIS post-graduates by 11,700 students in 2021, and would disproportionately affect higher-skilled graduates with more than two years of industry experience. While this story is still playing out, we should already anticipate a tighter IT labor market, particularly among higher-skilled technology jobs.

Increased Competition for Highly Skilled IT Labor

Prior to the pandemic, the U.S. Bureau of Labor Statistics (BLS) estimated that approximately 1,469,200 full-time software developers were working in the U.S. in 2019, earning an average salary of $107,510. Over the next 10 years, BLS estimates the U.S. labor market will add

316,000 software developer jobs, which is a phenomenal 22% growth rate, or an average of about 31,000 new jobs each year. By comparison, lesser-skilled computer programmer jobs would decline by 9% to fewer than 193,800 jobs by 2029, showing a continued shift in the U.S. labor market toward higher-skilled IT jobs that include the engineering practices of software design, software construction and maintenance. The 43% decline in new CIS graduates reported by the ACE would reduce BLS estimated job growth by 38% in 2021 by leaving thousands of jobs unfilled.

In our review of published 2018 data from the Student and Exchange Visitor Program (SEVP), 61% of the top 200 companies that hire graduates under Optional Practical Training (OPT) conduct business in management consulting, and information technology, including retail, finance, and healthcare;[9] see the sidebar here. This includes popular consulting companies, such as Deloitte, PriceWaterhouseCoopers, and KPMG, as well as popular technology companies, such as Amazon, Apple, Google, and Microsoft. We estimate that in 2018 there were 46,700 new workers authorized under STEM OPT who were potentially working in IT-related fields. If true, then a decline of 11,700 CIS graduates in 2021 could reduce the available OPT-authorized IT workforce by as much as 25%.

The Impact of Labor Shortages on IT and Innovation

When labor-supply shortages arise in IT, the impact can negatively affect both productivity and innovation. In a survey of electronic and mechanical engineering and IT firms in Northern Ireland, Bennett and McGuinness found that skill shortages in hard-to-fill and unfilled vacancies reduce firm-level performance.[1] Hard-to-fill vacancies include those requiring more experience and qualifications, such as IT positions that require at least two years of experience, which are reported to be 40% more difficult to fill than entry-level positions. Unfilled vacancies are measured by the raw number of open positions within the last 12 months, which is independent of how recruiters interpret "difficult to hire." In general, Bennett and McGuinness found that hard-to-fill vacancies reduced productivity levels by 65%, while unfilled vacancies reduced productivity levels by 75%. This productivity loss is amplified when the company has a large proportion of new graduates and inexperienced workers, or when the company has significant investments in R&D, which otherwise drives up productivity when labor shortages are minimal. Substantiating the impact of labor shortages on innovation, Horbach and Rammer analyzed three years of the German Innovation Survey and found that unfilled positions in high skill areas correlates with increased canceling of innovation projects.[4]

Unfilled positions lead to increased churn as skilled employees jockey for better jobs at more attractive companies. What makes a company attractive to a prospective employee is driven in part by the skills that a prospective hire feels they can develop on the new job. Based on an analysis of employment data from over 50,000 workers, Tambe et al. found that IT employees accept a "compensating differential," such as trading pay for other job attributes, when they can work with novel and emerging IT systems and develop their skills on the job.[7] Furthermore, their

Optional Practical Training

For nonresident aliens to work in the U.S. after graduation, they must first have a valid work authorization, which has historically included Optional Practical Training (OPT).[a] The OPT began in 1953 to authorize international students to work for a period of 6–18 months as determined by their school and training agency (18 Fed. Reg. at 3,529). This program has since evolved to meet the demands of modern educational and workforce requirements. Today, international students enrolled in bachelor's, master's and Ph.D. programs can apply for 12 months of OPT at each educational level.[2] With the Science, Technology, Engineering, and Mathematics (STEM) OPT extension, CIS graduates can apply for an additional 24 months, for a total of up to three years. After this period, CIS graduates must leave the U.S., if they have not obtained a new work authorization, such as an H1-B visa.

a see https://bit.ly/3fLBhwj

analysis shows employees value working on interesting IT systems above most other employer attributes, such as pay and other benefits. They also note that recent graduates who arrived with newer skills in a high-demand job market would have more job options, and thus be more competitive hires.

How Can Companies Improve Their Retention and Hiring?

Instead of waiting for positions to become hard-to-fill and unfilled—leading to more lost productivity and reduced innovation—companies can take two strategic steps to attract and retain high-skilled employees: establish a dual career path for managerial and technical staff, and invest in employee education and training.

In 1988, Ginzburg and Baroudi identified the need to define a non-managerial technical career ladder to complement the traditional management track for promotions.[3] Over the last seven years, we observed that over 50% of graduates of the Master of Software Engineering (MSE) program at Carnegie Mellon University (CMU) have entered senior positions. These graduates enter either a managerial track, such as Project and Program Manager or Staff Software Engineer, or they enter a technical track, such as Senior Software Engineer and Software Development Engineer II and above. The technical track encourages career growth without shifting one's responsibilities to primarily cover management activities. In April 2020, we looked at career paths of alumni who graduated from 2015–2017 recording 44 alumni who ascended the technical ladder within their companies, and 10 who ascended by changing employers. Companies that allow employees to move between tracks afford employees more flexibility to pursue skill development within the company versus looking outward for open positions elsewhere. For example, we observed CMU MSE alumni working for a few years as technical leaders, building critical service infrastructure, who later chose to develop their personnel and project management skills by moving to a management track. We also see the converse, though less often: after having managed a team for some time, an alumnus/alumna chooses to re-enter a product or project team as a technical leader in a non-management role. In our discussions with alumni, these shifts were not viewed as career compromises, but as skill development opportunities.

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Another way to attract and retain employees, and to support internal career advancement, is to engage employees in on-the-job education by providing online learning benefits in addition to pay. One consequence of the pandemic has been large moves by colleges and universities toward online learning. Coursework in artificial intelligence and machine learning, DevOps, and software architecture are now online and taught by the world's experts in these topics. Online learning opportunities come in different sizes, from one- to three-course certificates to part-time degree programs that students complete over two to three years. In many cases, employees dedicate 10–12 hours a week to online courses, while applying this advanced knowledge to their workplace projects. To build such benefits, companies should consider several issues, including: how to allow for flexible schedules that accommodate online classes; how much to compensate employees for course tuition, recognizing these newly learned skills will transfer to their workplace performance; and whether a certificate or a degree program is the right incentive for recruitment and retention. Certificates may be attractive to senior employees, whereas a graduate degree could entice recent hires looking for more experience and seek additional formal education aimed at advancing their careers internally.

By emphasizing career paths that foster skill development, companies can move to keep employees more engaged with new opportunities that demonstrate their intellect and entrepreneurship. Moreover, providing corporate support for online software engineering education can re-energize a culture of innovation. Together, these investments can help companies reduce their exposure to the effects of this pandemic, while the upstream supply of IT labor replenishes to meet growing demand.

Conclusion

It is evident a labor shortage is expected to arrive soon and that it will disproportionately affect highly skilled workers. With an estimated reduction of 11,700 CIS graduates in 2021[5] and the BLS estimated 22% growth in software developer jobs,[8] there could be thousands of positions left unfilled or hard-to-fill. The added difficulty of hiring skilled employees from a smaller labor supply has the potential to cost companies through lost productivity and reduced innovation. The remaining question is how will companies creatively hire and retain high-skilled employees amidst all the coming turmoil? Companies can get ahead of the shortfall with two strategic steps: establishing a dual career path that allows employees to grow, and investing in employee education and training. C

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