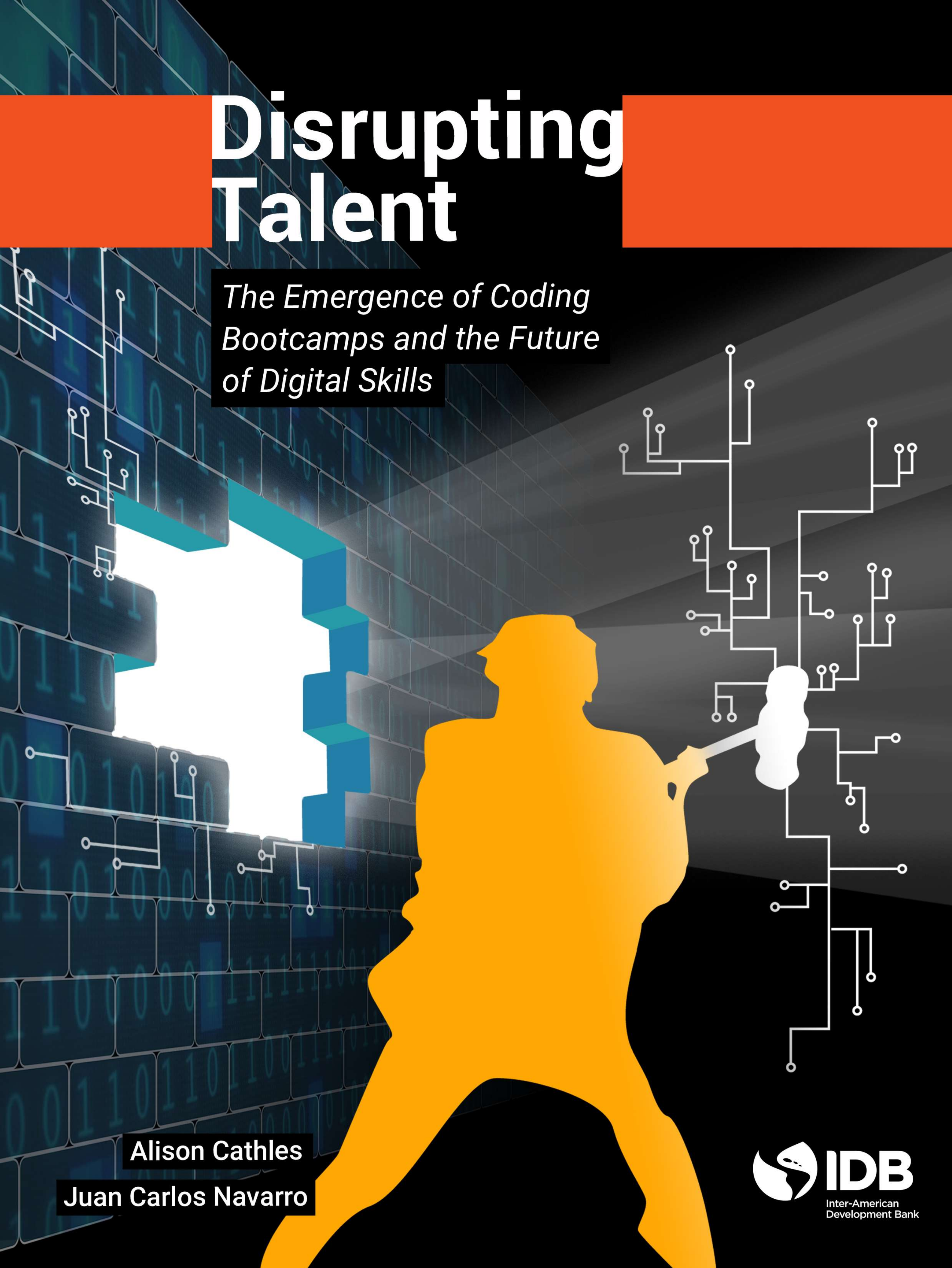
Disrupting Talent

The Emergence of Coding Bootcamps and the Future of Digital Skills



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Abbreviations

AI	artificial intelligence
CIRR	Council on Integrity in Results Reporting
IIA	Israel Innovation Authority
IT	information technology
LAC	Latin America and the Caribbean
SME	small- and medium-size enterprise
STEM	Science/Technology/Engineering/Mathematics
UI	User Interface
UX	User Experience

Executive Summary[1]

Private or nonprofit digital skills training programs, referred to as coding bootcamps, have emerged to address severe shortage of talent in the area of digital skills. Bootcamps are not perfect; they do not represent the magic bullet that will contrive such skills out of thin air, nor should they be touted as such. Nevertheless, they are creating alternative educational pathways in economies affected by the extraordinary challenges brought about by the digital revolution. Evidence indicates that bootcamp graduates are eagerly welcomed by top companies all around the world in their desperate need for human capital with programming skills and dexterity for such areas as artificial intelligence (AI) and data analysis.

This report maps this new breed of provider of digital skills training around the world as well as in Latin America, highlighting the trends and lessons learned where possible. The analysis in this paper does not constitute an assessment of the effectiveness of bootcamps involving an experimental or quasi-experimental evaluation. Rather, it endeavors to document and verify the extraordinary claims of bootcamps regarding their outputs in terms of the acquisition of skills and the employability of their graduates. Hence, it examines the issue of results by using all the information that has been gathered.

The coding bootcamp industry is nascent, having emerged less than 10 years ago with a handful of providers in the United States. It is now a burgeoning industry that has grown remarkably fast and spans across the world. Bootcamps appear rather effective at identifying the needs of industries, swiftly tailoring their instruction to meet the latest industry trends. They deliver highly sophisticated, albeit significantly practical, skills in a short period of time at a relatively low cost. There is variation in the quality of coding bootcamp programs, but almost as quickly as the industry has emerged, entities have established themselves to assist prospective students by providing rankings and certain standards from which to judge the cost-benefit of enrolling in a coding school. Bootcamps are increasingly rigorous about their admission process, which often includes two separate interviews that establish an applicant's potential technical capabilities and her/his soft skills.

[1] The authors would like to thank the following people for their collaboration and for taking the time to discuss with us digital skills training programs and/or related policies: Naomi Krieger Carmy (Head), Societal Challenges Division, Israel Innovation Authority; Nicolle Jasbon (Project Manager and Co-Founder), Bogotá Dev; Marcela Torres (CEO and Co-Founder), Hola Code; Ilana Milkest (CEO and Co-Founder), World Tech Makers; Rafael Anta (Advisor to the Executive Vice-President), Inter-American Development Bank; Elena Heredero, IDBLab; Pauline Henriquez LeBlanc (Consultant) Inter-American Development Bank; and Sergio Rodríguez (Consultant), Inter-American Development Bank, Country Office in Peru.

Outstanding examples already exist of efforts by the public sector to facilitate the growth of coding bootcamp providers (and graduates) in places where policymakers have identified a need that was not being filled through natural market mechanisms. Rather than consider the coding bootcamp as a one-off investment for the tech sector, its evolution suggests that it should be better described as part of the process of building a digital talent pipeline for most sectors.

Current technological trends are reshaping the educational services toward the delivery of an improved blend of vocational training and general education—deemed essential for continuous upskilling—in digital economies. The lessons learned by coding bootcamps, acting as skills accelerators, can potentially be shared in traditional education and training settings. The development of a digital talent pipeline for upskilling and reskilling is critical in modern economies; however, to carry it out effectively will require an in-depth understanding on the part of public and private leaders, alike, of the technological potential and talent gaps that are specific to different industries, countries, and regions.

1. Background

The focus of this paper is on the advanced end of the digital skills spectrum. The International Telecommunications Union identifies computer programming and network management as advanced digital skills with the following examples: AI, big data, coding, cybersecurity, Internet of Things, and mobile application development (i.e., blockchain, machine learning, and big data) and digital entrepreneurship (ITU, 2018).

Digital skills are being developed across a continuum, and they constantly are being updated alongside developments in technology. As such, there are two implications for today's workforce: (i) many workers will need to 'upskill' continually so that they can work more effectively in their current positions with digital technologies, and (ii) many people will need to reskill in order to prepare themselves for work in new roles (Orlik, 2017).

There is increasing demand for computer programming skills in nontech jobs. Such skills appear to enhance job security, partly because computer science skills are considered complementary to traditional domain-specific skills (i.e., marketing or design). On the basis of discussions with global industry leaders, a recent report by Deloitte Digital considers the speed with which industries are likely to be affected by digital technologies and how massively these technologies will disrupt business practices (Deloitte, 2015). Most industries will be impacted severely, with the banking, retail, insurance, media, software-ICT, and professional service industries among the most likely in the short term. Conversely, the extractive industries, such as oil, gas, and mining, will suffer relatively smaller impacts over the longer term. The manufacturing, healthcare, transportation, government service, agriculture, utilities, and construction sectors occupy the intermediate section in the impact scale.

In a recent report, Burning Glass Technologies found that computer science skills are increasingly required across the labor market. Sixty percent of the fastest growing and highest paying skills relate to computer science in the following five job areas: data analysis, engineering and manufacturing, design, marketing, and programming and information technology (IT). Surprisingly, however, a small percentage (18 percent) of listed jobs in these five areas requires a computer science degree (Restuccia, Liu, and Williams, 2017, p. 7).[2]

A good example of the increasing ubiquity in the demand for computer science skills across industries and occupations is the field of what is referred to as Art & Design, as detailed in Table 1, excerpted from Restuccia et al., (2017). Today's artists and designers benefit by acquiring web development skills and up-to-date knowledge to enable them to translate their designs into digital material. Web developers and user experience designers are now in high demand. In advanced economies as a whole, beyond the creative economy, most software developers do not work for software firms (Indeed, 2015).

[2] The Burning Glass Technologies report indicates that although a computer science degree is not required, at least a bachelor's degree often is.

Table 1. **Growth in Demand for Computer Science Skills for Designers, 2014–16** (in percent)

Rank	Skill	Growth
1	Information technology industry experience	268
2	Software architecture	109
3	AngularJS	108
4	Video production	68
5	Motion graphics	66
6	3D modeling/design	64
7	Maya	60
8	Git	60
9	Software engineering	58
10	Color theory	56

Source: Restuccia, Liu, and Williams (2017, p. 13).

Such facts suggest that everything that can be digitalized will be digitalized and, therefore, every company will need to become a tech company to some extent (TechRepublic, 2018). This creates a challenge for businesses, requiring them to seek talent that includes up-to-date mobile and digital skills. ManpowerGroup released, in 2015, the results of a talent shortage survey of over 40,000 recruiters in more than 40 countries. The results indicate that three of the 10 most difficult positions to fill relate to IT and coding. While not specific to IT or coding, five Latin American countries (Argentina, Brazil, Panama, Colombia, and Mexico) appear in the top 10 countries experiencing the most significant talent shortages (ManpowerGroup, 2015).[3]

Closer scrutiny indicates that the need of firms for digital capabilities is relevant at multiple levels within an organization, including digital talent, digital leadership, and digital entrepreneurship. The proliferation of skills training programs around the world has resulted in a variety of courses applicable to people with diverse backgrounds and at various levels within the workforce (i.e., entry-level to executive talent) to gain the skills and/or knowledge necessary for the field of digital technology—skills that will help secure a job or, in the case of leadership, to manage a business.

[3] The field of digital skills and training commonly applies the expression “talent” to what would better be described as “human capital”. Thus, the shortage of talent does not necessarily refer to the scarcity of people with talent or those who have potential; instead, a shortage of talent refers to a deficit in the number of workers who have the necessary skills or human capital required for jobs within the digital economy. This paper follows the field in using the word “talent” in an effort to prevent the excessive proliferation of terms and clarifications.

Nevertheless, the brisk pace at which digital technologies continue to evolve creates uncertainty. While there is substantial information available, to maintain a systemic perspective remains a challenge. It is necessary to provide an initial mapping of digital skills training programs on offer to develop the (i) digital talent, (ii) digital leadership, and (iii) digital entrepreneurship around the world—particularly in Latin America and the Caribbean (LAC)—in order to facilitate an in-depth understanding of how such programs can be leveraged (or supported) to increase digital capabilities across the economy. This paper attempts such an initial mapping, with a focus on (i). Some brief references to (ii) and (iii), what they are and why are they important can be found in Appendix C.

2. Introducing the digital bootcamp

Coding bootcamps can be described as skill accelerators; they are intensive three-to-six-month programs that provide the practical foundations of computer programming and related digital skills in a hands-on learning environment, one that combines traditional vocational training with socioemotional tech skills in an effort to prepare students for entry-level tech positions (Mulas et al., 2017). Short and intensive bootcamp-style programs are a relatively familiar concept in the IT industry used, for example, by professionals to gain specialization in a particular computer programming language. Nevertheless, the coding bootcamps that are currently gaining international attention are a new phenomenon because they tend to target people who are outside the industry and have very little experience in coding, and because they have spread all around the world (ITU, 2017). Providers are mostly commercial or social enterprises that fall beyond the formal education system of the countries in which they operate (ITU, 2018). Some bootcamps consider themselves training startups in their attempt to disrupt the technical education market by way of radical innovations in technology and business models.

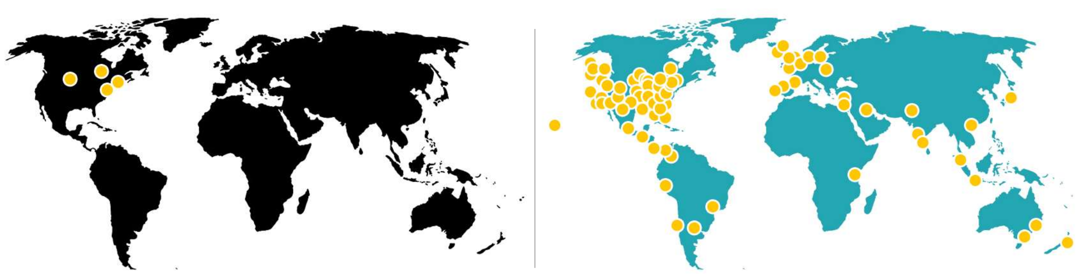
3. Bootcamp Market Size and Growth Rate

According to Course Report—an often-cited authority on immersive technology education—results from a survey of 95 bootcamps that offer full-time courses (at least 40 hours a week) in Full Stack Web Development, Mobile Development, or Front-End Web Development, and have a campus in the United States or Canada indicates that 20,316 people will graduate from in-person bootcamps in 2018, with another 1,846 people expected to graduate from 13 online bootcamps.[4] Approximately 25 percent of bootcamps offer corporate training programs through 634 corporate partners. In 2018, corporate training programs will potentially graduate another 16,593 students. The burgeoning bootcamp industry currently brings in about US$240 million in revenue (Course Report, 2018).

The growth rate of coding bootcamp graduates is impressive. From 2013 to 2018, the number of graduates from in-person bootcamps in the United States and Canada has grown by 748 percent. Although those from online bootcamps number far fewer than those from in-person bootcamps, online graduates from 2017 to 2018 have grown by an estimated 173 percent (Course Report, 2018).

This trend goes beyond the United States and Canada. Figure 1 illustrates the proliferation of coding bootcamps in various regions of the world. According to the ITU, bootcamps have sprung up exponentially from only a handful of providers in 2011 in response to the increase in demand for software developers in all economic sectors (ITU, 2017).

Figure 1. **Proliferation of Bootcamps around the World since 2011**



Source: Excerpted from Linkedin and Bootcamp.me.

An estimate by Linkedin and SwitchUp suggests that there were 300 coding bootcamps operating worldwide in 2018.[5]

[4] See participating schools in the Course Report survey at www.coursereport.com/reports/2018-coding-bootcamp-market-size-research.

[5] Information obtained from www.Linkedin.com and www.SwitchUp.org, accessed November 2018.

4. What Is Coding? What Programming Languages Are Required? What Kinds of Jobs Are People Getting?

The internet, computers, and mobile devices have become an integral part of our lives. Users make use of them to communicate with friends and colleagues, manage finances, book holidays, shop, order food, and store and transfer information. Despite this, only about 40 percent who employ software at work utilize it effectively (Orlik, 2017).

To understand why so many software programmers are in demand, one can imagine a pyramid. At its base is the hardware, followed in the middle by the operating system while, at the top, lie the programs that a person uses. An "application stack" runs over the top of the operating system and the hardware (for a basic definition of coding see Box 1). With the proliferation of web applications that allow one to do everything from online shopping to online banking—and since modern applications have simultaneously become more complex and user-friendly—there are programmers behind the design and development of each web application.[6]

Box 1. What is coding?

Coding is defined by the International Telecommunications Union as "Writing instructions for a computer programme" (ITU, 2018). Various computer languages are used to make and process every website that is visited and every application on smart devices.

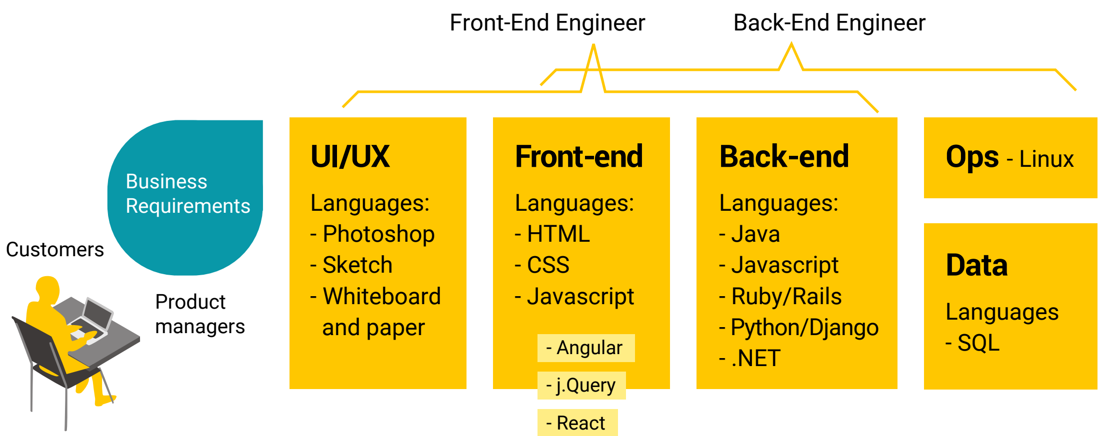
Computers understand languages that are made up of many complex combinations of zero (0) and one (1), known as a binary code. The code represents letters or numbers (or other characters) that when combined and translated through a coding language (i.e., Javascript, Python, or C++), become recognizable to computers so that they can perform the requested tasks. This binary code presents a language barrier between computers and most people.

Source: Rajan Selvan (2018).

[6] Based on Course Report webinar with Jeff Casimir in 2017.

Jeff Casimir, Founder of Turing School in Denver, Colorado, provides a simple definition of "application stack" (Eggleston, 2017). He also provides examples of computer programming languages that are used in each part of the stack, as well as the job types that are typically associated with different parts of the stack. Figure 2 is an illustrative example of the full web application stack based on Jeff's webinar, which can be found on the Course Report website.[7]

Figure 2. **Application Stack Based on Course Report's Webinar with Jeff Casimir**



Sources: Adapted from Eggleston (2017) with Jeff Casimir; and Google Images.

Although the term "full stack" is frequently used, Casimir argues that nowadays, most people specialize in one part of the stack. The past 10 years have seen an evolution of programming languages; for example, front-end at one time was a tiny part of the development stack and only required HTML knowledge. Someone applying for a position as a front-end engineer (or developer) today is likely to be expected to be fluent in at least three computer programming languages (HTML, CSS and Javascript), as well as, perhaps, in the libraries of Javascript (i.e., Angular, j.Query, React), all of which are sufficiently complex to be considered the fourth languages.

UI, which stands for user interface, primarily focuses on the design or "look" of the application. Digital skills training programs in UI instruct students on how to edit the interactive parts of web applications. This includes, for example, the styling and designing of anything clickable, form fields, and drop-down options (Freedman, 2018).

UX, defined as a user experience design, works out how better to target an audience. Those in UX conduct data analyses and market research in an attempt to determine the motivation and potential satisfaction clients will have when using a particular application before launching a product. The role of UX also is to analyze the success or failure of the product following its launching (Freedman, 2018).

[7] See www.coursereport.com/blog/full-stack-developer-vs-specializing-within-the-web-stack.

As described by Casimir at Turing, UI and UX alike are responsible for understanding the use of the application from the perspective of the user, and they work with nonexecutable markups of the application. Job titles associated with UX and UI include UX designer, UI designer, and product designer. The front-end then takes the markup and develops a prototype in HTML, CSS, and some Javascript. Job titles associated with front-end include front-end engineer, front-end developer, or junior developer. This is essentially the "digital architecture" of the application, although at this stage the application is not ready for the market. Back-end takes the prototype and makes it market ready by placing it into a system that is able to handle multiple thousands of requests per minute. Job titles relating to back-end are back-end engineer and web application developer. Behind the back-end is the "Ops" team (with job titles such as operations engineer and DevOps engineer), responsible for getting the application to run on the server and to reboot in case there are any crashes. User data are stored behind the back-end, where data scientists pick up the data to mine information. In 2016, Indeed (a job search engine) reported that some of the top 10 hardest-to-fill jobs in the tech industry were front-end developers, full stack developers, and back-end developers.

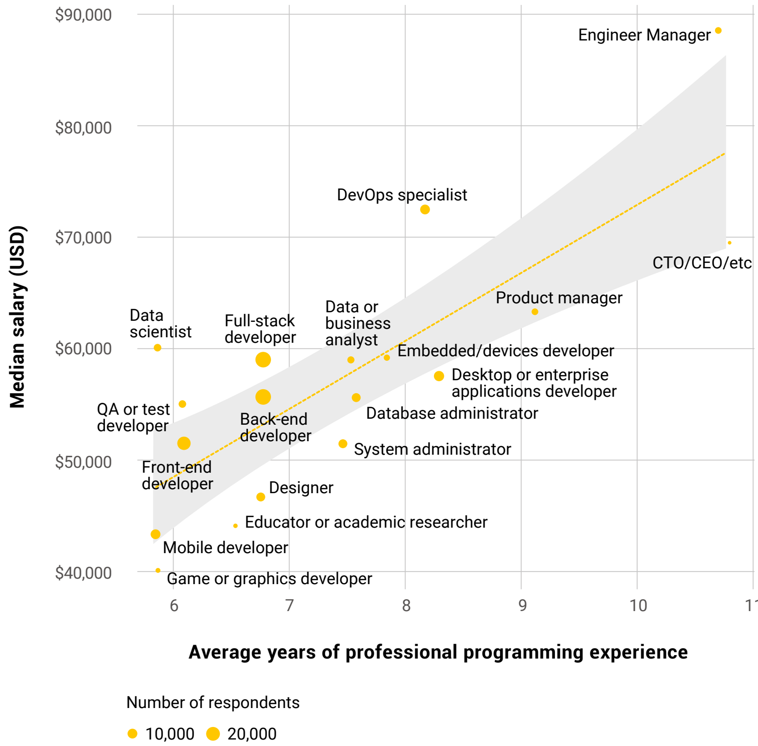
Stack Overflow is an online community question-and-answer forum for software developers that has been in existence for over 10 years and has 9.6 million registered users. For the past eight years, Stack Overflow has conducted an annual survey of developers, the latest in January 2018. This particular survey had over 100,000 responses from software developers from 183 countries around the world. Less than 5 percent (4,162) of respondents were from South America.[8]

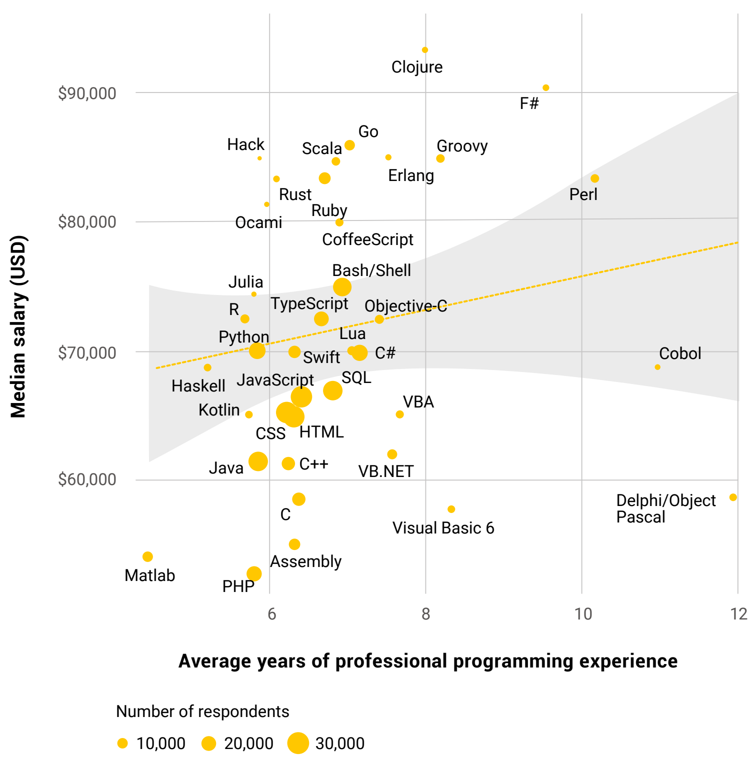
A section of the survey was dedicated to salaries and corresponding years of experience associated with various kinds of software developer jobs and programming languages worldwide. The local currency references of respondents were converted into U.S. dollars. Figure 3 shows two graphic excerpts from Stack Overflow's report of its survey results. The plots show average salaries on the vertical axes and years of experience on the horizontal axes.

The size of the bubble in the right-hand panel indicates the number of respondents in each type of software developer job. In the right-hand panel, the size of the bubble represents the number of respondents using specific programming languages.

[8] The report does not offer statistics on respondents from Central America or the Caribbean.

Figure 3. **Average Salaries and Years of Experience by Type of Developer Job and Programming Language**





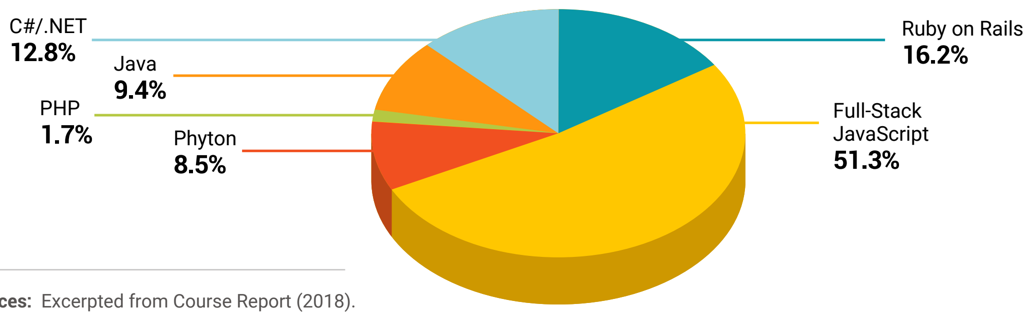
Sources: Excerpted from Stack Overflow (2018).

Stack Overflow notes that while, worldwide, the highest earners are engineering managers and DevOps specialists, there are nevertheless regional differences. For example, in Europe, back-end developers are among the top earners.

Javascript was found to be the most common programming language for the sixth year in a row (Stack Overflow, 2018), and it is also the most common teaching language, used in a little over half of web development bootcamps (Course Report, 2018). This is because more than 80 percent of developers use JavaScript and it is the foundation of almost all (95 percent) websites; it also can be used in backend games and applications (TechRepublic, 2018). To succeed with Javascript, a solid background in HTML and CSS is essential. Javascript is also the language many coding bootcamps use in the technical assessment part of their application process (Crispe, 2018).

Computer programming languages taught at coding bootcamps tend to closely follow the needs of the industry. As the telephone interviews conducted for this paper revealed, many of the instructors and bootcamp founders are themselves developers and remain engaged in the coding community. Figure 4 shows a pie chart of the programming languages—taught in full stack development programs—from a sample of 274 courses from 95 in-person schools. Course Report (2018) is based on courses that meet the following criteria: full time, in person, nonaccredited, programming-specific curriculum focused on full stack web development, mobile development, and front-end web development in the United States and Canada.[9]

Figure 4. **Programming Languages Taught in Full Stack In-Person Coding Bootcamp Programs**



Sources: Excerpted from Course Report (2018).

Huge growth is expected in the blockchain market, with bootcamps also teaching courses in blockchain technology. The key programming languages used in blockchain development are C++, Java, Python, Simplicity, and Solidarity. In the scope of Course Report (2018), there are eight specific bootcamp courses for blockchain, most of which are 12 weeks long and cost between US$1,499 and US$14,950. Three blockchain bootcamps are available online. Two further coding bootcamps exist, covering blockchain as part of their overall curriculum. Moreover, there are a variety of introductory resources, many of which are available online (Stewart, 2018). Typical job titles relating to blockchain are blockchain project manager, blockchain developer, blockchain quality engineer, and blockchain web designer.

[9] A full list of schools participating in Course Report's survey can be accessed at www.coursereport.com/reports/2018-coding-bootcamp-market-size-research.

4.1. Coding, data science, web design, and cybersecurity bootcamps

The rankings of SwitchUp, an online platform described in further detail below, are separated into the following four bootcamp categories: Coding, Data Science, Web Design, and Cybersecurity. While many bootcamps offer coursework that may cut across this categorization of bootcamps, coding bootcamps are by far the largest in number. SwitchUp (more on SwitchUp in the next section) states that the top 50 coding bootcamps were selected from 300 coding schools and over 9,000 student reviews (SwitchUp.org). In contrast, the 15 best rated data science bootcamps are ranked out of 40, and the web design and cybersecurity rankings list 14 and only 2 bootcamps, respectively (SwitchUp.org).

To partially assess the concentration of course offerings in coding bootcamps, an imperfect approximation was conducted using a key term search within the course titles of SwitchUp's top 50 coding bootcamps. SwitchUp provides a list of courses for each of the top 50 coding bootcamps. The key term search included variations; for example, "full-stack" with a hyphen is listed in the title of 16 courses; "full stack" without the hyphen is listed in eight other course titles; and "fullstack" with no space is listed in four other course titles, totaling 28 course listings including the word "full stack". Data science, data analytics, and analytics/analyst were combined into one category. The searches are not case sensitive, and almost all of the top 50 coding bootcamps offer more than one course. Some titles may offer training on a topic not listed in the course title. For example, it is surprising to discover only one back-end term in the course listings, although it is assumed that the full stack courses include back-end coursework. Table 2 shows the results.

Table 2. **Terms Included in SwitchUp's Top 50 Coding Bootcamps**

Full stack	**28**	Data science and analytics	**13**
UX	**11**	Machine learning	**2**
UI	**15**	Data visualization	**1**
Front end	**10**	Blockchain	**1**
Product management	**2**	Artificial intelligence	**1**
Back end	**1**	Cybersecurity	**1**

Source: Authors' elaboration based on an analysis of courses listed under SwitchUp's top 50 coding bootcamps.

5. Training Effectiveness

Since these bootcamps have emerged so recently, one question that immediately arises is the quality of courses. SwitchUp is an online platform that began in 2014 to assist prospective students to evaluate and differentiate between the various available training programs. A remarkable development in itself within the bootcamp industry, it represents the emergence of a quality control mechanism that did not originate out of public sector regulation; rather, it emerged as a result of the market forces that influence industry.

One of the resources offered by SwitchUp is a ranking of coding bootcamps. To be considered for the 2019 rankings, the coding bootcamp should have on offer career services, have at least 30 verified reviews from alumni and students, and have at least a four-out-of-five-star ranking at the time of publication.[10] Appendix A shows the top 50 coding bootcamps ranked by SwitchUp. The table also indicates whether the organization awarded merit badges to any of the 50 top-ranked bootcamps, depending on whether or not they offer online or part-time courses, publish an outcome report that has been verified by a third party, and are able to guarantee jobs. Of the total bootcamps in the table in Appendix A, 44 percent offer online courses, 60 percent offer part-time courses, 44 percent have an outcome report that has been verified by a third party, and 24 percent guarantee a job.

Around 60 percent (13) of the coding bootcamps that have third-party verification of their rather impressive outcomes fall under the Council on Integrity in Results Reporting (CIRR). Averaging the outcomes of those 13 bootcamps, 86 percent of students graduated on time and 80 percent are employed at a median salary of US$71,618.[11]

[10] For further information, see www.SwitchUp.org.

[11] This is the average of the median salaries reported across the 13 bootcamps. Occasionally—and in the case when the bootcamp has more than one location—the median salary of the first location, listed alphabetically, is used.

6. Delivery Channels (In Person or Online)

Although 22 (44 percent) of the top 50 bootcamps offer some of their courses online, only three are exclusively online. Thus, most (19) that do include online courses also offer in-person training programs. The majority (31) are exclusively training programs that require a physical presence at the location of the bootcamp. Some of the in-person bootcamps offer preparatory courses to be completed online, although once the coursework begins, a physical presence is expected. Many of the bootcamps have campuses in various cities around the world.

7. Applying for Bootcamp: What Are the Prerequisites?

One of the most interesting—and perhaps disrupting—features of bootcamps is that students come from a wide variety of educational backgrounds. One neither needs a degree nor computer science experience. Bootcamps appear to classify advanced digital skills as a trade that can be learned by many rather than as a highly sophisticated technical skill that presupposes advanced training in the science/technology/engineering/mathematics (STEM) disciplines or a degree in computer science. Thus, bootcamps are quite open to alternative educational backgrounds and do not require formal education requirements such as a bachelor's degree.

This, however, should not be confused with a lack of diligence in the selection of students. All of SwitchUp's 2019 top 50 bootcamps appear to have an admission process. The application process is similar across bootcamps, and usually entails a short questionnaire whereby applicants list their education, work experience, and background information. This is followed by two interviews, a technical one as a test or "coding challenge" and a personal one (Mulas et al., 2017).

The application process is rigorous and interviews held in relation to this paper indicate that bootcamps seek not only technical capabilities but also soft skills. The chief executive officers, general managers, and admission officers of seven leading coding camps in New York City indicated, during a recent roundtable discussion, that applicants have to demonstrate qualities such as persistence, willingness to work hard, problem-solving skills, and a passion for coding (Crispe, 2018).

Remarkably, technical skills are considered less of a barrier than soft skills. Bootcamp representatives emphasize that people who are curious about whether a coding bootcamp would be a valuable experience for their career have the option to take a free online starter course. Free workshops and meetups are offered by many bootcamps and are designed to assist students with the onboarding process in addition to helping prospective students assess whether they have any interest in pursuing coding. Based on its admission process experience, what can be equated to remedial education resources (most of which are free) also have been developed to aid highly motivated candidates achieve a minimum capability or the required technical dexterity to enable them to enrol in bootcamp courses. In fact, "feeder" prep courses have emerged for many bootcamps. Online advice for prospective students suggests that these courses are more than a good idea; they should be considered quasi-mandatory. At Hack Reactor, for example, 30-40 percent of students have taken the Hack Reactor preparation program.

Persistence in moving through the "preparatory" courses and activities becomes somewhat a test of soft skills, since it favors highly motivated students. Otherwise, soft-skill interviews appear to be more of a challenge for prospective students, since bootcamp representatives consider some of the related skills (e.g., leadership, motivation) as what they refer to as "unteachable" (bootcamps in developing countries may be taking a different position on soft skills, given differences in the training environment; see Box 2).

Along the same lines, digital skills training providers emphasize on their websites and online forums that bootcamp courses are intensive and that it can be a stressful learning process. Since the target is the adult learner, many adult students find it difficult to begin to learn again (Crispe, 2018; Orlik, 2017). It can be rather frustrating and challenging to be placed in a situation where the answers are not clear or easily understood, which is why the first interview during the selection process—based on those bootcamps with which interviews for this paper were held—focuses on establishing whether or not prospective students have researched the bootcamp training process and whether or not they have taken into account the required time commitment and the stress involved.

Box 2. Coding Curriculum Sharing Experience in Haiti: Building Confidence to Succeed

Jules Walter, a Haitian graduate taking a mobile development course at CodePath, was so inspired by his experience that he launched a program initiative in Haiti in 2015. In support, he was provided a computer lab at a Port-au-Prince high school, while CodePath shared its curriculum with him. Students were mainly recruited through Facebook, resulting in the selection of 20 students from 150 applicants. Despite the fact that commitment and collaboration were emphasized during the application process, nine students dropped out in the first two weeks of the program.

Slow internet and weak English language skills proved to be major obstacles, although the greatest of the challenges identified by Jules Walter, was that many students lacked the inspiration and the confidence to believe that they could become developers. The absence of successful role models with similar backgrounds in the field of software development contributed to this factor. Once Jules had taken this into account, he began a one-on-one mentoring program, sharing his own success story to encourage program participants to value software engineering as a viable career path. Jules argues that bootcamps may fail to address such an issue in groups that are underrepresented within the industry.

Source: Walter (2015).

The Bootcamp application process also highlights a "coding culture", whereby the commitment to foster a positive learning environment of which one becomes a part is essential. Jeff Harr of Fullstack Academy and the Grace Hopper program emphasize that bootcamp programs are committed to open, inclusive, diverse, and transparent environments. Having the right attitude is underscored by Will Sentence, Chief Executive Officer of Codesmith, who describes an instruction model—frequently used by bootcamps—where students program in pairs. He claims that it is important to the culture of bootcamp that students have an attitude of mentorship and knowledge sharing, rather than a "me-first" or knowledge-possessive attitude (Crispe, 2018).

Diversity of gender, race, and sexual orientation is highly appreciated by the coding bootcamps, and applicants from diverse backgrounds, encouraged to apply, are often offered scholarships. Most bootcamps will require some level of English language skill, regardless of whether or not the training program is offered in another language. An interview with one particular bootcamp revealed that it offers a complete training program in Spanish, providing a distinctive feature for that particular bootcamp.

The acceptance rate in a selection of bootcamps recently analyzed is as low as 3 percent (Mulas et al., 2017). Representatives from bootcamps interviewed by Course Report resist the use of statistics based on acceptance rates, partly due to the fact that prospective students are encouraged to apply more than once (Crispe, 2018).

Nearly all bootcamps indicate that applicants must bring their own laptops to training. As noted in a telephone discussion with a particular bootcamp in LAC, this presents a challenge in this region. As such, this bootcamp has sought ways in which to provide the necessary resources, on a case-by-case basis, for those students who are unable to provide their own laptops.

8. Tuition

What is the price tag of a coding bootcamp? Table 3 illustrates the average costs for coding bootcamps in Canada and the United States, comparing the expense and duration with degree programs in the United States. According to Course Report (2018), the average tuition price of an in-person, full-time bootcamp in Canada and the United States, typically requiring a commitment of a minimum of 40 hours a week, is approximately US$12,000 (Can$11,906). The range is from zero to US$24,000, although most (55 percent) fall within the US$10,000 to US$15,000 range. While most in-person bootcamp courses surveyed by Course Report are 12 weeks long, the survey reports an average duration of 14.3 weeks. While online bootcamp courses tend to last a little longer, averaging 15.4 weeks, they are somewhat less expensive at little more than US$11,000 (Course Report, 2018).

For the sake of comparison, an out-of-state bachelor's degree in computer science in the United States costs over US$40,000 a year on average, totaling almost US$170,000 for the four-year degree. For a two-year degree, the average cost is about US$20,000 a year and a total of US$40,000 for the degree. Thus, the majority of bootcamps charge a tuition fee that represents a small fraction of the cost of a four-year (or even two-year) computer science degree.

Table 3. **Costs of Canadian and U.S. Bootcamps versus U.S. Computer Science Degrees**

	Average cost (U.S. dollars)	Average duration
Coding bootcamp with courses in Canada and the United States	$11,900	14.3 weeks
Online bootcamp (led by instructor)	$11,118	15.4 weeks
Two-year computer science associate program (i.e., traditional higher-vocational in the United States)	$40,000	2 years (expected)
Computer science bachelor's degree program in the United States	$170,000	4 years (expected)

Source: Course Report (2018) Coding Bootcamp Market Size Study; and Collegecalc.org.

Note: Statistics are based on the 2017-18 IPEDS Survey of the U.S. Department of Education, reported by Collegecalc.org, available at www.collegecalc.org/majors/computer-science.

Many bootcamps offer payment plans and scholarships. Course Report (2018) notes that in 2018, there was an increasing trend among bootcamps to offer deferred tuition and income-sharing agreements (i.e., once students have a job, they are able to pay the school a portion of their salary for a period of time). The report identifies five bootcamps with tuition deferments and 12 with income-sharing agreements. Gellman (2018) describes how the financing scheme for income-sharing agreements varies between bootcamps. Since many of the bootcamps are new, however, and have been operating for only a year or less, it is difficult to evaluate these financing mechanisms in terms of success. Europe, in turn, has developed free-tuition models, mostly funded by philanthropy (see Box 3).

Box 3. **Philanthropically Funded Bootcamps and Public Sector Label of Endorsement: Unique Examples**

École 42: Free and without teachers

Xavier Niel, a French billionaire and founder of the second largest internet service provider in France, financed the creation of École 42, promising to fund its operating costs for 10 years. The first campus opened in Paris in 2013 and the second in Silicon Valley in 2016. Similar to other coding schools, it has a competitive application process, and those between the ages of 18 and 30 are encouraged to apply. While the program is free for those admitted, the training program is longer than in most bootcamps, generally lasting three years (Rowan, 2017).

The selection process includes an online game, whereby from 80,000 who play it, about 25,000 complete the game and 3,000 are invited to participate in la piscine, which is an intensive month-long selection pool (15 hours a day seven days a week) to compete for one of the available 1,000 slots. While the free tuition and absence of educational requirements makes the school more accessible to some, women nevertheless represent less than 10 percent of students (Rowan, 2017).

École 42 has a unique pedagogy of peer-to-peer and project-based learning. There are no teachers and the students must learn from each other and correct each other's work. Students are able to learn at their own pace, advancing through various project levels represented by video games. Once a project is completed, they advance to the next level.[a]

Grande École du Numérique: Quality assurance for individuals and employers

In 2015, four ministries in France jointly launched the Grande École du Numérique as a way to provide seed funding to new digital skills training programs, as well as to offer a comprehensive catalogue of training providers and courses that have been granted the label of endorsement. Training providers must re-apply for endorsement every three years and are committed to inclusivity (Orlik, 2017). While the label of endorsement is not a full-fledged accreditation, it reflects some level of public sector assurance for individuals selecting a training program as well as for employers seeking to hire graduates.

[a] See École 42 website at www.42.fr/linnovation-pedagogique.

Another financing option is through private lenders that partner with bootcamps (i.e., Earnest, Skills Fund, Pave, and Climb Credit). General Assembly, for example, offers tuition financing through Climb Credit, although its chief executive officer prefers a better payment option, since these loans may prove to be prohibitive for students with a poor credit history (Gellman, 2018). Furthermore, most bootcamps are not eligible for traditional student loan financing through federal student aid programs (Rose, 2018).

In general, bootcamp leaderships appear to be mindful of reducing the financial barriers for students wherever possible. Course Report states that 35 of the bootcamps covered in their report offer scholarships. Course Report and SwitchUp alike provide a list of the coding bootcamps that offer scholarships, updated in September and October 2018, respectively. The scholarships range from discounts of US$500 to scholarships that waive the full tuition, with many offered to military veterans, under-represented groups, and women (see Box 4).

Available information regarding bootcamp tuition in LAC (Table 5 on page 25) shows that the cost for the student is less expensive on average than the coding bootcamps in Canada and the United States. Nevertheless, one bootcamp in LAC that was contacted for this paper stated that before pricing the courses, careful consideration had been given to what would be affordable. Even then, it may remain a stretch for some. This source, as well as a digital skills training provider in the LAC region, expressed an eagerness to offer more scholarships to participants, particularly with a view to including minorities and those from lower-income backgrounds.

Box 4. **Coding Bootcamp Scholarships for Women**

Course Report identifies 29 bootcamps that offer either automatic or competitive scholarships for women (Hantel, 2018). More than half of these offer automatic scholarships for women, 15 of which are cash discounts ranging from US$500 to US$3,000, with an average discount of US$1,225. Coder Academy offers an automatic 50 percent discount and Dev Masters provides an automatic scholarship of up to 10 percent off tuition for women. There are another 12 bootcamps that offer competitive scholarships for women, whereby the women would have to complete an application process to win these scholarships. In terms of competitive scholarships, 4 bootcamps offer to cover a percentage of the tuition, ranging from 25 percent to 100 percent; 8 offer a range from US$500 to US$5,000 at an average of US$1,700; and one discounts the tuition by US$100 per month. Application for a scholarship is separate from the admissions process.

It is recognized that women are under-represented in the tech industry, making up less than 20 percent of the tech workforce.[a] Only 9 percent of the 100,000 respondents to Stack Overflow's Developer Survey in 2018 were women. Less known is whether or not women may be more efficient coders than men. Data from GITHub, an open-source software community, has been shown in a recent publication to demonstrate that women tend to be more competent coders than men. Researchers found that codes written by women were more likely to be peer-approved than codes written by men, but this was true only if the peer-evaluators remained unaware of who wrote the codes (Terrell et al., 2017). In response to this potential bias, Laboratoria—a bootcamp in Latin America originally funded in Peru but now active in several countries in the region—was established for women only.

[a] Evia https://www.evia.events/info-women-in-technology, accessed October 2018.

9. Bootcamps in Latin America and the Caribbean

Only two of SwitchUp's 2019 top 50 coding bootcamps are located in the LAC region. Le Wagon and Ironhack are ranked as the top two bootcamps and are located in Argentina, Brazil, Colombia, and Mexico (Table 4; see Appendix A for greater detail). Coding bootcamps around the world tend to exist in major cities and this holds true with regard to Latin America.

Table 4. **SwitchUp's Coding Bootcamps in the LAC Region**

		SwitchUp 2019 Ranking	
Country	**City**	*#1 Le Wagon*	*#2 Ironhack*
Argentina	Buenos Aires	✓	
	Belo Horizonte	✓	
Brazil	Rio de Janeiro	✓	
	Sao Paulo	✓	✓
Colombia	Bogota		✓
Mexico	Mexico City	✓	✓

Source: SwitchUp.org.

Table 5 provides a list of other coding bootcamps in the LAC region. It is evident that coding bootcamps in the region (as in the rest of the world) frequently offer multiple courses. Courses within the same bootcamp, however, can vary in terms of price, duration, and requisites. As such, note in this paper has been made when information is specific to a particular course, particularly in the case of many course offerings. Some of the coding bootcamps in the region are now listed as having closed, such as Hackership and GoCode in Costa Rica; devSchool.io in Guatemala; and CodeaCamp in Mexico. Further investigation is needed to learn more about why these coding bootcamps closed.

Disrupting Talent

Table 5. **Summary of Coding Bootcamp Providers in the Latin America and the Caribbean Region**

Provider	Courses Offered	Location	Modes of Delivery	Application Process	Cost	Duration
Le Wagon	Coding Bootcamps, Full Stack Web Development	Argentina Brazil Mexico	In-person	Application, interview, successful completion of Ruby Track on CodeAcademy	Different rates in various cities	9 weeks
Ironhack	Coding Bootcamps, Full Stack Web Development, Front-End Development, and Web Design (UX/UI)	Brazil Colombia Mexico	In-person	Apply online, technical assessment, personal interview, deposit, and pre-work	Approximately US$3,500 to US$4,500, depending on location	9 weeks
World Tech Makers	Product Management, Data Science, Front-End, Full Stack, Mobile Development	Brazil Colombia Mexico Online	In-person and piloting additional online courses	Interview, test, and prep-course	Varies. Online starting at US$29. In Colombia, courses cost US$1,500 or US$2,500; in Mexico and Brazil, US$3,000	12 weeks
Plataforma 5	Introductory (Front-End or Back-End), Coding Bootcamp	Argentina	Introductory (online or in-person)	Introductory: Laptop for in-person. Coding Bootcamp: knowledge of HTML, CSS and Javascript plus Interview and technical exam.	Intro approximately US$200 or US$250. Coding bootcamp, US$3,900	Intro (part-time 54 or 36 hours); Full-time coding bootcamp (600 hours)
Laboratoria	Bootcamp	Chile Peru Mexico	In-person	Women only, register, exam, Interview, pre-course		6 months
Bogotá Dev	Ruby on Rails (Spanish), Full Stack (English)	Colombia	In-person (Piloting a part-time night course)	Two interviews	US$800 within LAC US$1,199 outside LAC	5 weeks (Ruby on Rails), 10 weeks Full Stack
NivelPro	Visual Design, UX/UI, Mobile Development, Full Stack, Digital Marketing, Big Data, Machine Learning, Blockchain	Colombia	In-person	Varies by course. For Full Stack, knowledge of Windows XP, 7, Mac OS X, Internet, HTML, and at least one programming language, preferably JavaScript.		8 weeks (120 hours)
Hola Code	Full Stack web development	Mexico	In-person	Motivation letter, online exam, submission of a 1-3 minute video (teach us something), final interview to assess technical skills and cultural fit	Tuition deferment. Students only pay back tuition once they have secured a job in the tech industry. A weekly stipend is provided during the program.	5 months
Desafio LATAM	Mobile Development, Front-End, Full Stack, Digital Marketing and Sales	Chile Mexico	In-person	No programming requirements, but basic computational skills and reading skills in English plus participation in preparatory workshops	US$1,000 for Full Stack	3-6 months (180 hours) for Full Stack
Udacity	Nanodegree in Front-End Web Developer, Data Scientist, Programming for Data Science, Machine Learning, Blockchain Development, Business Analytics, and more	Brazil	In-person and online	Prerequisites for Front-End Developer: access to a computer with a broadband connection to install programs, Basic HTML, CSS, and JavaScript (or another programming language), independently solve and describe solution to a math or programming problem, English language skills, self-driven and motivated to learn.	Front-End Developer approximately US$1,020	4 Months (10 hours per week) for Front-End Web Developer

Source: Course Report, SwitchUp, websites of various individual organizations, and telephone discussions (October and November, 2018).

Note: Not included in the table, the program Jóvenes a Programar, launched by the Plan Ceibal in Uruguay, lacks some of the distinctive features of bootcamps as described in this paper, such as a highly intensive training experience. However, it offers a suggestive example of a coding school that has made an effort to adapt to the particular context of a LAC country. The program recruits students that have only reached lower secondary education, includes teaching English as part of the training, and provides laptops to students. Jóvenes a Programar has been organized in partnership with the ICT´s business association and tailors its curricula to current labor market demands. It is a government program that has attracted international support from the IDBLab.

10. Enter Public Policy

What do coding bootcamps have to offer to education at large? International organizations, governments, the private sector, and media alike are aware that today's technology puts pressure on the education system to transform and upgrade its practices to become more flexible and create more opportunities for people by enabling them to re-tool along their career paths (Mulgan, 2016). Despite some scholars tipping their hats to traditional higher vocational education tracks as the ones primed to adjust most quickly to address industry's human capacity needs (i.e., Holzer, 2017), even they may be too slow to keep pace (Mulas et al., 2017).

The resurgent interest in vocational education as an alternative pathway remains partially shadowed by the stigma held against vocational education in many societies (OECD, 2010), overlooked as a reliable source of crucial skills for the innovation system (Dalitz and Toner, 2016). Coding bootcamps—perhaps because of their specific connection to the hi-tech industry—are not affected by such stigma in the same way that other forms of vocational education may be. Furthermore, the ITU suggests that coding bootcamps have a lot to offer and could share their educational methodologies with universities (ITU, 2018: p.43). Bootcamp and similar online certification processes are proving to be better equipped to respond in real time to industry needs. This paper has documented a few cases whereby universities in Latin America are now granting credits to students who complete bootcamp courses.

A recent document by Orlik (2017), aimed to guide policymakers through a variety of mechanisms that can be used to help upskill the workforce, identifies five significant obstacles. These are as follows:

- **Culture of learning:** The traditional system, for the most part, expects people to finish school and enter the workforce. The trend now, however, is to keep abreast of technological change, which requires the continual update of skills.
- **Motivation:** OECD (2016) discovered that many of those occupations with the potential for transformation as a result of digitalization are unaware of impending changes; thus, they have not prioritized the need for digital training, upskilling, and reskilling.
- **Leadership:** Strong leadership and an in-depth knowledge of digital trajectories are essential at the top level of organizational management.
- **Resources:** Firms are used to devoting limited resources (time and money) to train employees.
- **Access to training:** People and firms require support to identify ways to access courses that will develop digital skills.

Orlik (2017) highlights a range of public sector interventions to facilitate a variety of digital skills training programs in addition to coding bootcamps. Examples include financially supporting individuals (or corporations); establishing a voucher system for employees;

providing financial support to associations (or networks of training programs) to establish quality standards; launching publicly provided trainings;[12] and providing public financial support to citizens who wish to improve their digital skills (e.g., SkillsFuture Singapore).

Most examples of public sector intervention tend to focus on two of the five obstacles identified by Orlik; and most frequently, the intervention aims either to increase (a) available resources, or (b) access to training. These are sometimes complemented by another objective such as the creation of awareness for a culture of learning. Most cases to date, however, fail to move sufficiently toward the search for constructive synergies between private provision and public funding or regulation that are based on enlightened public policies in other areas of education (Navarro et al., 2004).[13]

One exception, provided by an intriguing public-sector intervention, is the recent effort by the Israel Innovation Authority to host a competition for coding bootcamps to win an outcome-focused grant to train software developers and computer programmers in Israel (Box 5). This remarkable program possibly represents the best attempt to harness the potential of digital skills bootcamps within the framework of innovation policy.

Box 5. **Israel Coding Bootcamp Competition: Public Sector Initiative to Increase Educational Pathways to Hi-Tech**

In the face of a shortage of software developers and computer programmers in Israel's thriving hi-tech industry, the Israel Innovation Authority (IIA) sought ways to increase the number of pathways to the industry. Inspired by the success of nonacademic coding bootcamps in the United States, the IIA launched a competition for coding bootcamps in 2018 for bids to operate a coding bootcamp program and receive compensation for achieving results. Coding bootcamp competition results were announced in June 2018, with 24 bidders and 7 winners. The program is expected to graduate 280 developers in the first year and approximately 2,000 over the next five years.[1]

The selection committee for the competition comprised top-level government officials, including the head of the IIA; representatives from the Ministry of Economy and Industry and the Ministry of Finance; senior managers from the tech industry in human resources, research and development, and general management; and experts with computer science and engineering instruction experience. Bidders were required to meet the necessary prerequisites, which included being "an Israeli corporation, lawfully incorporated and registered in Israel and operating in compliance with the laws of the State of Israel". They were required to provide (including but not limited to) the following:

- business plan
- description of course contents
- description of student selection/application criteria
- marketing plan to increase the number of potential students
- resumes of tutors or instructors
- three letters of support from hi-tech companies.

[12] As in the case of Digilyft, described in Appendix C.

[13] The central notion underlining such "enlightened" policies is the understanding of public-private synergies in education within a framework of principal-agent relationships, allowing for the strengths of private providers of training to be placed at the service of public goals through the application of performance contracts, regulation, and public funding. See Box 5 for a clear example.

Box 5. Israel Coding Bootcamp Competition: Public Sector Initiative to Increase Educational Pathways to Hi-Tech (Cont.)

The winners would receive a conditional base amount to commence operation, although all of the grant money would be awarded via several “pay-for-performance” subgrants. For example, a training grant would be awarded based on whether or not the coding bootcamp meets at least half its proposed quota, and a placement grant would be awarded to bootcamps for each graduate who gets a job with a salary of at least NIS 14,000 a month (approximately US$3,800) and stays employed for at least nine months within the one-year period post training. The placement grant is set according to the salary, determined by the difference between the wage and the baseline of NIS 14,000. Should the graduate earner be a woman or from a minority group, the grant awarded to the coding bootcamp increases.[2]

In a telephone interview with Naomi Krieger Carmy, Head of the Societal Challenges Division at the IIA, to learn more about the program and its experience, so far. She stated that the competition was the end of what could be a long business development process. Israel already has strong academic training in its highly developed Innovation system; however, academic graduates alone are not able to meet the local demand for talent. Prior to launching the competition, the IIA examined various local and international models, and designed parameters that would potentially lead to successful models. Parameters were applied in order to generate an example of what a good coding bootcamp should be, thus forming the basis for the strict selection process so that those coding bootcamps bidding recognized what was expected of them by the IIA. This would also ensure that the industry was not only aware that those bootcamps with IIA certification met a high standard, but also that if graduates were to be hired, they would be of high quality.[3]

On the one hand, part of this assurance includes a requirement that at least 50 percent of the bootcamp trainees are university graduates from the exact sciences (e.g., Mathematics or Biology), who have high abilities but do not have the time or money to return to university to study computer science or engineering. On the other hand, the program does not intend to dictate or continuously approve course content. This was done on a one-time basis (during the application process) and is re-evaluated annually. Bootcamps are free to change up to 25 percent of course content without the involvement of the innovation authority, thus allowing bootcamps the freedom to follow and adapt to industry needs without constraint, for example, in being required to submit a course syllabus through several rounds of approval.[3]

When asked if she has any advice for policymakers interested in adopting a similar approach to attract coding bootcamps as digital skills training providers, Naomi Krieger Carmy cautioned that it is essential to know the local context and have a very clear handle on the industry (the demand side). She emphasized the amount of research the IIA had undertaken prior to the competition with regard to the local market, including training alternatives, industry needs and preferences, and international models. Ms. Krieger Carmy reflected that it can be difficult to strike a balance between ideal results and realistic training provision. For instance, most of the coding bootcamp winners selected are based in the center of Israel. If they had made it a requirement for bidders to offer training in more remote areas, they may not have attracted sufficient interest from high-quality players. Furthermore, the tech industry is mostly located around the center. Setting up a training program in a remote area would be a difficult challenge as the graduates may not have jobs available.

Most of the seven winning coding bootcamps were established during the summer months of 2018, with the start of classes in the fall of the same year. It is therefore too premature to know the outcomes of the program.[3]

Box 5. **Israel Coding Bootcamp Competition: Public Sector Initiative to Increase Educational Pathways to Hi-Tech (Cont.)**

Two lessons can be drawn clearly from the IIA policy intervention. The first relates to the fact that good public policy should react constructively to market developments. The emergence of private providers of training in digital skills was not perceived a threat to public education; rather, it was viewed as an opportunity to resolve an issue of coordination. The issue at hand is defined as the severe shortage in digital talent. In some economies, private bootcamps sprang up naturally and provided a mechanism to help address this issue. In Israel, the public sector decided to intervene to act as a catalyst to facilitate bootcamps and increase the number of local people with the digital talent companies were seeking. Via the competition, the IIA influenced and verified the quality of the selected training providers. The second lesson relates to the need for solid public sector analyses and in-depth knowledge of technological trajectories within specific industries,[4] potentially crucial to the select the best policy levers. The IIA undertook a detailed analysis of the digital talent shortage in the economy, subsequently gaining the ability to steer the bootcamps toward appropriate targets in terms of content.

[1] See Israel Innovation Authority at https://innovationisrael.org.il/en/ for further information.

[2] Israel Innovation Authority: "Call for Proposals: Benefit Track no. 34 – Program for Advancement of Non-Academic Training Institutions."

[3] Obtained from personal communication in November 2018.

[4] Taking account of the larger perspective, this Israeli program could fall within a framework not unlike the Lee and Lim (2001) model of technological capability building. In that context, knowledge and resources are crucial for research and development outcomes and market success. Nevertheless, the decision making of firms is shaped by the technological regime in which they operate. The authors define crucial elements of the technological regime as the frequency of innovation, the predictability (fluidity) of the technological trajectory, and access to an external knowledge base. Different technological regimes will influence how businesses assess their chances of product development and market success which, in turn, will influence the strategies they opt for to acquire external knowledge and mobilize internal resources (i.e., financial, human, and physical). The authors posit that when the technological regime of an industry has an unpredictable technological trajectory and is characterized by high cumulativeness, it is more difficult to catch up. This, however, can be mitigated by access to external knowledge and government intervention. Arguably, digital technologies are characterized by frequent innovation, high cumulativeness, and fluidity. Employees with the software development know-how needed by firms—and, in this case, also government agencies—are in short supply everywhere, and so they are in Israel. Thus, while on the one hand access to a sufficient number of people with this know-how is constrained, on the other hand, new training (external knowledge) models have emerged around the world that consist of methodologies for the rapid acquisition of practical know-how in digital skills. In the case of the program at hand, the public sector in Israel facilitated access to external knowledge by way of fostering bootcamp training programs, in order to generate additional local human resources so that firms are able to participate and compete in continuous product development and, hence, accelerate the pace of technological capacity building in the economy.

The scope for policy intervention in fostering and cultivating digital skills training programs is vast. While a variety of approaches have been tried, the coding bootcamp industry remains nascent. It will take time before there is evidence of the effectiveness, for example, of large-scale interventions such as the one undertaken by the Israel Innovation Authority. This does not imply that there should be any hesitation about whether or not to engage in this topic. Signs point to the fact that bootcamps offer a new model of skills upgrading and pave alternative educational pathways that complement and may provide useful insight for traditional educational institutions. Section 12 provides various recommendations regarding the cultivation of digital skills training programs in the LAC region.

11. Critical Discussion

The fast-growing digital bootcamp industry, including some of its distinctive characteristics, opens the floor to questions on several important issues about the pace and nature of technological change, the future of technical-vocational and university-based education, instructional methods and, last but not least, the very nature of digital skills as something traditionally associated with STEM education. This section discusses a few of these key questions.

11.1. Are bootcamps the answer to the shortage of digital skills brought about by the digital revolution?

While demand for specific technical and professional skills varies geographically, technology is transforming the skill profiles that are most attractive to employers around the world (WEF, 2016; Bakhshi et al., 2017). Job growth has concentrated in the high-tech sector in Europe, particularly for software developers, and in the United States, prompting an increasingly urgent sentiment that equipping people with relevant digital skills is crucial for innovation and productivity (OECD, 2017).

The big challenge is that most adult workers need to skill-up in order to work effectively with available digital technology to maximize their productive contribution. Orlik (2017) argues that it is essential for governments to prioritize policy to ensure that its workforce (and citizens) develops digital skills and the capacity for continuous learning; otherwise, the risks are severe, leading to higher unemployment, reduced economic growth, and greater inequality. Companies, such as IBM, are altering their hiring practices from degree-focused to skills-focused in what they call "new collar jobs". IBM's chief executive officer is calling for hands-on experience, advocating skills acquisition through vocational education and coding bootcamp programs (O'Donnell, 2017; Umoh, 2017).

Indeed, a job site, surveyed 1,000 human resource managers and technical recruiters in 2017 from a variety of firms in the United States to ask what they thought about bootcamp graduates. Around 80 percent of respondents had hired a graduate from a bootcamp for a tech position and 99.8 percent would do so again. Overall, these employers appeared satisfied with the job performance of bootcamp graduates, comparing them favorably to computer science graduates (Indeed, 2017). Broken down,

- 72 percent said that the job performance of bootcamp graduates was equal to those in computer science;
- 12 percent believed that bootcamp graduates outperform those in computer science, and
- from the skeptics, 17 percent had doubts about the bootcamp graduates they hired.

11.2. Is the bootcamp model an effective educational alternative?

Job placement statistics reported by bootcamps, as noted earlier, are impressive and almost half of the top 50 coding bootcamps (ranked by and according to SwitchUp.org criteria) have third-party verification of their outcomes. Some people, nevertheless, are skeptical of bootcamp job placement outcomes, claiming "padded" numbers. Caution should be used, therefore, when interpreting some of the results. For example, according to Stack Overflow's 2018 developer survey, approximately 45 percent of bootcamp graduates reported that they had held positions as developers prior to attending bootcamp (Swanner, 2018). Jay Wengrow, Chief Executive Officer of Actualize, paints a rather bleak picture for the financial outlook of some of the most famous bootcamps in 2018. He is rather critical of the notion that coding skills immediately lead to jobs, citing the selectivity of top coding bootcamps in the industry and a case in which Flatiron was considerably fined for misrepresenting job placement outcomes on its website (Wengrow, 2018). In fact, in the absence of a full-fledged experiment, it is not possible to distill whether some portion of the high job placement rates could be attributed to those already employed in the industry. Nevertheless, if people employed in the industry consider bootcamp trainings useful for them, the trainings will continue to satisfy an important digital talent development purpose and resolve one obstacle; namely, to facilitate continuous upskilling among the adult working population (Orlik, 2017).

The World Bank recently conducted a randomized control trial of coding bootcamp participants in Medellín, Colombia, against a control group. While the report concludes that the bootcamp did not appear to have an immediate direct effect on employment outcomes, bootcamp participation did increase access to high-quality jobs in the IT sector. The report recognizes a series of methodological issues that limited these findings. First, due to a high refusal of training and the drop-out rate, adjustments were made to the selection strategy of the treatment and to the control groups that deviated from the original plan of the experiment; second, there was a significantly low endline survey response rate from the control group; and, finally, the sample size was rather small, thus requiring additional statistical restrictions that made it difficult to establish results of significance (World Bank, 2018).

Trochim et al. (2012) outline a school of thought in the evaluation literature that suggests that the sophistication of the evaluation method should be "matched" with the lifecycle stage of a program. This evaluation literature draws upon evolutionary theory to suggest that programs that are still in their initial stages, or are still undergoing rapid changes, are best matched with an evaluation that focuses on implementation. As a program matures and stabilizes, it is then better matched with an evaluation that assesses program effectiveness (Trochim et al., 2012). Viewed from this perspective, the fact that the bootcamp in Medellín had just begun its operations, perhaps a full-fledged randomized control trial may have been a more advanced evaluation phase than best suited with the lifecycle phase of the bootcamp.

11.3. Is there a need for public regulation or will the industry consolidate self-monitoring arrangements?

While employers may have been satisfied with bootcamp graduate hires, the vast majority (98 percent) tend to support increasing the regulation and accreditation of bootcamps (Indeed, 2017). Employers seek a way to distinguish between the best coding bootcamps and the next tier. Some bootcamps and their alumni actively encourage transparent reporting, as evidenced by the creation of the CIRR, a nonprofit organization dedicated to increasing and maintaining transparent reporting methods in the coding school industry. On its website home page, an alumnus of a CIRR member coding school is quoted as stating that she selected her coding school partially because of its employment outcomes and its strong reputation with employers, and "...Now, as an alum, it's even more important to me that the program retains transparency."[14] CIRR was established by bootcamps and it is a voluntary, self-monitoring mechanism. It was initiated partly because some schools did not like others inflating their own outcomes on their websites and, while it has a relatively small membership of participating bootcamps, it is a pioneer in creating standards for tracking important labor market outcomes. Other forms of technical training and higher education tend not to measure or track their labor market relevance although there is a growing societal and political perception that perhaps they should (OECD, 2017).

11.4. Are universities and vocational schools being disrupted?

Indeed (2017) found that despite positive responses from employers regarding bootcamp graduates, 41 percent would prefer to hire a candidate with a computer science degree. This signifies that employers continue to value a computer science degree. While 41 percent is a large portion, it is less than half.

In an interview about the future of tech education, Andrew Moore, Dean of Carnegie Mellon's Computer Science program—the most popular four-year bachelor's degree program in the United States with 177 graduates a year[15]—states that he is not worried about the prospects for his graduates. He argues that there are various roles within the industry; people who build technology and people who recombine technology. According to Dr. Moore, elite computer science degrees are producing graduates who will introduce the next ideas, and these programs are necessary now and will continue to be so. Nevertheless, Dr. Moore is concerned that human capital will be the binding constraint for future advances in technology, and his particular reflection on the contribution of Carnegie Mellon points to the fact that the massive upskilling and reskilling needs that many industries—if not the entire economy—demand will build the need for other suppliers, beyond the relatively small group of graduates occupying the upper end of digital skills (Swisher, 2018).

[14] For more information, see CIRR at https://cirr.org, accessed November 2018.

[15] For more information, see Collegecalc at http://www.collegecalc.org/Collegecalc.org, accessed October 2018.

Bootcamps, while they offer alternative pathways to enter the hi-tech sector, do not appear to be a threat to the upper end of the education market. The question remains, however, whether or not they are, in fact, becoming disruptive forces that will produce considerable challenges to the industry's mainstream vocational education schools and to the average university program.

Digital skills training programs increasingly have rigorous application processes, positioning them as potential competition to other forms of education; they also are able to retrain and upskill large numbers of people relatively quickly to fill a shortage in the supply of computer programmers. While one could question what may be the saturation point in the need for computer programmers, projections suggest that, if anything, there will be an increase in demand (e.g., in Europe and the United States) in the short-to-medium term. There also is the potential for the bootcamp-approach to spillover to other areas of education.

Digital learning environments offer a wide scope for learning analytics. Educational research was confined because researchers had to choose between breadth (large-scale assessments with shallow information about learning processes) and depth (small classroom studies, focused on learning, albeit on a limited scale). Today, the digital classroom offers data collection on learners in real time. (Kizilcec et al., 2016). Coding bootcamps, often operated by computer programmers, offer an opportunity for research on computer-programming-based adaptive learning methods, the effectiveness of gamification in learning, and the use of AI in the classroom.[16]

Those who have investigated the coding bootcamp methodology have noted that the way in which the trainings are delivered provides a useful model that can be applied to other forms of technical training beyond coding. In fact, there are a couple of examples of bootcamps that are designed to address advanced manufacturing skills affected by automation and digitalization (Mulas et al., 2017). More generally, it is inevitable to pose the larger query about whether or not bootcamps have created a novel template for vocational and technical training that is able to influence education at large.

Traditional criticism of vocational training has normally focused on the lack of responsiveness and adaptation to industry needs; rapid obsolescence of equipment and curricular content; antiquated teaching and learning approaches and methodologies; weak accountability and quality assurance mechanisms; low cost-effectiveness; and the scarcity of information about graduate careers and salaries. Suddenly, however, market forces have shed light on a new business model for training in digital skills—one that is rapidly growing and improving—to contest, rather convincingly, each and every single one of these lines of criticism.

The adequacy of this model for areas beyond digital skills training can be, of course, ultimately irrelevant. Nevertheless, an in-depth examination should be made of the benefits to learning this model and the extent to what it can offer to the traditional ways of training.

[16] Some bootcamps—most notably the Ecole 42 in Paris—already incorporate AI in the education process, for instance, by suggesting particular learning trajectories to various students based on data gathered as they advance in their education, and demonstrating their relative strengths and weaknesses.

12. Recommendations

The shortage of digital skills is considered, worldwide, a binding constraint in the process of digital transformation for all industries. The LAC region is no exception. The preceding characterization of digital bootcamps suggests that they may significantly contribute to resolving the challenges of digital reskilling and upskilling efficiently and cost-effectively. This, however, will require political will, the formation of public-private alliances, and effective public and innovative policymaking. The following is an initial list of recommendations:

1. Many introductory programming courses are online and are offered for free. Build awareness within the LAC region to enable prospective students to explore the least expensive options and personal preferences.

2. **At the local level, ascertain the binding constraint for prospective students.** While private sector providers are filling a gap, there may be ways the public sector can facilitate an environment whereby uptake becomes greater and faster. This may be in the form of financial assistance to attend coding bootcamps; provision of laptops for students accepted; financial scholarships for typically under-represented groups in the tech industry; housing and/or travel assistance to encourage applicants from remote areas or economically disadvantaged backgrounds; or large-scale public investment programs to proactively recruit more digital skills training providers to particular cities within the region. The opportunity to launch good public policy that takes advantage of what bootcamps can offer, while preserving their distinctive qualities, may well contribute to reducing the risk of a suboptimal provision of digital skills in the economy as a whole or in specific key sectors of the economy. Investment in this manner may provide a way to rebalance education opportunities for all.

3. Since bootcamps tend to concentrate around cities, **broadband infrastructure is necessary so that students in small cities or more remote areas can connect to the internet and participate in online courses.** The regional spread of infrastructure is critical and ways to increase accessibility to these programs needs to be considered.[17]

[17] While research for this paper has found that the majority of coding bootcamps are offered for in-person attendance, the number offered online is increasing. Thus courses may become more accessible to a greater number of people in the LAC region. Nevertheless, the challenges particular to online learning relate, for example, to self-regulated learning strategies and goal attainment. Kizilcec, Pérez-Sanagustín, and Maldonado (2016) surveyed almost 5,000 online students in six different types of online courses, including Computer Science. The courses were offered through Coursera by Chile's Pontificia Universidad Católica. The conclusion was that to effectively encourage self-regulated learning in online format, various strategies need to be considered depending on the social and cultural contexts. One digital skills training program provider that was contacted indicated that in order to encourage higher online completion rates, a mentor was made available. The combination of a mentor and the online material encouraged students to achieve their goals, thus leading to concrete improvements in terms of course completion.

4. It is clear that while coding bootcamps offer a platform for reskilling and upskilling, they are not a magic bullet. Bootcamps are selective and, while their selection criteria are not based on credentialism, prospective students are required to possess a mix of technical and soft skills; that is, prospective students must gain these skills before they are accepted into a bootcamp. There is scope for increasing accessibility to these programs through fostering more basic programs either in k-12 education, higher education or outside the formal education system.

5. **Align evaluation phases with those of program development.** While an assessment of bootcamp trainings is essential, it may be as important to consider the stage of the program. Nascent bootcamps should focus their evaluation on program implementation while those that are more mature should assess program effectiveness.

6. **Programming should be tailored to the local context**. Despite bootcamp methodology effectiveness in some contexts, local needs may require adaptation. This may include confidence-building, additional forms of mentorship, and the promotion of success stories that exemplify self-projected expectations of a career path in the high-tech industry.

7. **Increase access to bootcamp training programs by supporting the onboarding of soft-skill training**. Soft skills are valued by bootcamp training providers, and for those lacking this prerequisite, they can benefit from socioemotional pre-training programs. Many coding bootcamps offer such training in parallel to technical training; however, most on-boarding coursework is technical in nature.

8. **At the local level, thoroughly examine demand as well as investigate the advantage of developing bootcamps as a pipeline for digital education and training.** The ITU emphasizes the potential of coding bootcamps to share their effective and rapid teaching methodologies with other education providers. Coding bootcamps also offer opportunities to explore technological trends in education (i.e., computer programming based on adaptive learning methods, effectiveness of gamification in learning, and the use of AI in the classroom).

9. **Build learning mechanisms that will ensure that private sector leadership, management of small and large entities, and entrepreneurs are able to keep abreast of how to integrate the latest technologies into their business**, while taking into account that everything that can be digitalized will be digitalized. Despite the fact that this type of mechanism exists, it is not prevalent and should be increased.

10. **Seek expertise relating to the various digital skills required within particular sectors**, since it is perhaps more of a challenge to transition industries with existing non-digital systems into the digital era. More attention should be aimed at potential cross-collaboration between advanced digital skills in the tech industry and those evolving in other industries, including their capacities.

11. **Develop public-private synergies that will address the digital talent shortage**. This has been exemplified by the experience of Israel's IIA. It can be carried out by establishing synergies between public policies, including social inclusivity and the diversity of goals, with the bootcamps acting as private providers of training. The design and launch of initiatives along these lines should seriously be considered in any economy facing a digital talent shortage.

12. **Carry out an in-depth examination of the implications posed by a potentially serious disruption in the market in terms of technical and vocational training** (perhaps at the lower end of tertiary academic education as well). Bootcamps appear to be delivering, within their narrow—albeit important—target of digital skills learning, what traditional educational systems have had serious difficulties in doing; that is, high-quality, market-relevant, and cost-effective technical training that is highly responsive to the needs of industry. Bootcamps are rewriting the traditional rules that made high-tech skills and jobs a monopoly for highly trained engineers or mathematicians. With their significantly rapid growth, they have generated quality assurance mechanisms in the absence of public regulation. In the face of these developments, unless this can be achieved exclusively in the case of teaching coding skills—and it results completely inapplicable to teaching any other skill—can education institutions remain unaffected.

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Appendix A. SwitchUp's Ranking of the Best Coding Bootcamps Worldwide, 2019

Table A1. **Tallied Characteristics of SwitchUp's Top 50 Ranked Coding Schools Worldwide, 2019**

2019 SwitchUp Rank	Name	Available Online (1 = yes, 0 = no)	Verified Outcomes (1 = yes, 0 = no)	Part-time Option (1 = yes, 0 = no)	Job Guarantee (1 = yes, 0 = no)
1	Le Wagon	0	0	0	0
2	Ironhack	0	1	1	0
3	App Academy	1	0	0	1
4	General Assembly	1	1	1	0
5	Bloc	1	1	1	1
6	Thinkful	1	1	1	1
7	Flatiron School	1	1	1	1
8	HackerYou	0	0	1	0
9	The Tech Academy	1	1	1	0
10	Hack Reactor	1	1	1	0
11	Tech Talent South	0	0	1	0
12	Epicodus	0	1	1	0
13	Actualize	1	0	1	0
14	Startup Institute	1	0	0	0
15	Makers Academy	0	0	0	1
16	LambdaSchool	1	0	1	1
17	BrainStation	1	1	1	0
18	Coding Dojo	1	0	1	0
19	Codesmith	1	0	1	0
20	The Software Guild	1	1	1	0
21	Code Fellows	0	1	1	0
22	Tech Elevator	0	1	0	0
23	DigitalCrafts	0	1	1	0
24	Fullstack Academy	1	1	1	0
25	Wyncode	0	1	0	0
26	Lighthouse Labs	0	1	1	0
27	Skylab Coders Academy	0	0	0	0
28	Galvanize	1	0	0	1
29	Skillcrush	1	0	0	1
30	Dev Mountain	1	1	1	0
31	Ubiqum Code Academy	0	0	1	1
32	LearningFuze	0	1	1	0
33	CareerFoundry	1	0	1	1
34	RED Academy	0	0	1	0
35	Founders and Coders	0	0	0	0
36	Code Institute	1	0	1	0
37	Sabio	0	1	0	0
38	Horizons School of Technology	0	0	0	1
39	Launch Academy	0	1	0	0
40	Dev League	0	0	1	0
41	Turing School of Software and Design	0	1	0	0
42	Coding Temple	0	0	0	0
43	Claim Academy	0	0	0	0
44	devCodeCamp	0	1	0	0
45	Coder Foundry	0	0	0	0
46	Codeworks	0	0	0	0
47	V School	1	0	1	0
48	Neoland	0	0	1	1
49	Bitmaker Labs	1	0	1	0
50	SE Factory	0	0	0	0
	Total	**22**	**22**	**30**	**12**
	Percent of the Top 50	**44%**	**44%**	**60%**	**24%**

Source: SwitchUp.org. Available at www.switchup.org (accessed October 2018).

Appendix B. Telephone Interview Methodology and Telephone Interview Guide

A guide for the semi-structured telephone interviews was created for this paper. Questions were designed to gather information about each of the nine framework elements identified by Orlik, 2017 (Readie and Nesta) relating to the development of skills for a digital workforce.

The following coding bootcamp organizations were selected and contacted: Le Wagon, Ironhack, World Tech Makers, Plataforma 5, Laboratoria, DevBogotá Bootcamp, Hola Code, General Assembly, E´cole 42, Udacity, and Digital House, from which three formally scheduled telephone discussions resulted. Less formal telephone consultations were held with ICT, various digital skills training experts, and public sector authorities to discuss the trends, lessons learned, and good practices in the provision of digital skills training.

Telephone Interview Guide:

Please note: if your organization offers more than one digital skills training program, if possible, answer at the organizational level. If that is not convenient, please indicate the program to which your answers correspond: Program name. If the answer to a question is available on your website, please write: W.

General Question:
What makes your program distinctive?

Skills Forecasting
How does your program keep up-to-date with the needs of industry (the labor market)?

Curriculum Development
How often is the curriculum changed?
(If yearly, or less) How are staff able to change their curriculum so quickly?

Pathway Guidance
Does your organization help prospective students ascertain whether the program suits their aspirations?
If yes, please check this box: ☐ and describe how:

Assessment
How does your program screen applicants?
Are people screened on the basis of higher education credentials? If yes, please check this box: ☐

Funding
Does the program receive public or private financial support (or both)?
Public ☐ Private ☐ Both ☐
What is the cost of tuition for the students?
What kind of financial support (i.e. scholarship) is offered to students?

Wraparound Support
Are mentors, coaches, networking opportunities, childcare or compensation from time off of work offered as part of the program?
If yes, please check this box: ☐ and list which wraparound support is provided:

Training Delivery
Are flexible courses (part-time and/or online) offered?
If yes, please check this box: ☐ and please describe any systematic differences between the performance of individuals who pursue flexible courses?

Accreditation
Does the program have a third-party assessment of the programming?
If yes, please check this box: ☐
Is the program accredited?
If yes, please check this box: ☐

Career Support
What career support mechanisms are offered to the students?
Which of those are most effective?

Other: **These questions are optionally part of the semi-structured interview, depending on the pace and willingness of the respondent.**

1. Are you partnered with private sector companies? If yes, please check this box: ☐ and list which companies:

2. For the in-person coding camps, do you choose your location for one of the following reasons?

Prompt, for example: for industry, or a supply of un(der)-employed yet well-educated prospective students, or public support, or business friendly, innovation friendly, tech-friendly environments, other?
If yes, please check this box: ☐ and list which reasons:

3. What are the trends in terms of student profiles?

4. What are the trends in terms of completion and employment outcomes?

5. Is there a limit to the labor market demand for the skills learned in your program(s)?

6. Does the program face competition from other providers?

7. Describe the business model:

8. What are the program's biggest obstacles?

9. What is the program's best asset?

10. Is your program better positioned than traditional educational institutions to deliver the skills training programs you offer?

11. Is there anything else you would like to add?

Would you like to receive a copy of the study upon its completion? If yes, check this box: ☐

Thank you for your time!!

Appendix C. Digital Leadership Entrepreneurship

Digital leadership is no longer reserved for tech giants, since practically all companies now need leaders who understand how to use digital technology for their business. Most leaders, however, do not have the necessary skills to execute a digital strategy; if they do, they achieve higher profit margins (HBR, 2015).

Approximately 9 percent of respondents to Stack Overflow's 2018 Developer Survey reported that they work in the financial services sector or in technology companies, with another 4.5 percent reportedly working in healthcare technology or service companies. The demand for software developers for data mining and AI has affected most sectors and is significantly prevalent across the tech- and nontech-intensive industries. While IT companies may have sufficient coders, those beyond the tech sector may have only a few coders on the payroll who are in-house and some who are external to the company.

Firms must decide whether to train, buy, or borrow the talent they need. Mid-level managers, who supervise software developers and other IT professionals beyond the tech industry, are likely to have a background in or some knowledge of information systems and systems integration. Executives, who ultimately set the company direction and are responsible for making investment decisions, may not have a sufficient understanding of how technologies, such as AI and machine learning, can contribute to the productivity and efficiency of their business, nor what the implications are for the company (personal communication with an ICT expert). According to Orlik (2017), strong digital leadership is one of the five key barriers impeding the upskilling of the workforce within the digital era.

Executive programs relating to digital leadership are in place at institutions such as the Massachusetts Institute of Technology, INSEAD (France), and Vlerick Business School (the Netherlands). The broad goals of the programs are designed to assist executives and managers to gain an understanding of how to harness AI for their company; learn about the key concepts and skills relating to recruitment for the development of effective AI systems; and seek ways to overcome potential implementation/performance challenges, particularly in terms of large amounts of text data.

A program along these lines in the Latin America and the Caribbean region, Invensis, exists in Panama. The program's website offers course certification in the Foundation of Digital Awareness, targeting senior and junior executives, mid-management, business managers, and team leaders.

Orlik (2017) describes the Digilyft kickstart program, launched in 2017 by the Swedish Agency for Economic and Regional Growth. The objective is to increase the use of digital technology in small- and medium-size enterprises (SME), particularly targeting managers in the manufacturing industry. A pilot program evidenced that some business leaders consider "digitalization" to be a buzzword and they reflect a disinterest in taking the time to attend relevant workshops. To motivate these managers to attend is a challenge in itself, given that their time is their most valuable resource. The program, nevertheless, has contributed to some SMEs in developing new strategic outlooks as well as fostering collaboration between SMEs within the same industry. Relevant examples of specific industries are valued by managers.[18]

According to the Digital Skills Toolkit, produced by the International Telecommunications Union in 2018, digital entrepreneurship requires a mixture of traditional entrepreneurship skills and advanced digital skills. While digital entrepreneurship is an evolving concept and subject to ongoing analyses, it is especially relevant for enterprises that wish to engage intensively in social media, big data analytics, digital marketing, and web application development. Digital entrepreneurship training programs and strategies combine nondigital entrepreneurial skill development (i.e., finance, risk taking, critical thinking) with novel digital technology (ITU, 2018). There is, however, a difference between digital entrepreneurship, digital business in general, and digital startups and scaleups (EDCi, 2016). Digital startups and scale-ups relate to businesses that would not be operational without the internet.

There are a growing number of master's program courses available in the field of digital entrepreneurship; for example, Barcelona's (Spain) international business school, ESEI, offers a master's degree in Digital Entrepreneurship and HEC Paris (France) offers the Certificate in Digital Entrepreneurship for its master's program students. PitchIT Caribbean in Jamaica aims to cultivate developers and entrepreneurship teams in the Caribbean region through a combination of mechanisms (i.e., financing, training, mentorship, and access to facilities). A full treatment of these key areas of digital skills development lies beyond the scope of this paper and requires additional research effort.

[18] This Digilyft example is based on a case presented in Orlik (2017)

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