



**The Information and Communication
Technologies & Digital Media**
Sector Navigation Team

CALIFORNIA COMMUNITY COLLEGES

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PYTHON



SOFTWARE DEVELOPER HIRING CRITERIA

A TECHNICAL RESEARCH REPORT

JAVASCRIPT



JAVA



GITHUB



Introduction

Over a year ago, Van Ton-Quinlivan, Vice Chancellor, Economic and Workforce Development, California Community Colleges Chancellor's Office asked that the Information and Communication Technologies (ICT) and Digital Media Team investigate the shortage of Software Developers in the Bay Region. "The California Community Colleges need to be relevant in this marketplace," she said.

The Bay Region was and still is awash with boot camps, White House Tech Hire Initiatives, H1B Visas and no shortage of opinions on how to solve the problem. After interviewing the CEO's of Hackbright Academy and Rocket U with Clarke Porter, Vice President of Pearson VUE and Kay O'Neill, now with DreamCorps the flourish of boot camps reminded me of the Dutch Tulip Bulb craze of 1635.

Still, the urgency of our contacts with the San Francisco Mayors Office and the urgency of business contacts with high-end software development needs echoed repeatedly. An awkward confluence of need and political convenience coalesced around the notion that almost anyone could be boot camp trained to be a programmer.

Yet the boot camps screened hundreds to find a cohort of 20, inner city kids were quickly sidelined to web development as an 'experience' instead of moving in to close the developer gap. Most successful boot camp students were in their late 20's, post baccalaureate, with a penchant for math and \$15K and twelve weeks to spare. Finding relevance for the California Community Colleges (CCCs) was going to take a strategic market research approach.

Karen Beltramo, expert researcher with the DWM Center of Excellence pulled three years of software developer online job ads through Burning Glass, broke them down by software language and industry, then plotted the growth and frequency of languages in demand. Working with Scott Young of ListenToSee, Inc. (LTS) she was able to sort through the various language combinations and create a clear picture of the most effective software skills to teach. No small surprise, Python ranked high with Java, but C++ was and is amazingly resilient among the 20 or more alternatives.

Finding the most relevant play for the CCCs meant discovering the pathways to jobs that our typical students would seek. A great many adults come to the CCCs for retraining and up skilling in addition to approximately 70% that are new to higher education. Scott Young, LTS, retained Allison Marino, MS MIT, to become a field Principal Investigator based upon her knowledge of software as a new entrant, her network of professionals in the Bay Region and her uncanny ability to meet and interview anyone in any company. Allison's findings are in the following report.

Dennis Mohle, ICT-Digital Media Deputy Sector Navigator and Computer Science Faculty has integrated these finding with the Academic Senate's Discipline Input Group (DIG) into best Computer Sciences practices.

As you will see, the three pathways produced results. The pathways and the corresponding courses available at Bay Region CCCs will be available on the SD EDGE website this fall. This single site will help to guide students of different backgrounds and needs into a successful transition to becoming a Software Developer. In this way the inherent assets of the Bay Region will become relevant to this issue and where we lack curriculum (yes, there is one course we lack!) we will see the Faculty of the CCCs rise to the challenge!

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BAY AREA SOFTWARE DEVELOPER SKILLS DEMAND AND ACQUISITION

By Allison Marino
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Executive Summary

This investigation was initiated to clarify Labor Management Information (LMI) defined from job postings in and around the San Francisco Bay area. Interviewing individuals in hiring positions, working programmers and placement agencies gave a fine detailed view of what the LMI data was telling us. This investigation was done using four guiding questions

1. What are the essential criteria that hiring managers use to fill software developer positions?
2. How do these criteria pertain to the Entry Level Persona, Career Transformer Persona and the Career Enhancer Persona? (Personas were identified as key segments of the California Community College student population.)
3. How are immersive 12-week software bootcamps currently succeeding?
4. What elements comprise software bootcamp programs?

Within the first few interviews it became clear that a Computer Science Bachelor's degree or higher is an unconditional requirement for entry-level hires in every sector of the technology industry. Some exceptions apply in times of high demand, or if the candidate has an exceptional portfolio. Furthermore, bootcamps succeed by accepting only candidates that have Bachelor's degrees and can pass entrance coding exams. The overwhelming majority of bootcamp entrants have several years of work experience as professionals in other fields.

While in-depth project work and the ability to navigate a technical interview are two essential criteria that influence hiring decisions, a candidate's ability to learn new material and function well in a team are also highly valued skills. Bootcamp programs tend to focus on teaching core Data Structures and Algorithms. However, they also spend significant classroom time teaching and practicing technical interview skills. Technical interviews are special events in the software developer hiring process designed to determine a candidate's ability to communicate ideas, perform under pressure, demonstrate a grasp of logic constructs, etc. These skills can be practiced and honed to successfully pass this interview.

Many bootcamps also provide job placement assistance and industry networking opportunities.

One-on-one interviews with technical hiring managers were conducted at a range of large firms (Apple, Oracle, LinkedIn, Netflix, Facebook, Google, etc.) and small firms (Twilio, Delphix), as well as firms not primarily known for software (Nextgen, UCSC), to determine what skills and criteria contributed to final hiring decisions for the different student populations. Additionally, software bootcamp CEO's, instructors, and students were interviewed and observed in training to better understand the Career Transformer pathway. The Principal Investigator's engineering background (MIT EECS MS, BS) and professional network enabled access to a variety of software hiring managers that would have been difficult to reach through traditional HR channels.

Software Developer Hiring Criteria

Software employers value both foundational academic knowledge and the ability to learn. A third factor uncovered in this research significantly influences hiring decisions: in-depth project work. In-depth projects demonstrate the ability to manage complexity, to take initiative, to make architecture decisions, and to follow through to completion. An entry-level applicant can catch a hiring manager's attention with a great project that goes beyond a classroom assignment. For experienced developer positions, the applicant typically has past work projects to show. Without fail, every manager interviewed cited project quality as a determining factor in the hiring process.

The fundamental concepts and methodologies of software development are relatively stable and are not tied to any single programming language. This foundational material is well-represented in the California Community College (CCC) system by the Computer Science Transfer Model Curriculum (TMC).

The exact implementation of these fundamental concepts - the actual software used by industry in products - changes and evolves constantly. This changing environment makes the ability to learn and apply new material (programming languages, development environments, design practices) a critical software development skill.

A Computer Science Bachelor's degree (or higher) is the ideal degree for a software development position. However, a candidate with a Bachelor's degree in another field can be successful. Regardless of educational background, an exceptionally strong portfolio can open doors to employment.

Persona: Entry Level

For students just entering community college after high school, the direct pathway to software development employment is completion of the Transfer Model Curriculum (or other curriculum defined in an articulation agreement for guaranteed transfer placement) and subsequent completion of a Computer Science Bachelor's degree. The quality of projects and summer technical internship completed during the student's undergraduate years will influence hiring prospects upon graduation.

There is currently no reliable path into software development without a Bachelor's degree. Fifteen years ago, Web Development was a non-degreed pathway into software development. More recently, Mobile Development has been a non-degreed pathway into software development. In both of these cases, demand exploded and all that was needed for entry was a portfolio showing websites or mobile apps. This type of opportunity can pop up in software, and one particular skill can be very "hot" for a time, offering a sliver of opportunity for a talented, self-taught individual, regardless of degree.

Completion of the Computer Science Transfer Model Curriculum at a community college allows a student to transfer into the CSU or UC system as a junior in Computer Science, a very cost effective way to get a Computer Science Bachelor's degree. The gating factor for the student is access to the core courses in the correct order. Identification of the cross-compatibility of these courses across campuses could increase the flow of future software developers through the community college system. The following Transfer Model Curriculum Computer Science requirements were pulled from the Course Identification Numbering system (<https://c-id.net>) in February 2016, and are subject to review and may change over time.

Entry Level Pathway Transfer Model Curriculum in Computer Science (With C-ID)

Computer Science Classes:

- COMP 122: Programming Concepts and Methodology I
- COMP 132: Programming Concepts and Methodology II
- COMP 142: Computer Architecture and Organization
- COMP 152: Discrete Structures

Calculus Classes:

- MATH 210 & MATH 220 or
- MATH 211 & MATH 221 or
- MATH 900S

Physics (Calculus-based version) Classes:

- PHYS 205
- PHYS 210

Persona: Career Transformer

The Career Transformer has a Bachelor's degree and several years of work experience in a field other than Computer Science. This person is switching into software for any number of reasons- the good salaries, the interesting work, or the reliable job market. The Career Transformer is motivated and focused, and building on an already considerable store of work and life experience. The only thing the Career Transformer does not have a lot of is time.

Enter the modern software bootcamp, which promises to transform anyone who can do Algebra II into a software developer in twelve weeks, at a typical cost of \$12,000. Bootcamps are growing quickly, and a majority of bootcamp graduates are achieving significant salary gains. Course Report's 2015 Coding Bootcamp Alumni Outcomes and Demographics Study identified the average nationwide bootcamp salary gain as \$18,000. However, that number is only for the 66% of total survey respondents (665 people) who found full-time employment. Bootcamp data representing all students in a cohort is hard to come by. Bootcamps screen their applicants, require a coding challenge prior to acceptance, and have options to exit students from the program if they are not on track for placement after graduation.

The instructional quality varies by program, as does the level of individual versus team work, but the general approach is a handful of one-hour lectures per day interspersed with lab time (with TA's nearby) to help the lecture material sink in during the initial weeks. Once students have gained a programming foundation, a progression is made into individual projects with lectures and industry guest speakers. The level of placement assistance varies by coding bootcamp.

Hackbright, a well-respected all-female bootcamp in San Francisco, does coding instruction in a pair programming format to accelerate student learning. The Hackbright program also includes two full weeks near the end of the program of technical interview instruction, practice, and coaching. Hackbright has two

full-time staff (formerly of Riviera Partners recruiting firm) assisting students with job placement, though there is no job placement guarantee. The post-Hackbright salary average is \$90,000, representing the 90% of Hackbright graduates that have full-time developer positions within a few months of graduation. Taken together, these details illustrate the level of student support required to make a bootcamp program viable. The value of industry connections in the hiring process cannot be overstated.

Aside from the obvious efficiency of the process, one reason people like to attend Bootcamps (when so many educational programming and CS resources are available for free) is the camaraderie of going through the intense learning curve with other like-minded students. The full-time nature of Bootcamps also reduces context-switching, since it is not possible to work full-time and attend a bootcamp. However, that also makes Bootcamps out-of-reach to individuals wanting to make a career switch into software development who require income from a job during the transition process.

Fortunately, pursuit of the elements of a bootcamp can also be undertaken individually, as broken down in the following pathway analysis. When looking at these elements, consider that the Career Transformer begins the path with two important traits: a known ability to learn (remember the typical Career Transformer already has a Bachelor's degree) and a commitment to follow-through. The Career Transformer is also likely to embark on this path with project experience in another field, as well as the ability to manage him or herself. By completing the elements of this pathway, the Career Transformer demonstrates an ability to learn new skills as needed, even if they are challenging.

Career Transformer Pathway Elements

Foundational Programming Knowledge¹

- Introduction to Programming C-ID COMP-112
- Programming Concepts and Methodology I C-ID COMP-122
- Programming Concepts and Methodology II C-ID COMP-132

General Interviewing Skill

- Ability to speak engagingly about projects
- Other interview basics (timeliness, dress, etc.)

1 - This is the most important pathway element. These courses form the core of programming knowledge and are essential to software development. The typical content of COMP-132 (HashMaps, Sorting Algorithms, various uses of binary trees and linked lists, big O notation) comes up frequently in technical interviews.

For reference, in many community colleges, COMP-122 is titled Structure and Interpretation of Computer Programs, and COMP-132 is titled Data Structures and Algorithms.

Practical Coding Environment Skills²

- Ability to write clean code with Unit Testing (built-in modular tests, positive and negative tests, load tests, etc.)
- Ability to check-in code, branch code, etc.
- Experience with different Integrated Development Environments

In-Depth Individual Projects (at least two)³

- Demonstrating coding skills and architecture choices
- Significant lab component
- Utilizing a framework or language new to (and chosen by) the student
- Demonstrating the ability to independently learn material on a project basis

Deep Knowledge of at Least One Programming Language⁴

- Usually this knowledge is acquired by doing in-depth projects.

Technical Interviewing Skill (different from HR screen interview)⁵

- Ability to succeed in successive one-on-one interviews with technical coding questions
- This book is considered the industry standard: Cracking the Coding Interview, 6th Edition: 189 Programming Questions and Solutions, by Gayle McDowell

Refined Online Presence⁶

- GitHub account showing checked-in open-source contributions and personal projects
- Groomed LinkedIn Account with proper photo

Expansion of Networking Capital⁷

- Networking through family and friends, a school pipeline, attendance at meetups, or other methods that expand software employment opportunity access
- For reference, the software bootcamps offer site visits to employers and bring in industry speakers to accelerate network development and opportunity for their students

2 - Pathway element not currently represented widely in the community college curriculum.

3 - Pathway element not currently represented widely in the community college curriculum.

4 - Pathway element not currently represented widely in the community college curriculum.

5 - Pathway element not currently represented widely in the community college curriculum.

6 - Pathway element not currently represented widely in the community college curriculum.

7 - Pathway element not currently represented widely in the community college curriculum. Items 2-7 are the glue that enable developers to work in a team, apply core CS knowledge in real-world applications, and thrive in the workplace.

Persona: Career Enhancer

The typical Career Enhancer is already employed in software development and has several years of experience. The Community Colleges can remain relevant to this student segment by offering courses that enable the Career Enhancer to update skills for a current job, to take a step into software management, or to make a lateral move within software.

For the Career Enhancer, a skill update could be learning a new language, a new development environment, a new framework, or a new approach (such as Test Driven Design Methodologies or Agile Development). For developers interested in software project management, the PMI ScrumMaster certification is consistently valued among employers, provided the developer already has a solid coding resume. Figure 3 shows the increasing frequency of both Scrum and Agile Development in requisitions.

To understand the Career Enhancer, it helps to get in the mindset of the developer. A developer seeks ongoing knowledge and satisfying development work. In general, software developers have software interests and pursue them purely out of that interest. This learning is in addition to any on-the-job learning that inevitably occurs in a software developer's career. For example, lots of developers signed up for Andrew Ng's Machine Learning class when Coursera first offered it, simply out of interest, not due to workplace demands.

Most software developers know several coding languages, and learn new ones by reading documentation, doing self-paced tutorials, or taking online and in-person classes. An intact corporate software team might go to an outside training company (Big Nerd Ranch, for example) for a week to solidify knowledge of a new Integrated Development Environment and language. There is no shortage of online material available to software developers who like that learning format. Online offerings include Coursera, Udacity, TeamTreehouse, iTunes University, EdX, Code Academy, and many more.

In practice, many students taking software Career Technical Education (CTE) classes within the California Community Colleges are working in technical fields, but not as software developers. To be a strong resource for all Career Enhancers, the Community Colleges need to clearly identify the skill level of their CTE classes. A straightforward method that could be applied across campuses (and that would ideally suit the SD EDGE project) is to key the CTE classes to core programming classes in the Transfer Model Curriculum: C-ID COMP-112, C-ID COMP-122, and C-ID COMP-132.

Valued Career Enhancer Skills

- ScrumMaster Certification from PMI
- JavaScript and JavaScript frameworks (Node, Angular, and React)
- REST (Representational State Transfer) protocol knowledge
- Python
- Functional language experience (in the context of big data and cloud computing)

This list is not all-inclusive. The Career Enhancer segment can be further guided by the Skill Demand Analysis figures. Interestingly, employers are starting to use LinkedIn as a way to find experienced hires. Hiring managers seek out the exact skills they are looking for, rather than waiting for candidates to submit resumes, and actively recruit individuals with the desired experience.

For the many and varied CTE courses offered by the Community Colleges, a close look at the motives (current work, career transition, personal interest) of students attending each particular class would make the value proposition each course offers in the context of industry clearer. The SD EDGE website (<http://www.sd-edge.org>), by providing better visibility for CTE classes throughout the region, will then be able to guide students to the courses they need.

Conclusion

Significant opportunity exists for the California Community Colleges to support students in all segments studied on the path to software employment. The Career Transformer pathway elements stand to be the most immediately useful knowledge gained from this research. They could form the basis of a one-year software developer slow-speed bootcamp curriculum. The Career Enhancer segment would benefit most from keying CTE classes to core programming levels (C-ID COMP 112 to 132) so that developers and other coders can easily find appropriate skill training. The Entry Level pathway is, thankfully, straightforward. Making sure there is ample availability in the core programming courses of the CS Transfer Model Curriculum is one direct way to immediately increase the throughput of software developers in the California Community Colleges.

Appendix A : Background

Working with the Information and Communication Technologies and Digital Media team, the Centers of Excellence analyzed Labor Market Information to establish a model of skill demand for software developers in the Bay Region. The results of that analysis are shown in Figures 1, 2, and 3. Notably, Figure 3 shows that JavaScript and Python have the highest growth rates (over a three year period) for skills requested in over 10% of all software developer requisitions. Requisitions list several desired skills, typically in clusters representative of the general type of developer work: Front-End, Back-End, Full-Stack, Mobile, Game, Cloud, and so on.

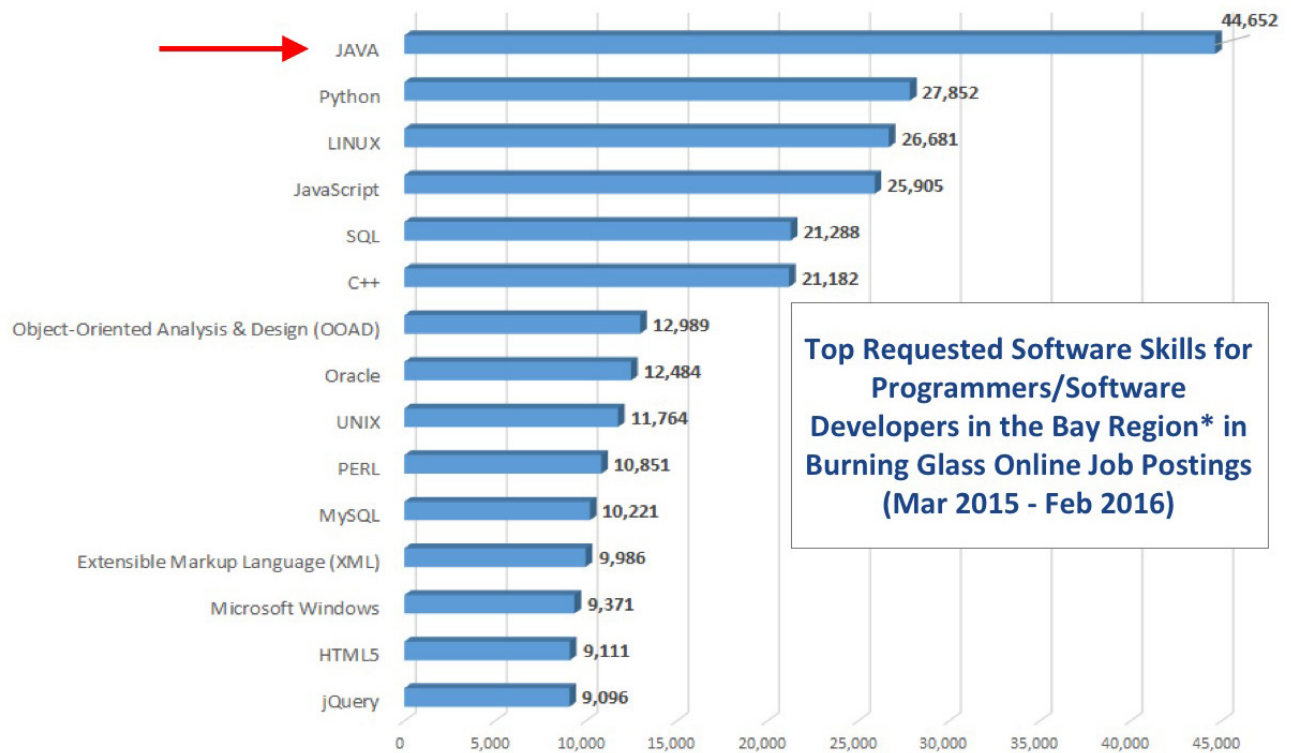


Figure 1 - Top Requested Software Skills

*Bay Region consists of 12 counties: Alameda, Contra Costa, Marin, Monterey, Napa, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano and Sonoma

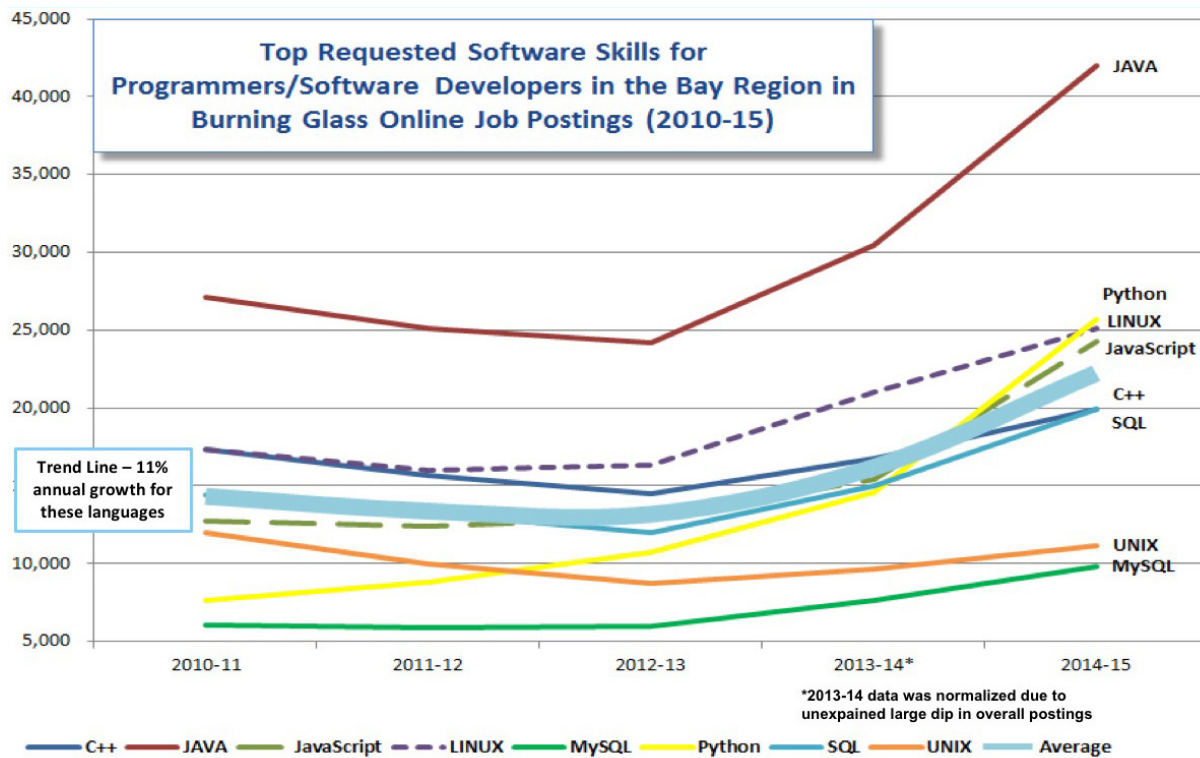


Figure 2 - Top requested software skill demand growth over a 5-year period from July 2010 to June 2015.

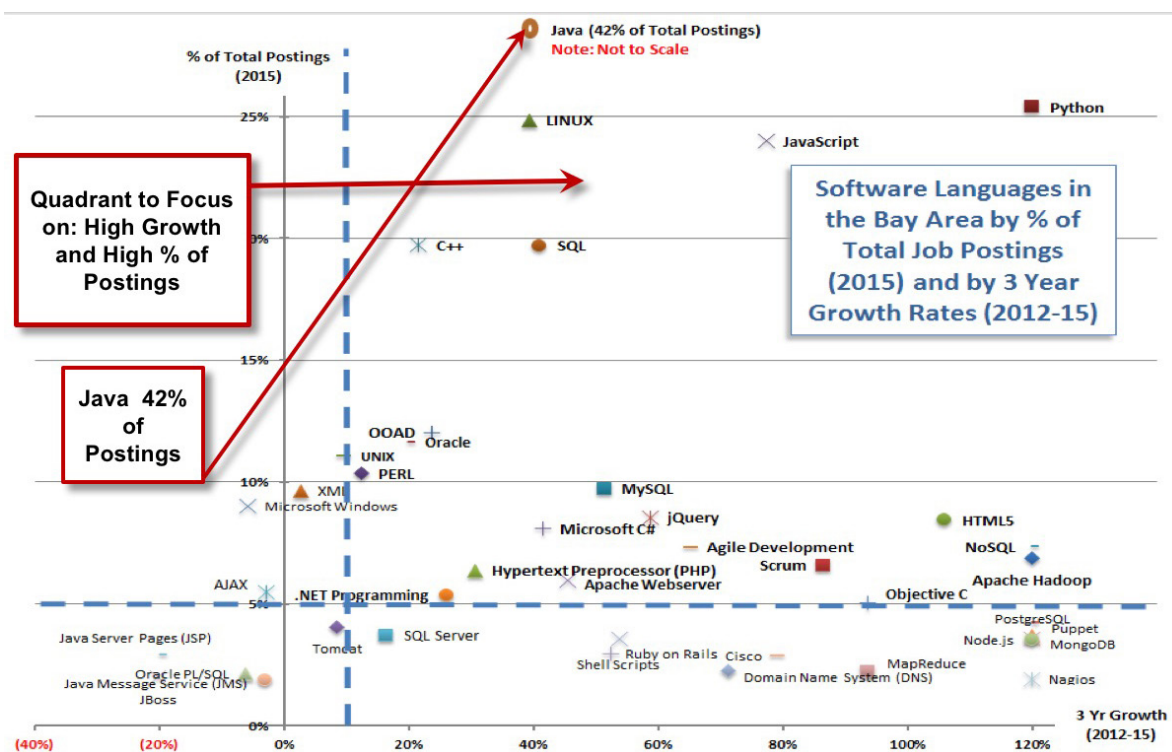


Figure 3 - Skills in the lower right part of the chart, below the dashed line, represent developing technologies early in their demand growth curves. Skills shown above and to the right of the dashed line represent both volume and growth.

These figures highlight relevant trends in requisitions. However, they do not illuminate the essential criteria hiring managers use to make employment offers. While significant knowledge of a skill in high demand is useful for experienced software position applicants, it is less important for entry-level hires, who must demonstrate a general technical proficiency and a fluency about their own projects in the hiring process. It is assumed that entry-level hires will be able to learn whatever languages are required for their specific work environment.

Project management, LMI data and other support provided by:



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