AN OVERVIEW OF COMPUTER SCIENCE MASTER DEGREE PROGRAMS IN THE STATE OF CALIFORNIA

Narayan Baidya, Wiselin D. Mathuram, Ajit Renavikar, JeongHee Kim, Jagadeeshwar R. Jupally and Rahul R. Guduru.

California Takshila University, 4425 Fortran Dr., San Jose, California-95134, USA.

ABSTRACT:

A sound education in information technology fuels the success of individuals as well as corporations in the modern life. Information technology offers numerous opportunities but faces unique challenges in the United States. In a populous state like California, where Computer Science (CS) has been taught at the college level since the 1950s, these problems are even acute. This article provides an overview of the current state of affairs in CS in California. We include wisdom from lessons learned from efforts to offer quality education in both public and private universities in California. In particular, we focus on the differential school system and the educational landscape of CS education in this state.

KEYWORDS:

Graduate education, California, STEM education.

1. INTRODUCTION

Ever since computer science became a college-level academic program in the 1950s, the level of interest as well as the number of enrolled students in this field has increased rapidly. Currently, computer science education appears to be poised for a stable expansion in the United States (Taylor Soper, 2014) [1]. Nevertheless, there is the probability that the growth in the field might halt just like it did in 2003 following the break of the technology bubble. To keep the pace of innovation and interest in CS, the perception of computer science needs to change from it being perceived as a marginal elective course developed as an afterthought to a fundamental core course that provides problem-solving and critical thinking skills on par with fundamental sciences such as biology, chemistry, and physics.

In addition, colleges should take advantage of the increasing interest in computer science among students and boost the number of course offerings to support the expanding need for engineers in the field. The high demand for computer science engineers is not only limited to the technology field but also to various other sectors [2]. (Jay Borenstein, 2014).

Policymakers should support colleges in transforming their computer science programs from a mainly theory based curriculum to one that offers a healthy blend of theory and the relevant applied technologies, emphasizing a hands-on experience in the industry. Colleges must be incentivized to increase their offerings in computer science, and should periodically update these courses as new technologies emerge. With the rapid growth of the computer science, universities in the United States need to generate highly competent graduates that have the ability to convert concepts into sensible cutting-edge solutions.

As a result of modern technology playing a bigger role in the life of US, growth in the computer science has been exponential. In the last decade only, CS jobs have grown by about 36% (United

DOI :10.5121/ijite.2018.7301

States Department of Labor, 2012) [3]. Consequently, the need for computer science engineers also increased much faster than any other field. Presently, there are over 545,000 unfilled positions that require computer science expertise [3] (United States Department of Labor, 2012). Simply speaking, the wild demand for computer science engineer within the US is larger than the number of engineers that US universities are producing. About 81% of computer science graduates find jobs in their field and even during recessions, there are 2 positions for each unemployed CS graduate which leads to a higher than average compensation [3]. (United States Department of Labor, 2012).

During the next decade, computer science jobs are estimated to increase by about 50,000 opening per year (Change the Equation, 2014) [4]. In 2011, Code.org forecasted that the American market will certainly develop about 1.4 million computer science jobs. However, universities will only be able to produce only 400,000 engineers by then (Werf & Sabatier, 2009) [5].

COMPUTER SCIENCE EDUCATION IN THE US

Currently, the American universities are producing about 50,962 bachelor degrees, 22,777 master degrees, and about 1826 doctoral degree in computer science are insufficient to meet the current growing demand (United States Department of Labor, 2014) [6].

Computer Science education in the United States faces many challenges and opportunities. The obstacle for American institutions is to broaden the pipe of computer science employees getting in the workforce. To achieve this, colleges have to work on creating interest in computer science courses among a wider and more varied population by enhancing the quality of computer science courses and also increasing the variety of offered courses in the undergrad as well as the graduate programs (Michail N. Giannakos, 2017) [7].

Most of the students who pursue computer science are international – about 49% of graduate student in the computer science field are foreigners and leave the US within 5 years of completing the program (National Science Foundation, 2012) [8]. Unlike the undergrad level, graduate computer science programs in the US is considered to be the best in the world and draws brilliant students from across the globe.

COMPUTER SCIENCE EDUCATION IN CALIFORNIA

California is the hub of technology where a large number of information technology companies chose to do business. Since the 1990's, California started to attract information technology companies from around the world which pushed universities to invest in computer science education to fill the gap between offer and demand.

Many branded high-tech companies are in Silicon Valley-and every year thousands of new high-tech start-ups take their first steps here. This high-tech ecosystem is largely supported by people with computer science and related background. Technologies and product development are driven by the skilled and qualified employees with a college degree, bachelor or higher, creating a strong demand for people with such skills.

According to the *Computer and Information Sciences and Support Services*, the working population in Computer and Information Sciences most commonly hold a Bachelor's degree; some hold a Master's degree and few hold a Doctorate degree (Figure 1).

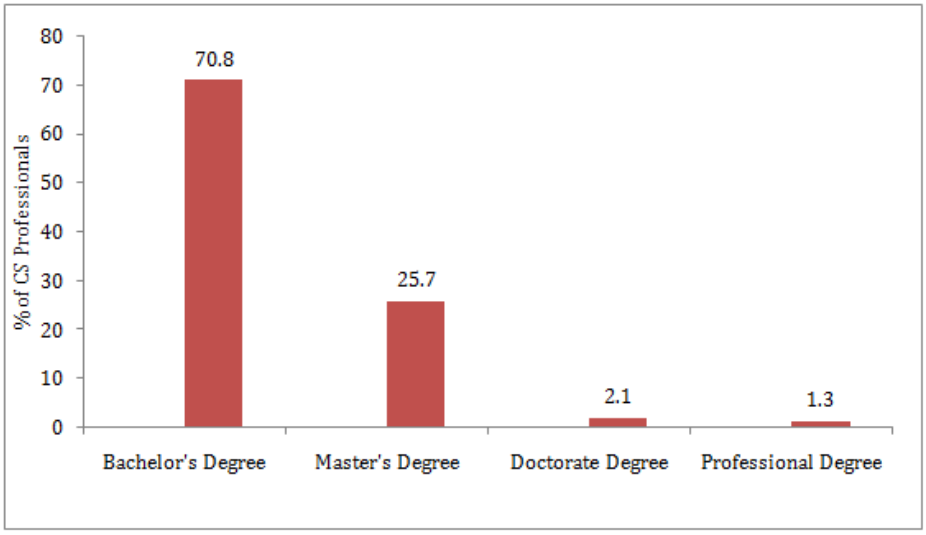

Figure 1: Educational background of the Computer Science Professionals

Just to give some perspective, California currently has over 65,000 unfilled jobs in the computer science related field, while California's universities graduated around 3,500 students in 2014. Therefore, a large demand-supply gap exists at–present. The High-tech industry is in need of employees with technical skills in many new areas that are not part of most computer science programs in the state. This is mainly because of the curriculum structure, the maturity of the students and lack of practical experience of the teaching faculty.

One may recall that the state of technical complexity doubles approximately every 18 months (famous Moore's law). Now consider this Google CEO Eric Schmidt posits that "The amount of technological advancement that occurred in the year 2000 occurs every 1 hour and 6 minutes in 2013, and will occur every 30 seconds in 2020." To prepare for this rapid paced advancement of the technologies, Governor of California just passed a bill to promote computer science education in K-12 level.

However, nothing has been done to meet the current skill deficit in California. Rather California higher education system remained in the past and slows to act with the required speed. California administration either lacks proper motivation, guidance, and skills to understand higher education in computer science. We do not see how the state can alone solve this skill deficit in California. The state needs the private organizations to fill this humongous gap. Furthermore, quite often just bachelor degree is not sufficient to keep the necessary edge in innovation and product development.

Employees with a bachelor degree, who are seeking to enhance their skills, changing their fields and joining computer science to keep their employment and/or advancing in the field, are often dissuaded due to lack of appropriate programs and compatibility with the work-school schedule. A Computer Science Master degree program is suitable for working professionals with a bachelor degree in many fields. This is the opinion of many pioneers in the field including Late CEO of Apple, Steve Jobs.

In California, there are handful private institutions (around 10) that are offering MSCS programs. In reality, California needs over 100 private institutions that offer MSCS program to meet the demand of its crown economic engine the innovative high-tech sector. We set out to explore how California overcomes its talent deficit situation with its existing Master of Science in Computer Science (MSCS) programs. In this article, we review MSCS offered by the California state and private Universities.

STATE REGULATION

It is important to note that in California private postsecondary educational institutions are under the California Department of Consumer Affairs (DCA). DCA has delegated its responsibilities of licensing and over sighting state's postsecondary private educational institutions to the Bureau of Private Postsecondary Education (BPPE) since 2010. DCA was solely responsible for these functionalities from June 2007 to December 2009. Prior to 2007, California's Private postsecondary instructions were under Bureau of Private Postsecondary Vocational Education (BPPVE). BPPVE was under DCA. BPPVE mainly was state-funded while the present organization is primarily funded through fees, fines, and charges from the institutions it gives license and regulates. There is some degree of conflict of interest in this mechanism of funding the bureau's activities. Institutions under BPPE have seen a sharp increase in numerous fines and charges compared to its predecessor, BPPVE.
On the other hand, state universities are fully funded by the state and student's tuition and fees. State universities do not pay any fees to BPPE and/or other organization under the state government.

DATA COLLECTION AND DISCUSSION:

We reviewed MSCS program curriculum of 14 state universities and 9 private universities.

These universities offer various numbers of courses for their MSCS program ranges from 12-69. Most common is the high twenties. In average students need to complete 12-15 courses to graduate.

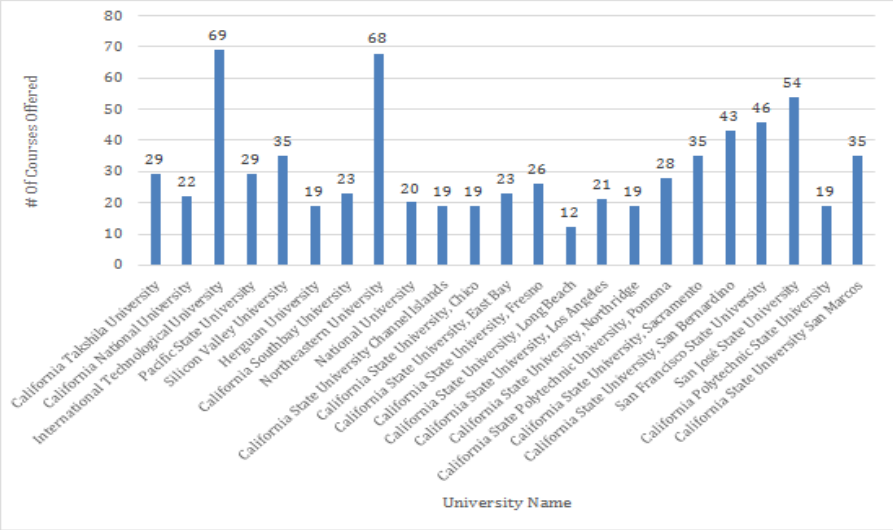

Figure 2: Total number of courses offered at the graduate level in most univeristies in California.

13 state universities require a minimum of 30-semester credit units to graduate from their MSCS program, while one state university requires only 32-semester units (Table-1). Whereas private universities, in general, require 36-semester credit unit for an MSCS degree (Table 1).

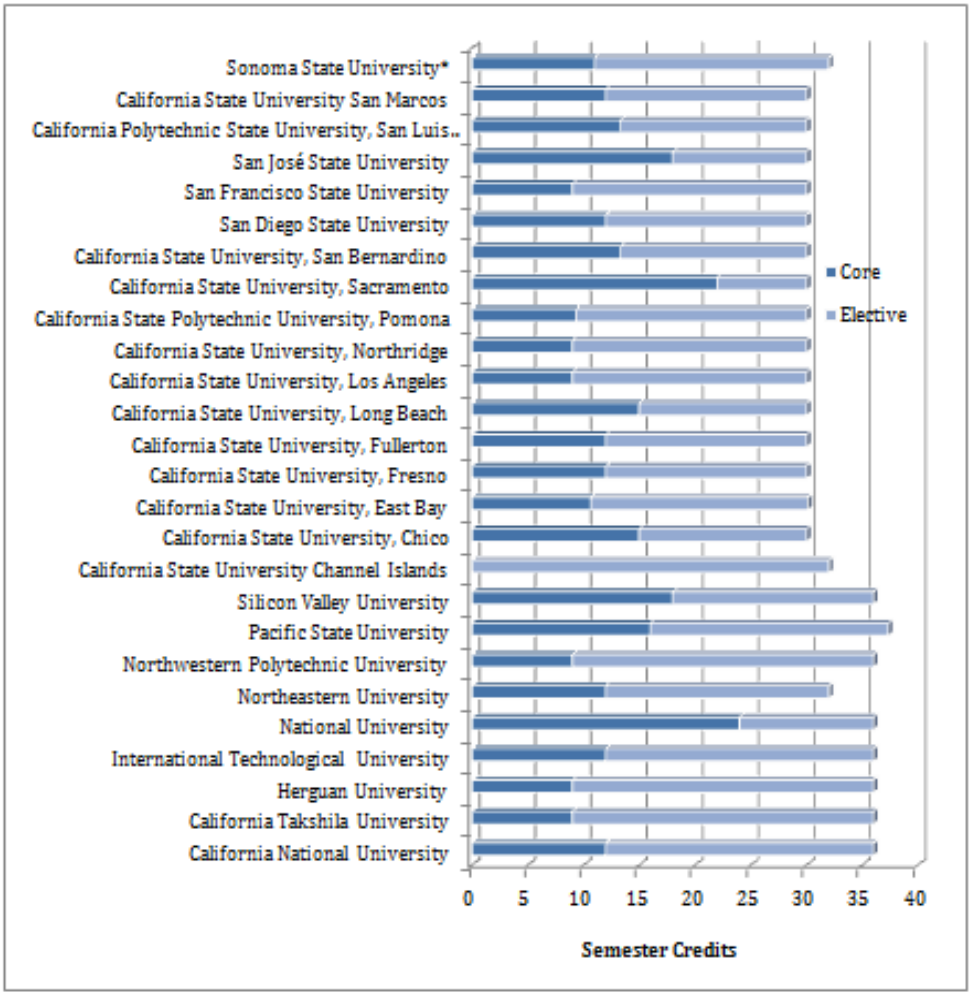

Figure 3: Core (Breadth)/Elective Units Requirement for Graduation /MSCS

Among the 14 state universities, 13 have course requirement that is directional and provides fundamental core concepts, e.g., algorithm, programming and data structures. However, California State University at Channel Island does not have core concept requirements. All the private universities that we reviewed offer well-balanced core concept curriculum for the MSCS program. On the task of building broader skills and knowledge that current employers seek private universities do the better jobs than the state universities (Table 2). 75% of the California MSCS programs offer courses on software, algorithm, programming, web technologies, system design, database, artificial intelligence, and pattern. Graduates with knowledge in Big data, Agile methodologies, cloud computing, and security are in high demand, however, only two private universities (California Takshila University and International Technological University) regularly taught these course, and three other private universities offer 60% of these courses. State universities primarily shy away from these courses.

Google search provided top IT skills, high demand tech skills for 2016 and 2017. The table below is a good comparative analytics of high demand computer subjects taught at the California institutions at the graduate level.

Table 2: Contemporary Tech Skills, with high Demand in the Industry, Related Courses Taught at Various University in California

High Demand Tech Skills	California Takshila University	California National University	International Technological University	Pacific State University	Silicon Valley University	Sofia University	California Southbay University	Northeastern University	Henguan University	National University	California State University Channel Islands	California State University, Chico	California State University, East Bay	California State University, Fresno	California State University, Long Beach	California State University, Los Angeles	California State University, Northridge	California State Polytechnic University, Pomona	California State University, Sacramento	California State University, San Bernardino	San Francisco State University	San José State University	California Polytechnic State University
Programming	+	+	+	+	+	-	+	+	+	+	+	-	+	+	-	+	-	+	+	+	+	+	+
Big Data	+	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agile	+	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cloud	+	-	+	-	+	+	-	-	+	+	+	-	-	-	-	-	-	-	-	-	+	+	-
Mobile	+	-	+	-	-	+	+	+	+	-	-	+	-	+	-	-	-	-	-	-	+	+	-
Security	+	-	+	-	+	+	-	+	-	-	+	+	+	-	-	+	-	-	+	-	-	+	-
Network Distributed	+	+	+	-	+	+	+	-	-	-	-	+	+	-	-	+	-	+	+	+	+	+	+
Machine	+	-	+	+	+	+	-	+	-	-	-	+	+	-	-	-	-	-	+	+	+	-	-
Artificial	+	+	+	+	-	+	-	+	+	-	+	+	+	+	-	+	-	-	+	+	+	+	+
Cryptography	+	-	+	-	-	+	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-	+	-
Web	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
warehouse, Data	+	-	+	+	+	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
Dot Net	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Management IT	+	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-
DevOps	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blockchain	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**16**	**3**	**11**	**5**	**8**	**12**	**5**	**8**	**7**	**4**	**6**	**6**	**7**	**4**	**1**	**5**	**2**	**3**	**8**	**5**	**7**	**8**	**4**
%	100%	19%	69%	31%	50%	75%	31%	50%	44%	25%	38%	38%	44%	25%	6%	31%	13%	19%	50%	31%	44%	50%	25%

Programming is one of the key subjects that a computer science student is expected to have knowledge and understanding of. Thus we see over 80 percentages of universities in California are offering programming languages (Figure 4, Table 2).

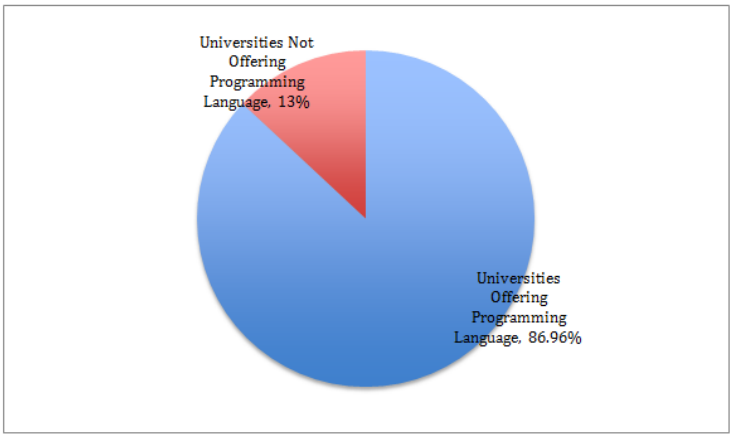

Figure 4: University Offering Programming Language

Web technology related courses is another subject that most universities teach in their MSCS programs. Artificial Intelligence is very demanding and popular subject for the MSCS curriculum and 70% institutions included artificial intelligence as an elective course. Little over 30% programs offer cloud computing and less than 20% programs have big data and Agile methodology courses. Only One institution offers Blockchain course while no institution in California teaches courses on the Self-driving vehicle. The brain of a self-driving vehicle is a complex and highly sophisticated mix of Artificial Intelligence (AI), deep learning and other computer software areas (Figure 5).

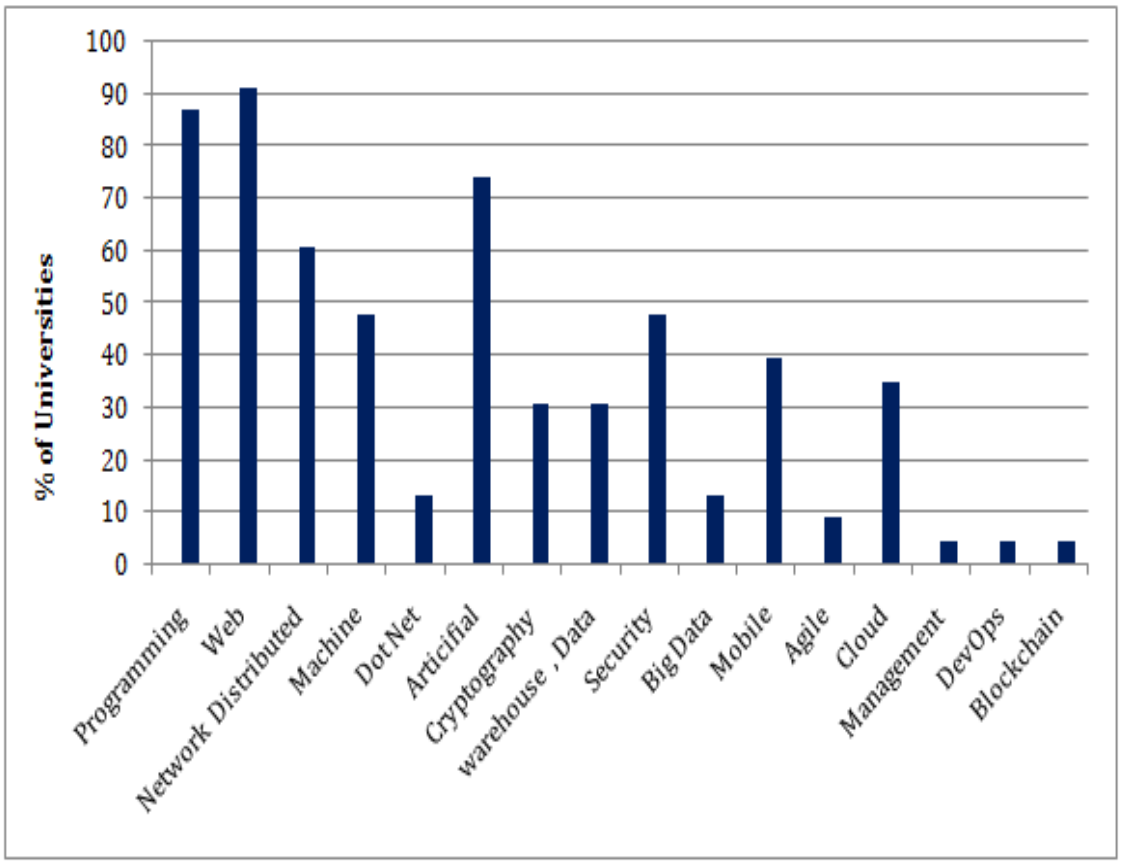

Figure 5: Percentage of Universities offering 16 high demand courses

These findings will help current graduates and professionals to gain a better understanding of options they have in identifying programs that best fit their needs and situation. We certainly see that the California MSCS education programs lack innovation and speed to support state's high-tech economy by graduating students either in numbers or in preparation to take on industry's need from the day one. As the saying goes-Elephant Can't Dance", the state university is not equipped with the tenacity and urgency to adopt market's needs. However, a small group of private university proved that –"Rabbit Can Jump". And, we certainly need 100s of Rabbits-start-up innovative Universities in the State of California.

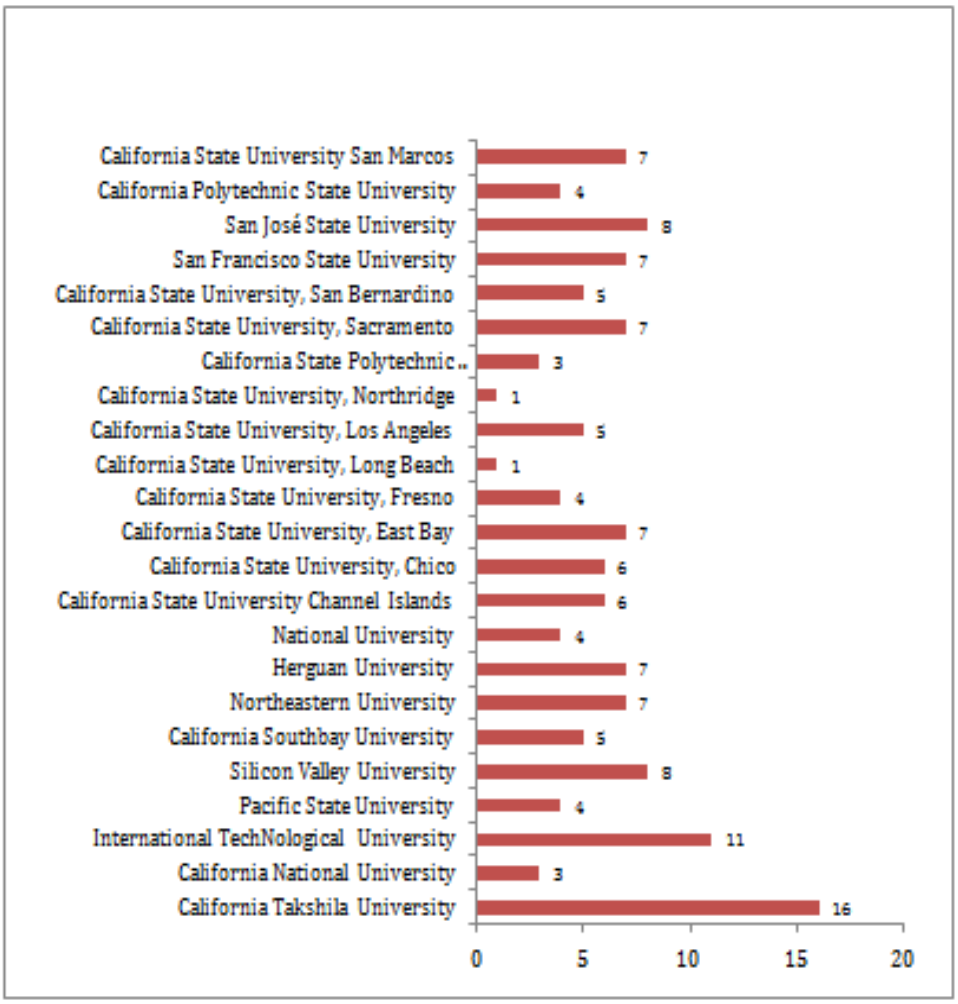

Figure 6: Percentage of Highdemand Courses Offered by the Universities

CONCLUSION

After this work we concluded that education within California is either unable or not ready to meet the advancement of computer science technology. Few private schools such California Takshila University have taken proactive strategy to educate its graduates with appropriate and innovative courses. While California colleges are trying to keep up with the technology sector, State regulator such as Bureau for Private Postsecondary education (BPPE) is counterproductive it helping state cope with the imbalance in demand and supply of knowledgeable IT professionals. Intern harming California's multi- billion dollars economy primarily based on computer science. In fact, BPPE yet to understand how computer science and IT-software essentially inseparable. We believe this study will be a huge help to California's senators, Assembly members and executive branch to take little more seriously the problems that exist within their systems. Finally, we believe this study Will help prospective students identify schools for their MSCS study not based on traditional brand, but based on the school current program.

REFERENCES

[1] Taylor Soper, (2014), Analysis: The exploding demand for computer science education, and why America needs to keep up, (June 6, 2014), GeekWire

[2] Jay Borenstein (2014), The Modernization Of Computer Science Education, Crunch Network (Jul 23, 2014), TechCrunch.

[3] United States Department of Labor. (2012). Labor force statistics from the Current Population Survey. Retrieved from https://www.bls.gov/cps/.

[4] Change the Equation (2014). STEMtistics.Retrieved from http://changetheequation.org/stemtistics.

[5] Kirkegaard, J. F. (2007). The accelerating decline in America's high-skilled workforce: Implications for immigration policy. Peterson Institute.

[6] Van Der Werf, M., & Sabatier, G. (2009). The college of 2020: Students. North Hollywood, CA: Chronicle Research Services.

[7] United States Department of Labor.(2014). Median weekly earnings of full-time wage and salary workers by detailed occupation and sex. Retrieved form https://www.bls.gov/cps/aa2012/cpsaat39.pdf

[8] Michail N. Giannakos, Ilias O. Pappas, Letizia Jaccheri, and Demetrios G. Sampson (2017), Understanding student retention in computer science education: The role of environment, gains, barriers and usefulness, Education and Information Technologies, September 2017, Volume 22, Issue 5, pp 2365–2382

[9] National Science Foundation (2012). Science and Engineering Indicators 2012, retrieved from https://www.nsf.gov/statistics/seind12/pdf/seind12.pdf

[10] Mary K. Pratt, 10 Hottest Tech Skills for 2017, Computerworld, (Dec 7, 2017)

[11] Catherine Fisher, The Top Skills That Can Get You Hired In 2017, LinkedIn, (Oct 20, 2016)

[12] Sohan Murthy, The 25 Skills That Can Get You Hired in 2016, LinkedIn, (January 12, 2016)