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GAPS IN THE COMPUTER SCIENCE CURRICULUM: AN EXPLORATORY STUDY OF INDUSTRY PROFESSIONALS

Chris B. Simmons
Department of Computer Science
University of Memphis
Memphis, TN 38152
901-678-5465
cbsmmons@memphis.edu

Lakisha L. Simmons
School of Business Administration
University of Mississippi
University, MS 38677
662-915-5777
lsimmons@olemiss.edu

ABSTRACT

Our study explores current industry needs in suggesting how to better prepare computer science graduates with the appropriate background that will enable a successful career. With the increase in outsource development, computer scientists find themselves in some project management related capacity. Unfortunately, computer science graduates lack the interpersonal skills needed to successfully fulfill duties associated with outsourcing. We report findings from qualitative interviews from IT professionals in Fortune 500 businesses, small-to-medium businesses, and non-profit organizations. Our analysis concludes that modifying computer science curriculum to provide more emphasis on negotiation skills, time management, cultural differences, outsource management, and information assurance would make the most difference, in addition to a strong technical background.

INTRODUCTION

The computer science curriculum has continued to evolve throughout the years within universities and colleges, even more so now with the high rate of outsourcing and drop in computer science enrollments [5]. It is essential to provide a curriculum that improves the industry as well as creates a well-rounded computer scientist. Patterson [7] highlighted the need for computer science (CS) educators to provide a curriculum that reflect opportunities and challenges of information technology in contemporary times. Therefore, is the CS curriculum relevant for today's industry needs? To date, there has been a lack of research focusing on the current workforce needs for computer science graduates.

Recent news indicates that industries that hire computer science graduates are changing in this time of hiring freezes, low budgets, and increased outsourcing for decreased costs. Some age old issues also still exist [e.g. 3]. In 2007, Havill and Ludwig [4] stated computer science undergraduates have difficulty expressing their work to a general audience due to the highly

technical nature. This provides valuable insight into the need to add focus on communicating in nontechnical terms more effectively.

Universities may teach students more about the development of technologies [8] as well as soft skills such as determining what to develop and how to communicate during development. There is a lack of research involving actual curriculum enhancements based on industry needs. For example, how to teach computer scientists to ask the right questions when attempting to contribute on a project team. Fitzpatrick [2] stated bridging the gap involves students experiencing projects in action to help provide a needed understanding of software development. We suggest curriculum enhancements based on such literature and exploratory interviews with 20 IT professionals in a number of industries. We asked how CS graduates are used in their companies and any suggestions for curricula enhancements so CS graduates could be more productive and useful.

CURRENT CURRICULUM

Research into the computer science curriculum has suggested various phases of software engineering are needed to improve students' knowledgebase when entering the workforce. Some literature suggests introducing extreme programming, testing methodology, and communication skills. Patterson [7] addressed the need to include open source software into the curriculum, as it provides graduates with the ability to help improve potential organizations. The need to present computer scientists with open source tools, such as Eclipse, enables CS graduates with near real world tools, contrary to programming on the command line. Douglas et al. [1] provided insight to the need of incorporating human computer interaction into the computer science curriculum, as 50% of code written for software applications is designed for the user interface. With this knowledge, it is becoming increasingly important for computer scientists to effectively elicit customer requirements to prevent rework. Fitzpatrick [2] introduced the Software Quality Star, a model for improving software quality motivated by ISO/IEC 12207, which attempts to integrate human-computer interaction (HCI) and software engineering to improve curriculum regarding customer usability. Havill and Ludwig [4] suggested three approaches to improving CS undergraduate programs, which include improving communication skills, exposing students to research early, and increasing exposure to mathematics. This is a valid point for computer scientists moving towards a graduate level degree, but lacks the increasing need of how to effectively work with customers and understand what is being requested. We seek to understand the current gaps in CS curriculum and what the industry needs from CS graduates.

METHODOLOGY

In order to understand what industry requires from newly minted computer science graduates, we conducted 20 interviews that consisted of 7 open-ended questions related to what technical industry professionals described as being an important need for future computer science professionals. Our interviews were conducted with IT professionals such as 6 Sigma Black Belts, Senior Project Analysts, Quality Assurance Analysts, Computer Scientists and one president of a nonprofit organization. The professionals were from 8 Fortune 500 businesses, 9 small-to-medium businesses, and 2 non-profit organizations. So far, we completed 20 interviews that provided insight to where organizations see the future of computer science and potential areas of focus in the computer science curriculum. We asked questions based on the literature above discussing outsourcing, soft and behavioral skills, and duties of CS graduates. In the results section we provide a summary of each question from each professional.

RESULTS

In this section we provide a summary of the interviews conducted with the IT professionals.

1. *What positions does your company usually fill with computer science graduates (not MIS or business information systems majors)?*

   There is a consensus from the interviews that a wide range of positions are available for computer scientists. Positions consisted of programmer analyst, software engineer, test engineer, network admin, telecommunication, application development, quality engineer, systems engineer, requirements engineer, project engineer, operation support, help desk, technical advisor, software architect, technical analyst, and business analyst.

2. *How important is it for computer science undergraduates to know how to gather and elicit customer requirements to fulfill IT positions in your company?*

   From the survey we find that gathering and eliciting customer requirements is very desirable skill set for computer science graduates. 80% of professionals surveyed stated the importance was high, where 20% stated the importance was medium to low. Those in the minority state a senior level person performs this job, but this further solidifies the need for computer science curriculum to include requirement elicitation techniques to create a well-rounded graduate when entering corporate America.

3. *What do computer science undergraduates need to have in their undergraduate programs in terms of soft/behavioral skill sets?*

   Participants suggested computer science curricula need to include training on effective writing skills for documentation and status reporting and communication and presentation skills. Team building, the ability to be flexible and how to deal with hostile personalities were highly emphasized. Negotiation skills, software requirement gathering, project management, and information management skills were also mentioned as important soft skill sets.

4. *What do computer science undergraduates need to have in their undergraduate program in terms of technical skill sets (e.g. programming languages)?*

   Our interviewees discussed the importance of object oriented programming, decoupling understanding, analytical skills, and integrity in programming. Specific languages such as Java, JavaScript, Ruby, Perl, HTML, CSS, SQL, Python, JUnit, .Net, C++, and UML were identified. Other concepts such as web services, network administration, server administration, database administration, and requirement engineering were stated.

5. *What do computer science undergraduates need to have in their undergraduate program to help them assist with your company's outsourced development efforts?*

Results suggest that more universities allow companies to come in to explain their needs. Others suggest the following training opportunities to assist in outsourced development: database knowledge, shell scripting, swing, configuration management, process improvement, unit testing, documentation, project management, time management, cultural differences, outsource management, information assurance, and tools and technologies that will help improve software during the software development lifecycle.

6. *What do computer science undergraduates need to have in their undergraduate program to help them when they are required to work on project teams (e.g. process improvement teams or new product development teams)?*

   Interview participants recommend the need for CS students to be familiar with process improvement frameworks (e.g. 6 Sigma and CMMI). Significant group project related skills, good communication, time forecasting, and how to ask the right questions were some of the most prominent comments for this questions. The systems development life cycle was described as a fundamental piece of CS curriculum but Microsoft Project, RUP, and PMBOK, placed in the curriculum could enable success when entering the workforce in any position.

7. *In general, what do computer science undergraduates need to know, to enable them to have a successful career in an IT department?*

   Participants mentioned that CS graduates need to know how their work affects the bottom line. Doing so could help them realize that their work matters and their best effort should always be put forth. Some characteristics mentioned include being flexible, being able to meet short and long term goals, communicating with upper management, having integrity and a great attitude. A wide knowledge of systems and technology integration, certificates on the latest technology, open source technologies, as well as being a good researcher, and obtaining a good mentor would lead to success in today's IT department.

CONCLUSION

This paper has presented preliminary, yet valuable information to improve the computer science curriculum in preparing graduates for today and tomorrow's positions. This exploratory study has been conducted using rich interviews from IT professionals in various types of organizations. Our analysis concludes that modifying computer science curriculum to provide more emphasis on written and verbal communication skills, gathering and eliciting customer requirements effectively (80% of respondents emphasized), the ability to be flexible and the ability to deal with varying personalities were highly emphasized. Negotiation skills, time management, cultural differences, outsource management, and information assurance trainings were some of the most notable skills in addition to a strong technical background. All of these skills will aid in improving graduates' ability to communicate on all levels of the organization when entering industry in an IT capacity position. This is pertinent as companies continue to outsource. The ability to provide well-rounded computer scientists is vital in these situations. With the current literature aiming to improve various aspects of the computer science curriculum, we feel there is a grave need to focus on the customer. We propose enhancing the computer

science curriculum to include more customer elicitation techniques, albeit potentially through a business, to improve the ability for computer scientists to hone in on the art of requirement elicitation and project management through communication skills.

Future research can further quantify the needs of industry. Then focus on how to successfully implement these important skill sets into CS curriculums. Requirements elicitation, communication, and project management skills within the computer science curriculum are some of the potential areas to make a great impact in the career success of computer science graduates.

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