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IT PROGRAM CURRICULUM RECOMMENDATIONS BASED ON A SURVEY ON KNOWLEDGE AND SKILL REQUIREMENTS FOR ENTRY-LEVEL IT WORKERS

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ABSTRACT

This paper provides an updated view of the importance of various skills and traits for entry-level IT workers as perceived by the IT industry based on a web-based survey administered to IT managers nationwide. The survey consists of 47 skills and traits that include personal and interpersonal skills, as well as technical skills. This study finds that the top 12 skills and traits are personal and interpersonal skills with honesty and integrity ranked most highly. The top 5 technical skills are operating systems, security, hardware, networking, and database, which have been part of the IT core for many years. The noticeable change in technical skills is the low ranking of programming. Based on the analysis of the survey, several ideas for curriculum recommendations for IT-related programs are provided.

INTRODUCTION

Information Technology (IT) is a fast growing profession. According to the U.S. Bureau of Labor Statistics, IT employment is projected to grow much faster than the average for all occupations and add 286,600 new jobs over the 2008-2016 decade (http://www.bls.gov/oco/ocos305.htm). Money magazine and PayScale.com have been giving ratings to careers in the past four years (2006-2010). The newest list of 2010 rated the top 100 careers with great pay and growth prospects in America (http://money.cnn.com/magazines/moneymag/bestjobs/2010/full_list/index.html). Out of the 100 careers, there are 26 jobs in the sector of Information Technology, with Software Architect ranked as number 1 ($119,000 median salary and 34% 10-year growth) and Telecommunications Network Engineer ranked as number 21 ($87,000 median salary and 53% 10-year growth).

The IT profession is also well known for its rapid development of new technologies. College students enrolled in IT-related degree programs should be prepared with knowledge and skills that are aligned with industry Therefore, constant curriculum review and development is crucial. Program enrollments have been rising since 2008, reversing the national decline that started in 2000. For example, according to the CRA (Computing Research Association) 2008-2009 Taulbee survey, the number of new students majoring in computer science increased 8.5 percent over the previous year. Computer science graduation rates should increase in two to three years as these new students graduate (Taulbee, 2008-2009).

The primary purpose of this paper is to provide an updated view of the importance of various skills and traits for entry-level IT workers as perceived by the IT industry and discuss the results in light of curriculum design. A nationwide survey was designed and conducted in 2010 on IT managers for the importance of various skills/traits to entry-level full-time IT employees.

LITERATURE REVIEW

This work is an extension of the two previous studies (Author1, Author2, & Author3, 2009a; Author1, Author3, & Author4, 2009b), which were based on a nationwide survey conducted in 2006. Authors (2009b) asked the managers and workers to rate the importance of the 32 skills based on the survey for 348 IT managers and 238 IT workers. Personal and interpersonal skills were consistently rated the most important on average with honesty/integrity the highest rated attribute on average. Awareness of IT technology trends, operating systems and networking were the highest rated technical skills/traits. Authors (2009a) examined gaps between industry and academicians' perceptions based on the survey for 348 IT managers and 78 faculty on the importance of 32 skills as they relate to entry-level IT workers. Overall, faculty and industry were in agreement about the ranking of the skills categories (interpersonal, personal, technical, organization, experience & GPA). There were some differences in specific skills (industry viewed hardware concepts, operating systems, packaged software and work experience as more important than faculty).

Many other studies have examined the perception gaps between IS/IT industry and academicians with regards to knowledge and skill sets (Cappel, 2001/2002; Kim, Hsu, & Stern, 2006; Lee & Fang, 2008; Lee, Koh, Yen, & Tang, 2002; Tang, Lee, & Koh, 2000/2001; Trauth, Farwell, &

Lee, 1993). For example, Kim et al. (2006) provided the perceived IS/IT skills gap from the perspective of end-users, academia, and IS/IT employers through a survey of end-users, IS curriculum models, and reports by employers. Project management was one of the highest ranked skills by the 71 respondents but is still only taught in a small percentage of AACSB accredited IS programs. In addition, security, ERP, end-user computing, and the integration of soft skills were indicated as being important and should be given more emphasis in the IS curriculum. A limitation with this study is that the all respondents were employees from one manufacturing firm in the northeast.

Many studies conducted in the past twenty years have investigated IT/IS knowledge and skills (Doke & Williams, 1999; Gallagher, Kaiser, Simon, Beath, & Goles, 2010; Lee, Trauth, & Farwell, 1995; Leitheiser, 1992). Gallagher et al.'s surveyed (2010) 104 senior IT managers in 94 non-IT companies in 2005 and found that foundational skills (programming, system testing, help desk, database, operating systems, voice/data telecommunications) are not critical to retain in-house. These skills are important to get hired, but over time the importance of these skills diminish. Another study by Lee et al. (1995) examined critical skills necessary for IS workers and made curriculum recommendations based on the findings. A lot of research consistently found that personal/interpersonal skills were more important in new hires than core technical skills (Fang, Lee, & Koh, 2005; Young & Lee, 1996).

In a recent study by Lee and Mirchandani (2010), students surveyed 70 IS managers. The IS managers rated their perception of the importance of the IS/IT skills in the past (five years before today), present and future (five years after today). The study found that the skills with fastest growing importance are wireless communication and applications, mobile commerce applications and protocols, IS security, web applications, services & protocols and data management. Based on these results, implications and recommendations for IS/IT educators, researchers, and practitioners are provided. However, in this study, only 21 companies from the Midwest U.S. were represented and the IS 2002 model curriculum used to identify courses was relatively old.

Based on a field study of 9 IT executives, Havelka and Merhout (2009) developed a theoretical model of knowledge, skills, and abilities desired for IT professionals, named "theory of IT professional competence". The theory was composed of four broad categories: personal traits, professional skills, business knowledge and technical knowledge. This study could help to better understand gaps between IT academic programs, employers' needs, and IT students' perceptions. However, the number of participants in this study was small. The theory needs to be further validated by larger scale studies.

In another study, Downey et al. (2008) surveyed 153 IT professionals from 6 organizations in the mid-South about skills important for entry-level IT professionals and used results to develop an IT model curriculum including core and specialization. Since only 6 firms represented, results do not generalize. In addition, this curriculum was written under the assumption of only 9-10 courses in curriculum. However, we have 15 IT courses in our curriculum (not including math, but including internship and 3 specialization courses). Another limitation with this study is that there are accepted model curricula but there was no comparison to these in the paper.

Lee and Han (2008) also studied skill requirements for entry-level IT professionals. The focus was on programmers/analysts in Fortune 500 companies and investigated the gap between the IS 2002 model curriculum and the requirements of the industry. They found that application development, software, social and business skills were highly valued, and recommended that knowledge of technological trends, knowledge of business functions and general problem solving skills be taken into account by the designers of future IS curricula. Java was still the most popular programming language (cited specifically in 30.7% of 837 ads for entry level programmers), followed by VB, then COBOL. Lee and Han (2008)'s study adopted Lee (2005)'s skill categorization, which was built on the coding framework proposed in the study of by Todd et al. (1995). Lee (2005) focused on the skills desired in systems analysts job ads posted on Fortune 500 corporate websites. Another related work by Lee and Lee (2006) looked at 555 IT manager job ads from 2001 to 2003 and concluded that IT managers needed both technical (although less in the area of hardware) and behavioral skills. It was also noted in this study that management positions only mentioned certifications in 7.7% of the cases.

There are other studies that also used job ads to collect data. For example, the study by Prabhakar et al. (2005) used Internet IT job advertisements to examine changes in demand of skills over a 3-year period (2002-2005). Identified top skills were web programming, Unix, C++, Java, SQL programming and Oracle DB. Five percent of jobs ads required certification. Gallivan et al. (2004) examined classified ads for IT professionals from 1988-2003. They found that job ads focused on technical skills rather than the "soft skills" that organizations claim are important in new hires.

Using a survey for more than 150 IS graduates, Plice and Reinig (2007) determined that emphasizing technical topics in the IS program helped graduates in the short term but maintaining the existing balance between business and technical skills taught in the program was beneficial to graduates in the long term as they moved to more managerial roles in their field. However, this study only looked at graduates from San Diego State University's IS program and there was no basis for judging IT and CS graduates.

Another research paper published in the same year is by Surakka (2007). The author used a Delphi technique to survey a small sample of Finnish IT professionals, academics and students to evaluate the importance of various subjects and skills related to software development. This study compared the results to prior similar research done by Lethbridge (2000a; 2000b). Several of the findings of Lethbridge's studies still hold, like less importance placed on continuous mathematics and basic science. In addition, new areas of emphasis were discovered, such as web-related skills. This study also analyzed the implication of the survey results for CS (Computer Science) degree programs. One of the limitations of this study is that the survey data was older and had a small sample size: 11 software developers answered the survey in 2003-2004, 19 professors or lectures in 2005 and 24 master's students in 2004.

Lastly, Abraham et al. (2006) conducted in-depth interviews with 104 senior IT managers. They found that the "business content" in IS curriculums was highly likely to be retained in-house by the interviewees. In addition, they found that technical skills were cited as being more likely to be outsourced while being listed as the skills most desired in new hires. The sample in this

research consisted of non-IT firms only and had a proportionally larger share of Fortune 500 companies than found in the overall population of organizations in the U.S.

METHODOLOGY

The primary purpose of this study is to provide an updated view of the importance of various skills and traits for entry-level IT workers as perceived by IT managers for a larger and broader sample than used in previous studies. To this end, a survey was administered to IT managers nationwide.

The survey instrument contains questions related to skills and traits of entry-level employees as well as demographic questions about the respondent and the respondent's organization. The questions relating to skills and traits were created by combining questions on the Authors (2009b) study with skills, knowledge areas and traits listed in the ACM/IEEE – IT 2008 curriculum guidelines and in the program outcomes in the ABET accreditation standard for IT programs.   Certification and research experience were added as traits. The rationale for including certification is that the ACM/IEEE IT 2008 model curriculum does not advocate certification as part of academic credit. The authors wanted to see if industry opinion differed. Research experience was added because undergraduate students sometimes get the opportunity to conduct research with faculty. The authors wanted to see whether industry considers research experience important.

The survey consists of 47 skills/traits that participants were asked to rank in terms of importance on a scale of 1 (not important) to 5 (very important). The survey was web-based and administered via email by a reputable online survey company to IT managers listed in a database maintained by the survey company. There were 315 respondents with 310 responses complete enough to use for analysis. Rationale for using a survey company is to gain access to the widest spectrum of IT managers as possible for the greatest generalizability of the study results. Of the 310 that were complete enough for analysis, 282 respondents were currently working in the IT industry. These 282 responses were used for analysis.

DATA ANALYSIS

Profile of Respondents and Their Organizations

The majority of respondents (72%) were currently in an IT leadership position (i.e. CIO, CTO, Director, Manager, Project Leader). The location of respondent's organization includes all but 7 states, as well as 3 international organizations. The size of the respondents organizations as measured by the number of employees varied from under 100 (17.4%) to over 10,000 (24.8%).

Respondents were asked about areas in which they were hiring entry-level IT workers in the next year. Table 2 shows the areas where respondents are hiring entry-level IT workers of the respondents who were hiring in the next year and knew the areas in which they were hiring (194 respondents). The respondents could select more than one area, so percentages add up to more than 100%.

Table 2: Areas for hiring entry-level IT workers (in the next year)

IT Help Desk	45.88%
Networking	34.54%
Programming/Software Engineering	33.51%
Database	29.90%
Security	29.38%
Systems Analysis and Design	25.26%
Business Intelligence (Reporting, Analytics, Data Mining, Decision Support Systems)	23.20%
Storage	22.68%
Web Design & Development	22.16%
Virtualization	21.65%
Enterprise Resource Planning Systems	20.10%
Disaster Recovery	17.53%

Importance of Various Skills/Traits to Entry-Level Full-Time IT Employees

In order to assess what skills/traits are important for IT-related degree programs, respondents were asked to rate the 48 skill/traits listed in Table 3 in importance on a Likert scale with 5 being "very important" and 1 being "not important". The mean rating, rank and adjusted rank are provided in Table 3. The adjusted ranking represents the ranking of technical skills and knowledge areas that would be part of all IT programs (database, networking, programming, web, human computer interaction, etc.) and a few that would be part of many programs (storage, virtualization, etc.).

The top 12 skills/traits are personal and interpersonal with honesty and integrity ranked the most highly. Of these, the only skills/traits not mentioned in the accreditation standards nor model curriculum are attitude, creative thinking and organizational skills. Attitude is the second most important trait of a new IT hire. The only personal skill that did not rank highly is entrepreneurial skills.

After personal and interpersonal skills, the next most important skill is "relevant" work experience (ranked 13) which is much more highly ranked than "any" work experience (ranked 25) or internship/co-op experience (ranked 43). It is curious that internship/co-op experience was not as highly valued as relevant work experience nor any work experience.

The top 10 technical skills are: operating systems, security, hardware, networking, database, packaged software, systems administration and maintenance, integration of IT solutions, business intelligence and web systems development. All technical skills, marked with an adjusted rank, are considered at least somewhat important (3.3+ on a 5 point Likert scale, between neutral and important). The technical skills with the lowest average ratings are ERP (3.30) and virtualization (3.46).

Awareness of IT technology trends ranked higher than any of the skills/knowledge areas typically taught in an IT program. In addition, awareness of the impact of IT on individuals, the community or globally was ranked higher than all but two of the technical skills.

Table 3: Importance of skills/traits

Skill/Trait/Knowledge Area	Mean	Rank	Adjusted Rank
Honesty/integrity	4.55	1	
Attitude	4.49	2	
Willingness to learn new skills	4.44	3	
Communication skills (oral and written)	4.42	4	
Analytical skills	4.40	5	
Professionalism	4.38	6	
Ability to work in teams	4.37	7	
Flexibility/adaptability	4.32	8	
Motivation	4.31	9	
Interpersonal skills	4.23	10	
Creative thinking	4.12	11	
Organizational skills	4.10	12	
Relevant work experience	4.05	13	
Awareness of IT technology trends	4.02	14	
Operating systems	4.00	15	1
Security	3.98	16	2
Awareness of impact of IT (on individuals, community or globally)	3.96	17	
Hardware concepts (PC, server, router, network)	3.95	18	3
Networking	3.93	19	4
Database	3.88	20	5
Packaged software (e.g. word processing, spreadsheets, etc.)	3.84	21	6
System administration and maintenance	3.81	22	7
Integration of IT solutions	3.80	23	8
Knowledge of primary business functions (e.g., finance, marketing)	3.74	24	
Any work experience	3.71	25	
Business intelligence (e.g. reporting, analytics, data mining)	3.71	26	9
Web systems development (XHTML, XML, Javascript, JSP, ASP, etc.)	3.70	27	10
Knowledge of your company's specific industry (retail, health care, transportation)	3.70	28	
Leadership skills	3.69	29	
Project management	3.68	30	11
Knowledge of your company	3.67	31	
Relevant certification	3.66	32	
System integration and architecture	3.64	33	12
Configuration management	3.62	34	13
Human computer interaction (e.g. interface design, user testing, etc.)	3.61	35	14
Systems development life cycle methodologies	3.60	36	15
IT disaster recovery	3.60	37	16
Storage	3.59	38	17
Information assurance	3.59	39	18
Programming (Java, COBOL, etc.)	3.59	40	19
High IT GPA	3.46	41	
Virtualization	3.46	42	20
Internship/co-op experience	3.45	43	
Relevant academic research experience	3.40	44	
High overall college GPA	3.31	45	
ERP systems	3.30	46	21
Entrepreneurial skills	3.27	47	
Extra-curricular activities	3.03	48	

IMPLICATIONS FOR CURRICULUM DESIGN

The most highly ranked skill is honesty and integrity. This is not surprising given that the IT staff is entrusted with the organization's data, information and systems that access the data and information. In addition, IT professionals are responsible for securing the organization's data, ensuring that sensitive data is kept private and confidential, and ensuring that the rest of the employees of an organization are behaving ethically with regards to IT (not surfing unauthorized Internet sites, not shopping online, not downloading non-work related applications, not using email for personal or unauthorized use, etc.). Although one cannot teach a student to be honest or to have high integrity, the teaching of ethics and ethical decision making can increase awareness of ethical dilemmas, especially as they relate to IT, as well as highlight the importance of considering alternatives when making decisions and the consequences of each alternative.

Similarly, teaching a student to have a good, positive attitude or influencing their willingness to learn, the second and third highest ranked items on the list of skills and traits, is difficult. However, as educators we can share these results and highlight the importance of attitude. We can also stress how much IT changes, especially in earlier classes in the curriculum, to educate students about the fact that they will be constantly learning in the IT field, arguably more so than in many other fields. Teaching students about professionalism, how to communicate and how to work in teams is important in an IT program as well.

IT related degree programs also need to include curriculum on trends in technology, what reputable sources to use to keep abreast of these trends and the impact of changes in technology on the organization and individuals in the organization. These topics were ranked as more important or at least as important as the top technical skills listed. Recognizing the impact of IT on individuals in an organization dovetails the "people-centric" approach (people and what they do are the most important considerations when developing and modifying systems) contemporary organizations are taking to improve information privacy and security in systems (Want, 2007).

The top five technical skills or knowledge areas identified were operating systems, security, hardware, networking, and database. Historically, these have been the core of the IT field and remain to be so today. An interesting note is the lack of programming, systems development life cycle (SDLC) methodologies and human computer interaction in the top ten skills. In addition, certification is ranked higher than all three. In the past, programming and the SDLC (one or both) have been mainstays of many IT related degree programs. Perhaps programming is more important for those hiring programmers and software engineers. Table 2 shows that 33.51% respondents are hiring programmers and software engineers in the next year, while Table 3 indicates a relative lack of importance of programming/software engineering with the programming skills only ranked as 41 out of 48. This disconnect is probably because those who are hiring programmers ranked programming higher than those who are not. Further explanation concerns the current state of the economy. Organizations tend to reduce spending and investment during periods of economic turbulence. The need for programmers and software engineers may be therefore be reduced if firms are not investing in the development or expansion of systems. In future work, we plan to investigate the importance of skills and traits from the perspective of those who are hiring programmers and software engineers.

CONCLUSION AND FUTURE RESEARCH

A survey with 282 respondents of which 72% were in a leadership role was administered to determine the importance of various IT skills and knowledge areas as well as personal and interpersonal traits. After analyzing the average responses, several ideas for curriculum recommendations for IT related programs were suggested. These included the importance of teaching ethics, professionalism, communication skills and how to work in teams. In addition, educators in these programs should stress the need for continued learning throughout an IT workers career and the importance of attitude and motivation in the IT field. Of course, one could argue that these personal and interpersonal skills are important in all fields and should be included as part of the core curriculum in all universities.

The core skills and knowledge areas in an IT program have not changed considerably. They are operating systems, security, hardware, networking, and database according to the responses in this survey. In addition, IT programs should include curriculum on technology trends and their impact. One noticeable change is the low ranking of programming, typically considered part of the IT core, in relation to other technical skills listed on the survey.

Areas of future research include a comparison of the current results to the study conducted in 2006 by Authors (2009b) and a comparison of the results to current model curricula and accreditation standards for IT related degree programs. As mentioned previously, another area of research is to compare the skill ratings for employers hiring programmers and software engineers to those that are not. This will highlight some of the key differences between important skills and traits for students in degree programs that focus on programming and software engineering, like computer science, and those for students in other IT related degree programs, like information technology and information systems.

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