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**PERCEIVED TECHNICAL INFORMATION TECHNOLOGY SKILL
DEMANDS VERSUS ADVERTISED SKILL DEMANDS:
AN EMPIRICAL STUDY**

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ABSTRACT

The field of information technology (IT) is well-known for being a fast-paced, ever-changing environment. For IT employers to meet the needs of a rapidly changing work landscape they must depend on the supply of appropriately experienced and educated IT employees—who in turn need to correctly gauge labor marketplace skill demands, and choose appropriate educational or training courses to gain the needed skills. This challenge of predicting the future IT job market supply and demand can be posed as, "How accurate are IT student perceptions of the IT technical skills demanded by IT employers?" and "What IT skills and jobs are being demanded?" This paper describes an empirical investigation to determine how accurately IT students view the IT technical skills necessary to be a successful IT professional, and how well their perceptions match those IT technical skills actually sought in IT online job advertisements. We find that several gaps exist between student perceptions of the skills they need versus the actual IT skills employers are advertising for. Results from this study could be useful to employers seeking specific technical skills and to students seeking to fulfill the employer needs.

Keywords: Information Technology Skills, IT Professionals, Technical Skills

INTRODUCTION

The information technology (IT) field is known for rapid and continuous change. Not only are established technologies such as programming and databases rapidly improving, but new technologies such as grid computing and mesh networking are constantly being developed and

adopted by businesses. To develop, apply, operate, and maintain these technologies, businesses must continually expand or create new IT employment opportunities and then seek IT workers with current and emerging IT experience and skills to fill these positions. According to the United States Bureau of Labor and Statistics [17], from 2002 until 2012 three of the ten fastest-growing oc-

cupations are network systems and data communications analysts, positions for whom the BLS expects to increase by 57 percent, computer software applications engineers whose growth is expected to be 46 percent, and computer systems software engineers with an increase of 45 percent.

Meeting IT employer needs for current and emerging IT worker skills has been an acute, national problem [12]. One of the possible reasons employers may have difficulty finding necessary worker technical IT skills is that learning information technology skills can be challenging and mentally complex. And not only must technology workers constantly update and enhance their technical skills, but training and educational institutions must also continually update their courses and the knowledge and skills of their professors [10]. A second reason may be that IT students anticipating employment opportunities may have difficulty correctly judging what IT skills will be demanded of them when they graduate so that they can wisely choose what courses to take [7]. The key research question for this paper is: do students accurately perceive what IT technical skills are demanded by employers?

For the purposes of this paper, IT technical skills are defined as "hard" skills acquired through training, education, or on-the-job experiences that are specific to computer-based hardware, software, databases, and data communications. These technical skills are distinct from "soft" IT skills, which are usually concerned with such areas as interpersonal communication, social graces, and general management skills. This paper focuses solely on IT technical skills since there is some research from job advertisements suggesting that technical skills are predominantly required for IT positions [11]. IT technical skills may include a working knowledge of certain or several hardware components such as CPUs and memory caches, software applications such as Cold Fusion, programming languages such as XML or Java, databases such as Oracle or Sybase, and data networking protocols such as TCP/IP. Additionally, technical skills include the processes to acquire and develop specific systems, write technical documentation for them, diagnose problems, and service and maintain them.

This paper describes empirical research on student perceptions of IT technical skills demanded by businesses compared to actual business IT technical skills demanded based on job advertisements. After recounting previous research on the topic, this paper then explains the research methodology, shows research data and analysis, discusses and presents conclusions based on the analysis, and then explains some of the limitations of this study as well as what future research could be done to further explore the findings.

Previous Research

Early research on IT job skills used newspaper position advertisements to identify which job skills were in demand. One of the earliest studies collected position advertisements from ten major city newspapers in 1989 and then in 1996 to develop a taxonomy of skills needed in IT [3]. Based on their findings, Litecky, et al., [11] replicated the study to update the findings and to further refine and classify IT skills sought by businesses advertising IT job openings.

McLean and Schneberger [13] conducted an exhaustive survey of IT job skill demands in the state of Georgia using localized IT job advertisements, and then compared them to what was being taught in the Georgia university system. The study grouped IT skills into *technical* (subdivided into "conceptual" such as networking and normalizing, and "work" such as C++ and SQL) and *non-technical* (subdivided into "business" such as marketing or sales, and "personal" such as interpersonal communications and project management). The study showed that technical work skills were the most demanded by Georgia IT employers in more than 10,000 Georgia IT job advertisements analyzed.

Other research has examined whether students are receiving the skills and education necessary to be successful in obtaining IT positions. A technical knowledge and skill requirements survey among 429 university students and faculty [16] found educational gaps in nine areas of IT knowledge and skills. Among the deficient areas identified were three in the technology category (systems development methodologies, implementation, and hardware). Janicki, et al., [8] surveyed 308 employers on the detailed skills needed for specific IT-related occupations.

Another educational and IT skills concern addressed by Petrova and Claxton [15] is that undergraduate academic programs are often too theoretical and the skill sets taught are out of date. As a result, some students may graduate with outdated skill sets that industry neither values nor requires [9]. Other researchers have found a technology adoption gap between academia and industry [4, 5].

The United States Departments of Labor and Education formed the Secretary's Commission on Achieving Necessary Skills (SCANS) to study the kinds of competencies and skills that workers must have to succeed in today's workplace. Results of the study were published in a document entitled, "What Work Requires of Schools: A SCANS Report for America 2000." The report [18] identified the following types of technology skills: 1) selecting

technology, which requires choosing procedures, tools, or equipment including computers and related technologies; 2) applying technology to task, which requires an understanding of intent and proper procedures for setting up and operating equipment, and 3) maintaining and troubleshooting equipment, which involves preventing, identifying, or solving problems with equipment, including computers and other technologies. While the skill sets are in terms of process, not topic (as are most other studies including the previous Georgia study), the SCANS report nonetheless highlighted a number of topical skills.

Other research has highlighted the longitudinal changes in IT skills demanded by employers. As information technologies have become more complex, so have employee skill levels [2]. The typical IT staff member has moved beyond data processing to embrace a variety of new programming languages and paradigms, networking protocols and devices, client-server distributed computing, and other business and technology related skills [6]. Due to shortages of qualified IT professionals and the ever-changing business environment, IT professionals are expected and required to remain on the cutting edge of technological advancements [2].

But how can IT employees stay current with new, in-demand information technologies if they don't know what IT technical skills are being demanded? Not found in information technology literature are studies directly comparing what IT skills students perceive to be necessary for getting an IT-related job, and what advertised IT-related jobs skills are being demanded.

RESEARCH METHODOLOGY

To answer the primary research question, "How accurate are IT student perceptions of the IT technical skills demanded by employers?" the researchers employed three data collection phases and three data analysis phases. The first data collection phase involved gathering students' perceptions of the IT technical skills required by IT employers. The second collection phase documented the actual skills demanded by IT employers. The third data collection phase used interviews, focus group techniques, and an open-ended online survey to better understand both student and employer perspectives on the importance of the necessary skills to be successful as IT professionals.

The three data analysis phases examined the importance of those skills perceived to be important by students, ranked these skills, and compared the results of the skills perceived to be important by students with the skills actually demanded by employers. Based upon our literature review, we considered six skill sets for our study: 1)

knowledge of computer hardware, 2) knowledge of databases, 3) knowledge of networking, 4) knowledge of standard software applications, 5) knowledge of programming languages, and 6) the ability to design user-friendly graphical interfaces.

Student Perceptions

To measure student perceptions of needed IT skills, a survey was conducted in upper level IT classes at an accredited four year university in the United States. While focusing on the technical skills needed for IT employment, the survey research instrument actually measured student perception of the technical skills necessary to be successful as an IT professional in today's global business environment. Demographic information (student age, gender, academic class, major, and frequency of college level information technology classes) was also collected.

The survey instrument used a five-point Likert-type scale to measure a respondent's degree of agreement or disagreement with the statements (1 = "strongly disagree" and 5 = "strongly agree"). The instrument was first pilot-tested using undergraduate level IT students who were not included in the actual survey, to eliminate survey question ambiguity and improve instrument reliability. The survey was modified after feedback from the pilot study. Survey variables were student views of technical skills such as programming, networking, and knowledge of databases as well as software applications, computer languages, graphical interface design, computer networking, and computer hardware. The survey instrument is provided in the Appendix.

The survey was administered in upper level information systems required courses, resulting in a useable sample size of 259 senior information systems majors—those who had taken a wide range of IT courses, were actively involved in employment searches, and were therefore expected to be familiar with a broad spectrum of IT skills and have a perception of what skills employers were seeking. To encourage student objectivity, the students were told that their individual responses would be kept anonymous. Students did not receive credit or compensation for completing the survey. Student perceptions were ranked by the six groups (software applications, programming languages, design of user-friendly graphical interfaces, databases, networking, and computer hardware) of technical IT skills.

We then set up a focus group with twelve students majoring in Computer Information Systems who were planning to graduate in less than three months. We asked them to discuss which IT skill sets are most in demand by employers, and also to talk about what skills are

no longer popular. Focus group participants provided richer insight of their opinions of necessary IT skills. The focus group discussion was transcribed by one of the authors and relevant quotes are interspersed in the findings section of this paper. Based upon the focus group discussion, we created and administered an open-ended, online survey consisting of essay-type questions so these students could provide their individual thoughts about which IT skills they perceive are in highest demand. The focus group and open-ended, online survey for students allowed us to confirm and better understand the findings from the original survey, and capture qualitative data which is integrated into the findings and discussion sections.

Employer Skill Demands

To answer the question of "What IT skills and jobs are being demanded?", we found that earlier research had shown that job placement advertisements can accurately show employer interest in those skills necessary for hiring IT workers, this research effort similarly used IT position listings. We analyzed over 21,000 online position advertisements using the keyword search approach and used the number of instances of technical skill keywords in listings to rank the demand for each IT skill. The same six groups of technical skills used in the survey of student perceptions of skill demands were used in searching job listings. These were software applications, computer languages, graphical interface design, databases, computer networking, and computer hardware. The keywords used for each group were taken from a widely used yearly survey linking IT skills with current salaries. This survey is performed quarterly by Foote Partners, LLC, a general management consultancy and IT compensation and workforce management research firm that continuously monitors the compensation, attitudes, and workplace experiences of 50,000 IT workers in the U.S., Canada, United Kingdom and Europe¹. The key words used in searching for IT positions were:

- **Software Applications.** Access, Acrobat, software application, cc:Mail, Cold Fusion, Excel, Frontpage, Groupwise, Notes, Outlook, PaintShop, PowerPoint, Word
- **Languages.** ActiveX, ASP, BASIC, C, CGI, COBOL, C+, C++, C#, Delphi, FORTRAN, HTML, JAVA, J2EE, J++, PERL, PHP, PowerBuilder, programming,

RAD, RPG, Script, SE, Smalltalk, SQL, VB, XML, .NET

- **Graphical Interface Design.** Graph, GUI, Swing, Webstart, Rich-client
- **Databases.** ABAP, Access, Apptivity, Baan, database, DBA, DB2, Edwards, Informix, MySQL, normalize, PeopleSoft, Oracle, relational, SAP, SQL, SQL Server, Sybase, Siebel, 2000 Server
- **Networking.** Apache, APPC, ATM, Ethernet, Exchange, IIS, IPX, gateway, HTTP, LAN, networking, Netware, networks, NT, router, SAN, SIP, SMTP, SNA, TCP/IP, VoIP, WAP, WAN
- **Hardware.** BIOS, bus, cache, circuit, clock, CPU, digital, disk, gateway, hardware, microprocessor, RAM, ROM, router, server

The searches were made in a comprehensive manner; advertisements that contained any of the group keywords were counted for that group. Listings were limited to the previous 30 days; to be all-encompassing, all job categories were used to find every job seeking IT skills, not just "IT jobs." All listings were searched and counted the same day for accuracy.

Determining which job sites to search was based on rankings from eleven authoritative sources on ten online job sites². Nine of the eleven sources ranked monster.com as the best source for online job listings, followed by hotjobs.com and careerbuilder.com. Those top three sites were used to perform the keyword IT skill searches. Dice.com was added to the top three since it listed IT jobs exclusively and could offer a valuable focus on IT skills.

We also interviewed several IT professionals to confirm support for the set of six technical skills included within our survey instrument.

¹ Available at http://www.footepartners.com/htscpi_latest.htm.

² The rankings came from 11 reference sources such as Forbes, Business Week, PC Magazine, Workforce Management, About.com, Yahoo! Internet Life, Resume-Help.org, and Job Looks. The 10 data sites were monster, careerjournal, dice, hotjobs, careerbuilder, americasjobbank, worktree, vaultsjobboard, directemployers, and headhunter.

DATA ANALYSIS

Student IT Skill Perceptions

Based on the demographic data from the surveys, the student sampling unit was comprised of 259 students composed of 74% males and 26% females, consistent

with previous studies suggesting that upper level IT classes consist of a much higher number of male students [14]. The results of the measured skill groups are shown in Table 1.

Table 1: Respondent Perceived Technical Skill Set Needs

| Associated Measures | Mean* |
|--|-------|
| Knowledge of standard software applications | 4.51 |
| The ability to design user-friendly graphical interfaces | 4.27 |
| Knowledge of programming languages | 4.27 |
| Knowledge of databases | 4.15 |
| Knowledge of networking | 4.14 |
| Knowledge of computer hardware | 4.10 |

*1= "strongly disagree", 5 = "strongly agree"

Advertised IT Employer Demand

We began the employer demand analysis by tallying the number of jobs within each group containing the IT skill keywords used, and ranking them in order from highest to lowest. The rankings from the survey instrument on student perceptions of what IT skills were needed to be successful in getting hired were compared directly with the rankings of IT skills from the online job listings.

Table 2 indicates the number of IT jobs listed online for each site containing the IT skill group keywords. The measures are listed in ascending order from the largest of the six groups to the smallest. Database skills were the most desired skill advertised followed by software applications. By far, the lowest number of jobs listed (68; 0.32%) involved the ability to design user-friendly graphical interfaces.

Table 2: Advertised Demand for IT Skill Groups

| Measure | Monster | Hotjobs | CareerBld | Dice | Total | % |
|------------------------------------|---------|---------|-----------|------|--------------|-------------|
| Knowledge of Databases | 671 | 588 | 5938 | 905 | 8102 | 37.65 |
| Knowledge of Software | 822 | 314 | 3330 | 637 | 5103 | 23.72 |
| Knowledge of Programming Languages | 899 | 788 | 1568 | 776 | 4031 | 18.73 |
| Knowledge of Networking | 526 | 184 | 1065 | 842 | 2617 | 12.16 |
| Knowledge of Hardware | 372 | 179 | 635 | 410 | 1596 | 7.42 |
| Design Graphical Interfaces | 16 | 6 | 29 | 17 | 68 | 0.32 |
| | | | | | 21517 | 100% |

DISCUSSION

Table 3 shows the combined rankings in ascending order by perceptive rankings for comparison to the advertised IT skills shown in Table 2. Interestingly, it appears that student perceptions of demanded IT technical skills were within one ordinal ranking for four of the six skill sets: knowledge of standard software applications, programming languages, networking, and computer hardware. Two of these two skill sets, however, had significantly different ordinal rankings. The ability to design graphical interfaces was perceived by the students to be in second place (tied with programming languages) while in IT advertisements it was ranked sixth, and in last place—with less than one third of one percent of the 21,517 jobs

advertised. Similarly, students perceived knowledge of databases to be ranked fourth out of the six technical skill sets we measured, while IT job advertisements ranked it number one for over 37% of the advertised jobs. Student perceptions of the marketplace demands for IT skill sets appeared to be fairly accurate except for these two particular skills.

Table 3: Combined Perception and Actual IT Skill Demands

| Measure | Perception mean rank | Advertised rank |
|--|----------------------|-----------------|
| Knowledge of standard software applications | 1 | 2 |
| Ability to design user-friendly graphical interfaces | 2 (tie) | 6 |
| Knowledge of programming languages | 2 (tie) | 3 |
| Knowledge of databases | 4 | 1 |
| Knowledge of networking | 5 | 4 |
| Knowledge of computer hardware | 6 | 5 |

To further explore student perceptions about databases, we set up a focus group with twelve computer information systems majors about to graduate, and also administered a more qualitative-oriented survey that captured their individual responses in essay form about their perceptions of these six groups of IT skills.

Even though over one-third of the jobs advertised in our study required knowledge of databases, students perceived other skills to be more important. Qualitatively, we found that most of the students despised using databases, which may be influencing their perceptions about the need to possess database skills. For instance, one student stated, “[Databases] are useless...” while another student said, “Get rid of [database management program] now, it’s doing nothing but hurting us. Real businesses don’t use it...” Since many students learn the basics of a DBMS in an introductory database class, this may be biasing their perceptions about the need to understand databases for employment.

On the other hand, students believe that the ability to design user-friendly graphical user interfaces is the 2nd most important skill set of the six we considered. However, only 68 of the 21,517 jobs we analyzed (0.32%)

were looking for this particular skill set. Students indicated that they would like our department to teach *more* classes to learn how to design user-friendly graphical user interfaces. One student mentioned, “I definitely think there should be more classes taught in designing user-friendly graphical interfaces. Visual Studio is a good beginning step, but I think there should be more advanced classes when you actually develop...” Other students indicated that they believe they should possess skills in related products such as “Adobe’s CS3 web development suite,” “Dreamweaver,” “Photoshop,” and “Flash.” These are not classes offered in our curriculum even though students perceive these skills to be important. However, our analysis of the jobs requiring these skill sets indicated that they are much less important than skills in areas such as databases and programming languages.

Students may be gratified to know that the results suggest they are doing a fairly good job of gauging employer skill demands, but they also suggest there may still be significant disconnects. Whatever means students are using to determine IT skill demands may need to be adjusted or extended to more accurately reflect actual advertised demands. While the choices for senior IT stu-

dents to rectify skill shortages are likely limited that late in the educational cycle, students can at least make employment marketing decisions (e.g., in choosing what to highlight in résumés) in light of demand skill sets.

Employers may also be gratified that students have a fairly accurate perception of the IT technical skills they seek, but the two apparent disconnects should give them pause. If IT employers want to be proactive in ensuring a well trained supply of IT workers to meet their IT employment needs, they might seek ways to more accurately portray those needs to students, and early enough for students to make appropriate course selections. IT employers should likewise be aware of what students perceive to be the demanded skills sets so that employers can lobby educational institutions to provide the courses to meet their actual IT skill demands.

Finally, educational institutions can continuously determine the IT technical skill sets demanded in the IT employment marketplace and help to ensure students are kept abreast of those marketplace demands. Educational institutions may want to form alliances with key players in the IT marketplace to further that goal and improve the effectiveness of course curricula. Colleges and universities can actively join forces with business and industry to prepare the workers of tomorrow for jobs in the so-called 'knowledge economy,' emphasizing the need to keep a competitive edge in rapidly-changing national and global markets.

But is there something else that may be learned from the two skills sets that were so dysfunctional in their rankings? Why those two and not the others? It is interesting to ponder if there is another factor at play—a factor that influences student perceptions about IT technical job skills. Databases have been used by businesses for almost forty years and, while the technology behind them continues to evolve, they are a mature technology with a relatively slow rate of change. Graphical user interface technology, on the other hand, is in many ways the opposite; it is a relatively new IT field especially in the area of rapidly growing Internet and web technologies. Could it be that database skills are perceived to be less "glamorous" while user interfaces are? That user interfaces offer a greater perceived future value than databases?

If so, what is the nature of an "IT glamour factor?" Is there perceived intrinsic IT technical and social worth (moderated by personal values?) that influence student perceptions about perceived IT skills? If true, the perceived technical and social worth of IT itself should be

taken into account by students scanning the IT market, by business IT employers advertising for IT workers, and by educational institutions in deciding which courses to offer. Students should understand what factors may be at play distorting the accuracy of their IT marketplace perceptions. Businesses could use such a factor to either attract highly skilled IT workers by encouraging a sense of glamour, or to counter possible misperceptions about skills thought of as unglamorous. Finally, educational institutions could consider purposely identifying misperceptions based on IT glamour and countering them with accurate marketplace data.

Future research should consider the influences that affect student perceptions of the skill sets desired by employers. For instance, which referent groups are most important in influencing student perceptions? It seems that professors would be most important, but since we do not teach most of the desired classes at our institution in designing user-friendly graphical interfaces, other referent groups may be important. Since students are on the Web quite a bit, does this influence their perception that graphical interface development is in great demand? It also might be that students simply lack the knowledge of which skill sets are in most demand by employers. Students are often misinformed, thus providing faculty an opportunity to provide them with accurate information. Perhaps professors could also do more to expose students to the real-world through trips to companies and bringing in guest speakers who hire recent graduates. Theories such as the theory of planned behavior [1] could be used in future research on this topic to determine the level of influence of attitude, subjective norms (referent groups), and perceived behavioral control (such as lack of knowledge) on student perceptions.

We recognize that the IT field rapidly changes and that some of the skill sets determined to be important at the time of our study will likely be replaced by other skill sets in the future. The purpose of our study is not to emphasize the particular skill sets we examined in our research, but instead, to point out the gaps between student perceptions and employer actual needs. We suspect that these gaps have existed in the past and will continue to occur in the future. It is important to recognize the gaps between student perceptions of the skills they should possess and employer actual needs for specific skill sets so that students are well-prepared for the workforce and employers can fill their open positions with qualified job candidates

CONCLUSIONS

This study examines the link between academia and the IT job market, and it offers a view of the dynamic links between the IT skill supply and demand which could be used by academics, students and future employers for short-term as well as long-term planning and decision making. Further, this study identified the IT technical skills students thought necessary to become successful IT professionals, the IT technical skills employers sought through online position advertisements, and the contrasts between the two categories based on some specific IT skill set rankings. The primary research question, "How accurate are IT student perceptions of the IT technical skills demanded by IT employers?" can be answered with "fairly accurately, but with several gaps that need further exploration." Another response, if addressing the two skills that were almost polar opposites, was that students did not have a clear insight into what skills are necessary for actual, advertised positions.

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APPENDIX: SURVEY INSTRUMENT

Please answer the following questions. The objective of this survey is to evaluate student's perception of the skills and attributes necessary to be a successful IT professional. We appreciate your cooperation in this study. PLEASE DO NOT IDENTIFY YOURSELF ON THIS SURVEY. ALL INDIVIDUAL RESPONSES WILL REMAIN CONFIDENTIAL.

Age: _____
 Gender: Male Female
 Academic Classification: Fr. So. Jr. Sr. Gr.
 Major: Business (IT) Business (Other) Non-Business Undecided
 How many required college level Information Systems courses have you taken, excluding this course? _____

Please indicate your responses by circling the appropriate number on the 5-point scale indicated.

| Research Questions | Rate Your Opinion of Each Question <i>1 = Strongly Disagree, 2=Disagree, 3 = Neutral, 4=Agree, 5 = Strongly Agree</i> | Rate Your Own Competency Level for Each Question <i>1 = Very Low, 2=Low, 3 = Moderate 4=High, 5 = Very High,</i> |
|---|--|---|
| 1. Knowledge of programming languages is necessary to be successful as an IT professional..... | 1 2 3 4 5 | 1 2 3 4 5 |
| 2. Knowledge of web server development is necessary to be successful as an IT professional..... | 1 2 3 4 5 | 1 2 3 4 5 |
| 3. Knowledge of computer hardware is necessary to be successful as an IT professional. | 1 2 3 4 5 | 1 2 3 4 5 |
| 4. Knowledge of databases is necessary to be successful as an IT professional..... | 1 2 3 4 5 | 1 2 3 4 5 |
| 5. Knowledge of networking is necessary to be successful as an IT professional..... | 1 2 3 4 5 | 1 2 3 4 5 |
| 6. Knowledge of telecommunications is necessary to be successful as an IT professional..... | 1 2 3 4 5 | 1 2 3 4 5 |
| 7. Knowledge of standard software applications (Microsoft Office products) is necessary to be successful as an IT professional..... | 1 2 3 4 5 | 1 2 3 4 5 |