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ABSTRACT

Organizations are always in search of appropriate information technology knowledge and skills to carry out normal business operations. Such demand is directly impacted by the overall economic conditions. During stressful economic times, managers, facing tough budgetary pressure, are forced to examine more thoroughly what knowledge and skills are needed to survive. This paper investigates the desired information technology knowledge and skills that employers are searching for in these turbulent times. We examine the content of job advertisements for information technology professionals placed in an online job placement website over a 2 year period, 2001-2002.

INTRODUCTION

The go-go days of the 1990's are a distant memory for information technology professionals as they experience layoffs, budget cuts, and the elimination of job opportunities resulting from dot com startups bankruptcies and changing economic conditions. The S&P500 is often used as a health indicator for the United States economy as well as a display of investor confidence that corporations can generate earnings. During the last decade of the 20th century, investor confidence increased as revenues climbed and stock prices soared. To many investors dismay, 2000 through 2003 resulted in a dramatic decrease in investor confidence and an economic reversal.

According to the Information Technology Association of America (ITAA), the economic downturn created a decrease of 528,496 information technology (10.4 million to 9.9 million) jobs in 2001. The decrease of five percent in the IT workforce was spread evenly across the United States (U.S.). The southern U.S. led the reductions as a percentage of the total, with 34%, which translated to 181,928 IT positions lost. Information technology organizations lost 15% of their information technology workers, while non- information technology companies lost only 4% of their workforce (ITAA, 2002).

The global economic downturn presents many challenges for business and government in relation to information technology investment. On the other hand, through all this upheaval, the use of the World Wide Web continues to expand from 66.9% in 2000 to 71.1% in 2003 (UCLA 2003). As a result, the decisions that organizations make during these stressful economic times dramatically affect the current and future availability of information technology knowledge and skills. In this tough environment, managers are more than ever before forced to safeguard the bottom line (Koong, Liu, and Fowler, 2003). They need to find someone who has just the right skills to perform job requirements. Job advertising is more carefully thought out and applicants are more strictly screened and examined. The current global economic downturn has certainly impacted the desired knowledge and skills in demand.

Working with 2001 and 2002 job advertisements, we investigate the knowledge and skills in demand by employers. Several studies (Todd et al., 1995; Walsh et al., 1975) have used job advertisements as a vehicle to determine the desired demand for information technology knowledge and skills. The significant difference between this study and previous works is twofold. First, previous studies occurred during a period of financial prosperity and

global economic growth that resulted in ever expanding information technology budgets. Second, this study uses job advertisement in digital form that enabled the researchers to analyze over 150,000 job advertisements.

The paper is divided into six sections. The next section presents the relevant literature about IT knowledge and skills. Five sections then follow: research question, research method, study findings, managerial implications, and conclusion.

A REVIEW OF THE INFORMATION TECHNOLOGY KNOWLEDGE AND SKILLS LITERATURE

During the last four decades, many studies (Trauth et al., 1993; Lee et al., 1995; Todd et al., 1995; Sheehan, 2000; Hazelhurst, 2001; Hellens, 2001) were conducted to investigate the supply and demand of information technology knowledge and skills. These studies focused on the particular knowledge and skills necessary to succeed in a changing business environment. They discussed the importance of information technology knowledge and skills as well as the lack of information technology knowledge and skills.

Employers and information technology professionals are both searching for knowledge and skills that will enable them to succeed. The pressure to build or buy information technology and deploy it successfully is increasingly more difficult as the availability of skilled and knowledgeable information technology professionals shrinks. One reasons for this shift in the supply of information technology professionals is the slow exodus of retiring senior information technology professionals. Other contributing factors are the transition from host-based skills to network computing (web services) skills (Benamati & Lederer, 2001), as well as current economic conditions, which appears to have the most critical impact.

It is a multidimensional issue consisting of general and specific knowledge and skill needs. Employers want employees with the requisite knowledge and skills to enable the successful development of information technology system (Wade, 2001/2002). Information technology professional are always searching for knowledge and skills that will, at a minimum, enable employment and at a maximum increase their worth in the market place.

In 1979, Zmud proposed a taxonomy for information technology professional knowledge and skills consisting of six skills: organizational overview, organizational skills, target organizational unit, general IS knowledge, technical skills, and IS product skills. Many studies built on this taxonomy (Cheney & Lyons, 1980; Harrison & Springer, 1985; Jenkins, 1986) and applied it to areas such as job classification (Vitalari, 1985; Lee et al., 1995; Snyman, 2001). These studies all suggest an increased demand for information technology professional that possesses a balanced set of skills (e.g. technical, organizational, functional, and managerial) (Doke et al., 1999; Klawe, 2001; Schambach, 2002). A balanced set of skills is important for information technology professional because of the numerous challenges involving the implementation of new information technology (Byrd et al., 2001) that requires solving complicated technical and non-technical problems.

In 1995, the Boston SIM (Lee et al., 1995) conducted a study that reinforced Zmud's (1979) taxonomy and suggested that organizations would demand a cadre of information technology professionals with knowledge and skills in technology, business operations, management, and interpersonal skills to effectively lead organizational integration and process reengineering activities. They found that information technology professionals should develop interpersonal and management skills to work with their functional peers in defining new ways to conduct business. The study identified four recommended knowledge and skills: (1) Technical Specialties, (2) Technology Management, (3) Business Functional, and (4) Interpersonal and Management for information technology professionals (Lee et al., 1995).

During the same period, different studies (Todd et al., 1995; Watson, Young, Miranda, Robichaux, & Seerley, 1990) using the previous studies as a basis, investigated the degree to which the perception of changing knowledge and skills requirements was matched to job advertisements. Todd et al. (1995) examined how the mix of skill requirements changed over the period 1970 to 1990 using a 1,234 job advertisement for programmers, analyst, and managers. It was argued that the suggested mix of knowledge and skills, as outlined in the ACM and DPMA IS curriculum, over emphasized the need for managerial and organizational knowledge and skills.

Many researchers have reported gaps between knowledge and skills that are taught in academia and those that are demanded by the information technology industry (Lee et al. 1995, Nelson 1991, White & Cook, 2003). This is sometimes referred to as the "perception gap" (Lee, Koh, Yen, & Tang, 2002). As a result, they (Todd et al., 1995) regrouped required knowledge and skills into three areas: (1) Technical - knowledge and skills in hardware and software products and languages, (2) Business - knowledge of industry and functional areas, management and organization skills, and interpersonal and communication skills, (3) Systems - problem-solving skills such as analytical and modeling, development methodologies, and analysis and design tools and techniques (Todd et al, 1995).

The intent of the Todd et al. (1995) study was to increase the understanding of the IS profession in order to enhance the processes of educating, training, recruiting, hiring, and promoting IS professionals (Todd et al, 1995). The study contradicted the prevailing research by suggesting that the need for technical knowledge and skills is greater than non-technical skills for information technology professionals. A natural limitation of the study was the difficulty of analyzing 20 years of newspaper job advertisements.

RESEARCH QUESTION

Job advertisements are a primary recruitment vehicle for organizations and provide an information rich resource for our investigation (Walsh, et al., 1975). Some suggest that hiring organizations are sending inconsistent messages to students and professors about the appropriate skills actually needed for the job (Trauth, Farwell, & Lee, 1993). "Educators preparing graduates for immediate placement into IS positions may be using valuable curriculum resources to teach techniques that will soon be (if they are not already) outmoded and for whom there is already a large base of skilled workers (Trauth et al., 1993)."

This situation is termed the "recruitment gap" (Trauth et al., 1993). A situation where the stated skill requirements listed in a job advertisement are not all of the knowledge and skills the employee actually requires for the position. For example, much of the academic literature (Vitalari, 1985; Nelson, 1991; Trauth et al., 1993) discusses the need for a balanced set of skills (technical and business). Yet, several studies have found that the emphasis in the job advertisements is on technical skills rather than on business and interpersonal skills. These studies suggest that organizations look for business and interpersonal skills during the interview process since they omitted these requirements in the job advertisement or the first screening stage (Todd et al., 1995).

One may think that job advertisements represent future employees because the job advertisement is intended to fill a new position in an organization. Yet, the design and construction of job advertisements is governed by existing employees. This implies that the job advertisement is really intended to replace a current employee and is a representation of both new and old employee knowledge and skills. Job advertisements are vehicles to address multiple levels of needs - individual, occupational, organizational, industrial, and societal. As such, job advertisements are linking pins to connect individuals, groups, occupations, and organizations. They serve to communicate information to particular types of individuals who fit the organizational mold. (Rafaeli, 1998)

We argue that job advertisements are a true reflection of the knowledge and skills desired by employers for new hires. Therefore, our research question is:

What are the knowledge and skills in greatest demand, as specified in online job advertisements, during this global economic downturn?

RESEARCH METHOD

Job advertisements are a primary recruitment vehicle for organizations (Walsh, et al., 1975) and the World Wide Web (WWW) is a de facto source for information technology professional to post resumes and search job advertisements. The WWW has usurped traditional newspaper job advertisement sections. This study analyzed job advertisements from July 2001 and November 2002. The relevant variables are the required knowledge and skills and the job types listed in the employer job advertisements. We first divide jobs into twenty two job types and

examine the change of counts for each during these two years hoping to discern the overall dynamics of the IT job marketplace. Second, we classify K-S into three categories: hardware, software and development methodologies. There are 41 K-S in the hardware category ranging from mainframes to routers, 60 in the software category ranging from Java to .Net and 9 in the development methodologies category ranging from implementation to maintenance. The change of each K-S from July 2001 and November 2002 is examined.

DATA COLLECTION

The data presented in this study is based on job advertisements posted at www.dice.com, an on-line placement company. Dice.com offers regional searches for job seekers in over 20 key markets such as: Atlanta, Austin, Boston, Dallas, New York, Orlando/Tampa, San Francisco and Seattle. Dice.com's Custom Search Network includes such sites as User Friendly, DevX.com, Dilbert.com, GirlGeeks.com, and ABCnews.com.

STUDY FINDINGS

Table 1 presents the job classification counts for the two periods. There is a minor increase in the demand for Business Analyst/Modeler and Application Programmer/Analyst, and a minor decrease in the demand for Software Engineer. In general, the differences are small.

Table 1: Job Classification Counts

Job Classification	2001 Count	2002 Count	Variance
Business Analyst/Modeler	20,404	22,541	2,137
Communications Specialist	1,238	1,247	9
Data Base Administrator	6,915	7,016	101
Other types of Engineers	7,559	7,514	(45)
Graphics/CAD/CAM	749	755	6
Hardware Engineer	4,199	3,647	(552)
Instructor/Trainer	864	962	98
LAN/Network Administrator	4,809	5,033	224
Manager/Project leader	13,555	14,167	612
Data Processing Operator	581	633	52
Application Programmer/Analyst	21,781	24,508	2,727
Quality Assurance/Tester	4,474	4,844	370
Sales/Marketing	7,248	7,741	493
Software Engineer	20,677	18,507	(2,170)
Systems Administrator	6,915	7,252	337
Systems Programmer/Support	3,922	4,156	234
Custom/Tech Support	4,957	5,501	544
Technical Writer	1,357	1,441	84
Web Developer / Webmaster	7,968	7,330	(638)
Finance / Accounting	1,705	1,943	238
Recruiter	633	609	(24)
Non Specific	5,360	6,664	1,304
Unknown	6	5	
Totals	147,876	154,016	6,141

Knowledge and skills in demand by period

The knowledge and skills findings for July 2001 and November 2002 are presented in Table 2. Columns 1 and 2 show the job advertisement counts and columns 3 and 4 show the difference and percentage difference between columns 1 and 2. To better focus our analysis, we divided the dice.com data into three groups: Hardware, Software, and Development Methodologies.

Table 2: Knowledge and Skills in Demand by Period

Hardware	Nov '02	Jul '01	Difference	Percentage
TCP/IP	3,646	3,842	(196)	94.9%
AS/400	2,653	2,346	307	113.1%
WAN	2,563	2,612	(49)	98.1%
SUN	1,695	1,669	26	101.6%
Routers	1,321	1,473	(152)	89.7%
HP	1,233	1,126	107	109.5%
Mainframes	1,162	1,049	113	110.8%
Firewalls	1,112	1,125	(13)	98.8%
ATM	1,094	1,244	(150)	87.9%
PC	867	831	36	104.3%
VPN	528	481	47	109.8%
Frame Relay	505	565	(60)	89.4%
Ethernet	439	498	(59)	88.2%
PBX	425	396	29	107.3%
Web Server	401	426	(25)	94.1%
Telephony	355	386	(31)	92.0%
T1	261	286	(25)	91.3%
ISDN	250	269	(19)	92.9%
RS/6000	237	212	25	111.8%
Hubs	224	262	(38)	85.5%
Apple / Macintosh	196	201	(5)	97.5%
DEC	165	179	(14)	92.2%
SMTP	145	154	(9)	94.2%
Switching	140	139	1	100.7%
T3	93	111	(18)	83.8%
Cabling	69	66	3	104.5%
Token Ring	66	70	(4)	94.3%
Gateways	63	57	6	110.5%
SGI	60	66	(6)	90.9%
PPP	58	62	(4)	93.5%
IPX/SPX	44	39	5	112.8%
Bridges	35	30	5	116.7%
Remote Access	33	33	0	0.0%
Video Conferencing	13	14	(1)	92.9%
NIC	13	13	0	100.0%
Multiplexers	10	7	3	142.9%
NNTP	8	13	(5)	61.5%
Punch Downs	3	2	1	150.0%
Mini	1	2	(1)	50.0%
Repeaters	1	1	0	0.0%
Print Servers	1	0	1	100.0%

Software	Nov '02	Jul '01	Difference	Percentage
SQL	18,052	17,302	750	104.3%
Unix Other	17,599	17,931	(332)	98.1%
C++	17,392	18,963	(1,571)	91.7%
Oracle	15,101	14,190	911	106.4%
Java	13,641	13,731	(90)	99.3%
HTML	7,895	8,127	(232)	97.1%
C	5,428	8,173	(2,745)	66.4%
Unix Solaris	4,583	4,689	(106)	97.7%
Visual Basic	4,547	4,556	(9)	99.8%
CICS	1,788	1,640	148	109.0%
RPG	1,785	1,599	186	111.6%
Shell	1,782	1,752	30	101.7%
MVS	1,732	1,580	152	109.6%
Linux	1,667	1,529	138	109.0%
AIX	1,655	1,429	226	115.8%
Windows 2000	1,595	944	651	169.0%
JCL	1,267	1,125	142	112.6%
Powerbuilder	1,248	1,275	(27)	97.9%
SAS	1,156	865	291	133.6%
P-UX	971	927	44	104.7%
Cold Fusion	671	712	(41)	94.2%
OOP	540	548	(8	98.5%
Netware	530	502	28	105.6%
Delphi	449	432	17	103.9%
Basic	391	381	10	102.6%
OS/390	389	334	55	116.5%
VMS	370	386	(16)	95.9%
.NET	342	32	310	1068.8%
JDE	337	236	101	142.8%
Windows 95/98/NT	325	323	2	100.6%
Active X	304	337	(33)	90.2%
ASSEMBLER	222	240	(18)	92.5%
DOS	219	221	(2)	99.1%
Smalltalk	197	198	(1)	99.5%
PHP	185	175	10	105.7%
FORTRAN	133	127	6	104.7%
Korn Shell	124	111	13	111.7%
Mac OS	121	124	(3	97.6%
MS SQL server	91	92	(1)	98.9%
OS2	85	76	9	111.8%
SCO	78	79	(1)	98.7%
OS/400	71	52	19	136.5%
Python	67	62	5	108.1%
Clipper	61	53	8	115.1%
Pascal	60	65	(5)	92.3%

Software Continued	Nov '02	Jul '01	Difference	Percentage
AWK	58	50	8	116.0%
EasyTrieve	55	44	11	125.0%
PL/1	52	48	4	108.3%
Windows 3.x	50	56	(6)	89.3%
BIOS	50	50	0	100.0%
Visual J++	40	36	4	111.1%
APS	39	28	11	139.3%
ADS	16	15	1	106.7%
Btrieve	12	10	2	120.0%
CULPRIT	5	3	2	166.7%
System 38	4	3	1	133.3%
DYL280	4	2	2	200.0%
System 36	4	1	3	400.0%
Mark-IV	3	1	2	300.0%
BeOS	1	1	0	100.0%
OS/VS	1	1	0	100.0%
Xenix	0	1	(1)	0.0%
Apple Share	0	0	0	
CP/M	0	0	0	
Gener/OL	0	0	0	
System 34	0	0	0	
Pro*C	0	0	0	

Development Methodologies	Nov '02	Jul '01	Difference	Percentage
Implementation issues	979	922	57	106.2%
Operations	514	443	71	116.0%
Documentation	391	327	64	119.6%
Maintenance issues	194	146	48	132.9%
Systems development methodologies	67	80	(13)	83.8%
Analysis design tools	27	31	(4)	87.1%
Analysis design techniques	5	7	(2)	71.4%
Systems approach	0	0	0	
General development phases	0	0	0	

In general, the job advertisements show the demand for hardware knowledge and skills is decreasing (22,357 in 2001 vs. 22,188 in 2002), software is increasing (158,484 in 2001 vs. 159,779 in 2002), and development methodologies are increasing (1,956 in 2001 vs. 2,177 in 2002).

Hardware Findings

All telecommunication related hardware knowledge and skills shows signs of a decreasing demand, yet server knowledge and skills show signs of increasing demand. More than 1,000 job advertisements were placed in 2001 and 2002 for TCP/IP (decreasing), AS/400 (increasing), Wan (decreasing), SUN (increasing), Routers (decreasing), HP (increasing), mainframes (increasing), firewalls (decreasing), and ATM (decreasing).

Software Findings

The software section is subdivided into operating systems, languages, and database.

Operating Systems: The operating systems in greatest demand are Other Unix (17,599 in 2002; 1.9% decrease from 2001) and Solaris (4,583; 2.3% decrease). Despite the percentage drop, Other Unix and Unix Solaris are still very dominant. Demand for other operating systems was limited -- MVS (1,732; 9.6% increase), Linux (1,667; 9.0% increase), AIX (1,655; 15.8% increase), Windows 2000 (1,595; 69% increase), and the demand for the rest is below 1,000.

Languages: SQL (18,052; 4.3% increase), C++ (17,392; 8.3% decrease), and Java (13,641; 0.7% decrease) dominated the language category. COBOL (3,655; 12.5% increase) continues to thrive but C (5,428; 33.6% decrease) dropped considerably. Other languages showed modest variation -- XML (3,782; 8.1% increase), JSP (1,922; 7.6% increase), ASP (4,393; 2.4% decrease), and Visual Basic (4,547; 0.2% decrease). There is a significant increase in the demand for .NET (342; 968.8% increase) but the total count is still quite small.

Databases: Oracle (15,101; 6.4% increase) dominated the demand for database knowledge and skills. The demand for DB2 (3,263; 19.0% increase) increased substantially while the demand for Microsoft SQL Server (91; 1.1% decrease) decreased and is quite small.

Development Methodologies Findings

Implementation issues, Operations, Documentation, and Maintenance issues dominated the knowledge and skills demand as demand increased from 2001 to 2002. However, the total number of job advertisements in this category is quite small compared to the other categories.

MANAGERIAL IMPLICATIONS

This study identified changes in demand for knowledge and skills in hardware, software, and development methodologies. As organizations search for the appropriate mix of information technology knowledge and skills to carry out normal business operations, the shifting supply and demand of knowledge and skills will have far reaching effects on business and government. The combination of a decrease in the demand for hardware knowledge and skills and an increase in the demand for software and development methodologies knowledge and skills is revealing. The increased demand for software knowledge and skills is interesting in that the demand is strong in areas such as web based technologies and weak in traditional 2nd (Assembly, JCL, etc.) and 3rd generation (e.g. COBOL, Basic, etc.) programming languages.

The increased demand for software knowledge and skills identified in this study is supported by a recent U.S. Bureau of Labor Statistics report. The report states that of the ten job classifications in greatest demand for the next ten years, four are information technology. They are application computer software engineers, system software engineers, network systems analysts, and data communications analysts. The knowledge and skills require for these classifications all require software expertise.

The implications for management are far reaching. First, in the event that the need for hardware expertise is simply a reaction to the current economic downturn, then the supply of knowledge and skilled hardware professionals will be limited when the economy recovers. Second, the emphasis on web based tools and products and the limited, or lack of, exposure to 2nd and 3rd generation technologies by university students may dramatically impact the labor pool as the baby-boomer generation retires over the next decade. When one considers the amount of mainstream (e.g. financial, manufacturing) transaction processing systems that are written in 2nd and 3rd generation languages, the implication are dramatic. Compounding the situation is the fact that many universities now use only Internet and web products and tools when teaching information technology courses. As a result, the new generation of programmers and systems analysts are receiving no exposure to older and often widely used technologies. Organizations may face aging information systems, developed with 2nd and 3rd generation software languages, and a limited pool of knowledgeable and skilled software developers to support these systems. Other possibilities include an industry-wide need to retrain and retool information technology professional over the next decade or to replace

information systems developed with older technologies with new systems based on web technology. In either case, the costs involved may be staggering and have enormous financial consequences for organizations worldwide.

CONCLUSION

This exploratory investigation on desired knowledge and skills for information technology professional suggests that the trend towards Web Services is strong, yet in a holding pattern. The knowledge and skills needed to develop Web Services for the .NET or J2EE environments show modest decline (probably attributed to the economic downturn) while continuing to dominate the raw counts. Although the data shows a percentage increase in the demand (9,828) for traditional transaction processing systems knowledge and skills such as COBOL, MVS, CICS, and the AS/400, the demand for Java (13,641) alone surpasses these four combined. In the near future, we plan to more fully investigate the general patterns of knowledge and skills in demand by today's employers with particular emphasis on demand for .NET and J2EE knowledge and skills.

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