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Abstract

Recent surveys and reports have highlighted "information technology (IT) skill shortages." However, it is not entirely a new phenomenon. The diffusion of new technologies always seems to alert us to a potential skill crisis. For firms, how should they manage the portfolio of IT skill sets? For researchers, what issues are high priorities on research agendas? For educators, do changes that occurred to the IT portfolio skill set affect what students need to learn and integrate. Towards these ends, the paper summarizes the recent trends, managerial issues and research issues related to the management of IT skills. It also gives some research directions for future agendas and endeavors.

Key words: Information technology (IT) skills, skills portfolio management, skills development, information systems (IS) personnel

Introduction

A number of recent surveys and reports (e.g., ITAA 2000; Office of Technology Policy 1997, 1998,1999) note labor shortages in Information Technology (IT). Notwithstanding the recent slow down of the U.S. economy, this labor shortage does not seem to be waning. A recent survey's results (ITAA 2001) show that approximately 450,000 new IT positions will go unfilled.

We note, however, that the IT labor shortage clamor is not a new phenomenon. McLaughlin (1979) addressed the issues on how firms attempt to overcome the programmer shortages over twenty years ago. Barr and Kochen (1984) warned that that there would be "serious labor shortages in computer-related occupations" continuing in the mid 1980s. The introduction of a new technology -- be it a computing platform such as the personal computer, a programming language or a development tool -- alerts us that a potential shortage of IT work force (e.g., Cook 1981; Dern 1982; McEnaney 1985) is brewing.

If the rapid pace of innovation continues to characterize the IT field, the shortage in skilled IT professionals is likely to remain a chronic challenge for firms. Thus, what are the key managerial issues that firms need to address at this juncture? For information system (IS) researchers, what are the major IS research questions on the changing IT skills portfolio? For educators, how are the changes in the targeted IT skills portfolio affecting the aims and goals of academic programs? Are new courses and/or new pedagogies needed to meet the needs of students and employers?

Managerial Issues for Firms

According to a CIO Magazine survey of 366 IT professionals, firms have greater difficulties in hiring such skill sets as application development, database administration and web development (Ware 2001). The firms also have greater difficulties in retaining IT skill sets in such areas as application development, database administration and network management.

Another study of IT professionals (Microsoft 1998, 1999) reports that firms need technical skills most for network operating systems (NOS), desktop applications, database skills, programming and software development, as well as the Internet/intranet development and maintenance. This survey shows that IT practitioners see networking (in particular, Windows NT/2000 systems), development and database (especially Oracle database systems) skills as areas of greatest demand, whereas universities and colleges see programming and software development as the areas of greatest demand.

Interestingly, the first survey shows that the 49% of the respondents recognize a crisis in getting and keeping appropriate IT skills whereas only 6% of these respondents recognized a crisis in getting and keeping an IT staff. In other words, employers find getting the right mix of IT skills is a far bigger problem than simply getting IT workers. Even though finding people with the right skills is probably the biggest issue, respondents report that 25% of their IT staff has had training for a new function or new job. Indeed, firms mostly use outsourcing and utilizing existing employees to cope with the skill gap between demand and supply (ITAA 2001).

These findings underscore how important the problem of skills portfolio management has become. Firms are finding it harder to find or keep people with the desired skills portfolio, or to develop needed skills in people without them. Also, the accelerating speed of technological advances aggravates these problems.

While the news media highlight current phenomena and/or new skills such as Y2K, Java and XML and web programming skills, making one think they are the most important skills to have. This is not true. Surveys show that the "old" language skills such as COBOL, C and C++ are still sought and very important (e.g., Fryer 1999; Goff 2000). In addition, e-commerce and traditional IS appear to be fusing, as enterprise resource planning (ERP), supply chain management (SCM) and web-based systems mesh together. How will that trend affect the portfolio of needed technical skills? Granting the importance of these technical skills in any portfolio, employers still favor other skills in recruiting IT professionals. Interpersonal skills and organizational loyalty through "the commitment to finishing assignments and projects" are the two most important "IT worker employability skills" (ITAA 2001). Therefore, what do all these trends mean in terms of how firms acquire, develop and/or maintain their required IT skill sets at the firm level -- or what we call firms' skills portfolio management?

From the standpoint of skills portfolio management, there are three major areas of managerial foci:

Skills Acquisition
- Recruiting for skills (e.g., desired profiles of talent, sources of talent, compensation)
- Building a skills inventory
- Outsourcing for needed skills

Skills Development
- Determining the desired skills portfolio (e.g., goal setting, required skills)
- Designing and implementing skills enhancement plans at the firm level
- Designing programs to allow skills transfer (e.g., C++ to Java)
- Developing a rotation process (e.g., IS department to IS user department, LAN manager to web master)

Skills Maintenance
- Retaining talent (e.g., benefits/compensation, work conditions)
- Updating skills

Research Issues on IT Skills Portfolio Management

One relevant research group for IT skills research is the Special Interest Group on Computer Personnel Research (SIGCPR) of the Association for Computing Machinery (ACM). A review of ACM SIGCPR Proceedings between 1985 and 2000 (Table 1, next page) shows that steady research efforts were made towards the managerial foci in the previous section.

Some of the most salient findings of these studies appeared in SIGCPR proceedings include:
- The importance of business skills (communication/interpersonal skills, industry/firm knowledge)
- The recognition that differences in personal traits and specific skill requirements exist among different IS positions (e.g., programmers, analysts, IS managers)
- Some awareness of a gap between industry skill needs and IS curricula in higher education

A review of IS journal articles (Nakayama and Sutcliffe 2000) echoes the main findings. Moreover, the following research areas are identified as key issues which also correspond to the key managerial issues of IT skills portfolio.

Skills Acquisition
- Determining desired talent profiles
- Retooling existing IT skills
- Determining the effectiveness and impacts of skill outsourcing
- Determining the effectiveness of various compensation methods (e.g., skill-based pay)

Skills Development
- Measuring and evaluating skills
- Defining the desired skills portfolio
- Determining skill enhancement plans at the firm level
- Finding commonalities between different skills
- Finding heterogeneities among skills
- Determining the impacts of job/position rotations
- Comparing full-time education, internal training, on-the-job training (OJT), self-study, industry certificates on a number of dimensions

Skills Maintenance
- Measuring the effectiveness of skill set use
- Determining the factors for retaining talent
- Finding the issues on skill updates
- Determining effective and efficient IT/IS training methods (see the last item in the above skills development section)

Table 1. IT Skill Issue Related Studies in ACM SIGCPR between 1985 and 2000 *

Category	Description	# of papers
Skills portfolio & requirements	Overall balance of skill sets; skills for IT workers and skills for a specific position such as CIO and analysts	22
Traits	Individual characteristics or traits on IT work	7
Training	Effective training methods for skill acquisition and/or transfer	9
Education	Educational contents and orientation of IS academic programs	8
Skill development	How to develop skills internally and/or externally	6
Recruitment & retention	Conditions and factors for optimal hiring and retention	12
Motivation	How to attain higher levels of IT worker motivation	5
Career anchors, career path	How IT workers make decisions and advance their career	15
IS human resource management	Evaluation and staffing of IT workers	18

*Adopted from Nakayama and Sutcliffe (2001)

Among many potential research issues, we note that two aspects of IS skills portfolio research are major challenges to IS research.

First, we need "standardization" in classifying skills. One extreme of categorization is to have just two major types of IT skill sets -- technical skills and business skills. At the other extreme is the micro-analysis of IT skills, attributing them to numerous entities such as programming languages, computing platforms, software packages, systems development methods, industries, organizations, and even geographic locations. What is needed is a definition of a minimum set of fundamental skills. This definition considers similarities and differences of skill natures from both theoretical and practical standpoints. In other words, we need skill standards that give a guideline for managers and researchers -- despite or because of the rapid pace of IT evolutions. Such standards also "provide workers and students with clear benchmarks leading to skilled, high-paying jobs of the future" (Rada 1999). Although we have not seen a widely accepted skills standard yet, an effort for skills standardization has started in the IT industry as part of its product marketing. In educational institutions, the effort is from the perspective of IT educational curriculum, and in government entities, the effort is from the perspective of building the infrastructure of their national resources (*ibid.*).

Second, we need to overcome measurement challenges from different skills or skill variables. If and when we have some level of IT skill standards, that will provide us with a map of IT skills (dependent/independent) variables. The next challenge is then

how to measure such variables. Like abilities and capabilities, skills are the potential for accomplishing tasks. That is, we can measure skills only when they are actually used. This leads us to a challenge in our empirical research -- how to measure what we cannot directly assess.

One traditional way for measuring skills is to develop standardized tests that assess proficiency. For example, we can focus on technical language skills to compare and contrast one's programming proficiency and/or learning efficiency in, for example, C vs. C++, C++ vs. Java, or C++ vs. C#. Such measurement efforts undoubtedly need participation from industry and educational institutions in planning and implementing the tests. Also they can help obtain "subjects" for measuring their traits, IT background variables, learning efficiency and skill levels. Similar efforts are also possible for targeting platform skills such as the administration of Linux and Windows 2000 systems.

Notwithstanding the technical skills issues, we also must categorize and measure business skills. For a starter, we want to assess peer evaluations of targeted IT professionals on the target's business skills in relation to their career progress, perceptions of the target's future prospects, the target's technical skills, and the target's business training/experience.

Another challenge in empirical research is that "subjects" (i.e., IT professionals) usually go through a variety of career paths within and across organizations -- rapidly in some cases and slowly in others. Results from a recent industry survey also attest that "IT is now a job marketplace where clearly marked professional career paths are sometimes difficult to find" (ITAA 2001). Tracing the status of IT professionals' skills and career progress probably requires focused research settings in terms of geographic regions and organizations.

To sum up, the conceptualization of skills is an important future milestone in skills portfolio research. In this conceptualization, we address such research questions as:
- How should we categorize IT skills?
- How should we categorize business skills for IT professionals?
- What are the "fundamental" skill sets? What skill sets are "temporary" versus those that have lasting value?
- How should firms acquire, develop and maintain a particular skill set?
- For both firms and IT professionals, is there an "efficient" chain or sequence of skills acquisition and development over a career life?

Educational Issues on IT Skills Portfolio Management

While researchers are interested in the conceptualization of skills, educators are interested in using such a conceptualization to develop better methods and approaches to teaching such skills. That is, will such a conceptualization help us in the design on courses so that new skills build efficiently on an existing skill set? We need to further explore how research can help us in developing better pedagogic tools for particular skills. For example, when does the use of multimedia result in a higher level of skills acquisition and when does it not?

The stated goal of most higher education is not simply teaching skills but rather imparting knowledge and training one in analytical techniques and logical reasoning to make the student capable of learning new skills on one's own. Given the velocity of change in the past few years in IT, are the fundamental skill sets we teach today appropriate in this new environment? If not, what are the changes that we need to make? Also, given this velocity, how often do IT professionals need to participate in continuing educational efforts to update their personal skills portfolio? In teaching IT managers, what is the sequence of business skills that is needed at each career stage? Currently many business schools emphasize strategic skills over tactical skills; is this appropriate in developing a robust, foundational IT skills portfolio?

Another area of concern is the mix of interdisciplinary efforts. Given the diversity of skill sets needed for IT professionals, what combination of academic disciplines meets the needs of IT students? Which disciplines answer the needs for select IT segments? What business disciplines and what computer science disciplines are essential for IT managers (and even for IT users), considering that IT use is ever more an integral part of business today? A good conceptualization of IT skills can provide the answers to many such questions. From these answers more effective and efficient educational efforts can result.

Conclusion

For firms, a lack of needed IT skills results in a hindrance to their success. Faced with skill shortages, firms have to plan and manage IT skill sets at the firm level strategically. For educators and researchers, skill shortages prompt to search for the

fundamental skills and how best to acquire and manage the needed skill sets at the firm level. Towards these ends, research on IT skills portfolio management is an important first step.

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