Human capital and organizational performance: a study of Egyptian software companies

Ahmed Seleim and Ahmed Ashour
Faculty of Commerce, Alexandria University, Alexandria, Egypt, and
Nick Bontis
DeGroote Business School, McMaster University, Hamilton, Canada

Received May 2006
Revised November 2006
Accepted November 2006

Abstract

Purpose – The paper seeks to test empirically a variety of hypotheses related to human capital and organizational performance within software companies in Egypt.

Design/methodology/approach – A valid research instrument was utilized to conduct a survey of 38 software companies who are representative of the 107 members of the Software Industry Chamber of Egypt. A correlation analysis and stepwise regression were conducted to ascertain the validity of the hypotheses.

Findings – Statistical support was found for six of the nine hypotheses tested.

Research limitations/implications – One of the limitations of this study is that human capital metrics were based on CEO self-reported scores. Thus, the ability to generalize is limited to this context.

Practical implications – Of all the human capital metrics collected, the number of superstar developers seems to be the most critical variable in predicting export intensity. Superstar developers are those individuals whose productivity equals four times that of the other developers and twice that of the star developers.

Originality/value – This paper tests empirically the relationship between human capital and organization performance in the Egyptian software industry context and provides support for the recruitment and development of superstar developers.

Keywords Human capital, Intellectual capital, Business performance, Computer software, Egypt

Paper type Research paper

Introduction

The world is experiencing a revolution in information technology, innovation, and telecommunications, which is driving the emergence of the knowledge-based economy. This requires successful organizations of the twenty-first century to recognize the importance of intellectual capital as a source of sustainable competitive advantage. The field of intellectual capital has developed in two phases. The first phase started in the 1990s and focused on raising awareness, defining concepts, reviewing case studies and developing initial conceptualizations (Sveiby, 1997; Stewart, 1997; Brooking, 1997; Bontis, 1996, 1998, Ashour, 1997; Edvinsson and Malone, 1997; Ross *et al.*, 1997; Davenport and Prusak, 1998; Nahapiet and Ghoshal, 1998; Kennedy, 1998; Sullivan, 1999). The second phase, which started in the year 2000, addressed measurement, modeling, international cases and various levels of analysis (Ashour, 2000; Bontis,

Management Decision
Vol. 45 No. 4, 2007
pp. 789-801

0025-1747
DOI 10.1108/00251740710746033

2002, 2003, 2004; Harrison and Sullivan, 2000, Guthrie and Petty, 2000; Petty and Guthrie, 2000).

In many of the aforementioned studies, intellectual capital is measured using perceptual scales. Few scholars have examined empirically the relationship between intellectual capital and performance using quantitative metrics. Furthermore, much of the literature focuses on the developed world and concentrates on Anglophonic or Scandinavian organizations. This particular study addresses human capital, which is considered one of the most important constructs of intellectual capital. It also focuses on Egypt, which is a burgeoning economy.

Literature review

The development of the field of intellectual capital has primarily been guided by the practices of pioneering companies around the world such as Skandia, Dow Chemical, and Celemi. The existing literature argues that intellectual capital is composed of three sub-constructs:

(1) human capital;

(2) structural capital; and

(3) relational capital (e.g. Ashour, 2000; Bontis, 1998; Bontis *et al.*, 1999, 2000).

Human capital in particular represents the individual stock of knowledge embedded in the firm's collective capability to extract the best solutions from its individual employees (Bontis, 1999, 2001). It is defined as the sum of the workers' skills, experience, capabilities, and tacit knowledge (Edvinsson and Malone, 1997, pp. 34-5). Davenport and Prusak (1998, p. 49) add that "human capital includes the intangible resources of abilities, effort, and time that workers bring to invest in their work".

Human capital is considered one of the core components of intellectual capital and is a critical resource in many industries such as software development, management consulting, and financial services. For example, McKinsey & Company recognize that the most important corporate resource over the next 20 years will be human capital, defined as talented, smart and sophisticated business people who are technologically literate, globally astute, and operationally agile (Dess and Shaw, 2001).

The relationship between human capital and various outcome variables can be traced back to many streams of research, including economic human capital theory (e.g. Schultz, 1961; Ducharme, 1998), organizational learning (Bontis *et al.*, 2002), the resource-based view of the firm (Barney, 1991) and more recently the knowledge-based view of the firm (e.g. Spender, 1996; Grant, 1996).

Individuals, organizations, and nations increasingly recognize that high levels of skill and competence are essential to future security and success. It is common knowledge that as individuals acquire more education and training during a lifetime, human capital drives the production of goods and services, as well as new innovations in the marketplace. Currently, such linkage between these human capital elements and economic development is well established. While the economic value of human capital cannot be questioned, an important concern among scholars is what type and how much human capital is required to create a competitive advantage for firms (Starbuck, 1992; Hassen, 1995).

Research framework

The Egyptian software industry is facing burgeoning growth with export sales totalling US$50 million within a total market estimated at US$140 million (El-Rashidi, 2002). Furthermore, Egypt has thousands of qualified software professionals and has become a major supplier of software products and services to neighbouring countries in the Arab region (*Arab Human Development Report*, 2002).

There is a much debate around what are the essential elements that constitute the human capital of a firm. However, as it relates to the software industry in particular, Seleim *et al.* (2004) describe human capital as the aggregate competence and experience of system analysts, programmers, developers and other technical personnel who are the drivers of innovation and creativity in that particular sector.

It is generally recognized that a strong aptitude of professional knowledge can be achieved by absorbing a unique body of information through formal education and a set of certain minimum standards. This is usually achieved through certification programs in many fields including software development and design. Professional certificates administered by international software firms are considered to be proxies of human capital proficiency in this industry. In 2001, the Egyptian government started a program to professionally train individuals to enter the software industry by investing 55 million Egyptian pounds (US$10 million). Between 2001 and 2005, 30,000 individuals completed training programs lasting six months (i.e. 26 weeks at 35 hours per week). These professional programs were developed so that individuals could receive standard certification in a variety of software platforms such as Microsoft, Oracle, Compaq and Sun. The most common certification completed through this program was the MCSE (Microsoft Certified Systems Engineer).

Roberts (2002) reported that Oracle certifications offered the highest rate of return for smaller solution providers, while Compaq certifications offer the best ROI for larger solution providers. Given the importance of these certification programs in the industry, as well as the Egyptian government's large investment in building the human capital in this sector, we would hope to find strong evidence of positive outcomes in organizational performance. Therefore, given the discussion above, we can hypothesize that:

H1. The higher the number of certified developers in the firm, the higher the performance of the firm.

Adequate numbers of information technology professionals are a key consideration for management, and individuals with specialized skills are in short supply (Senn, 1996). Research in the software industry has shown that outstanding developers and designers have the ability to produce computing and programming structures that are small in size, simple in form, and yet extremely fast (Brooks, 1987). Other studies argue that the level of talent of developers is the key critical factor in explaining the success and uniqueness of software programs (Dooley, 2000). Dooley (2000) found a significant and positive correlation between the quality of developers and the market share of a software product. Henderson and Cockburn (1994) reported that the acquisition of skilled scientists leads to higher productivity in pharmacy companies. Hussi and Ahonen (2002) found that efficient knowledge workers were considered among the most innovative and valuable assets of Finland.

Thus, the uniqueness of a star employee's skills and capabilities is a critical requirement for gaining competitive advantage. Superstar developers were defined as

individuals whose performance was four times the performance of their colleagues. Star developers were defined as individuals whose performance was two times the performance of their colleagues. Based on the aforementioned discussion, we can hypothesize that:

H2a. The higher the number of superstar developers in the firm, the higher the performance of the firm.

H2b. The higher the number of star developers in the firm, the higher the performance of the firm.

Voluntary turnover results in departing employees migrating to competing firms. This creates a loss of intellectual capital due to tacit knowledge leaving the firm (Stovel and Bontis, 2002; Droege and Hoobler, 2003). Research studies indicate that productivity is weakened as turnover increases (Dess and Shaw, 2001) and that revenue and profits are inversely related to human capital depletion (Bontis and Fitz-enz, 2002).

Although the turnover rate for software developers in Egypt is only 10 percent (see www.fei.org.eg and Seleim *et al.*, 2005), CEOs warn that software firms in Egypt suffer from employer loyalty since their skills are easily transferable to other companies. Based on the aforementioned discussion, we can hypothesize that:

H3. The higher the number of departing software developers in the firm, the lower the performance of the firm.

In the face of competitive and technological challenges, many organizations believe work teams are an effective approach to accomplish organizational productivity goals (Ranney and Deck, 1995). Teams can be defined as an inter-dependent collection of individuals, each of whom shares responsibility for organizational outcomes (Hackman and Oldham, 1980; Sundstrom *et al.*, 1990). Work teams can be configured in many ways such as project teams, self-managing teams, and semi-autonomous work groups. Given the importance of collaboration in knowledge work (Tjosvold and Tjosvold, 1995), it seems likely that the ability to work in a team in knowledge firms is more important (Ancona, 1990; Campion *et al.*, 1996; Henderson and Lee, 1992).

Heeks (1999) indicates that software enterprises in particular require effective collaboration mechanisms such as internal networking for strong productivity. Teams must also find ways to collaborate both in physical and virtual meetings (Choo and Bontis, 2002). Working in teams is considered an important core competence in achieving productivity and shared learning. Based on the aforementioned discussion, we can hypothesize that:

H4. The higher the number of developers who are able to work in a team, the higher the performance of the firm.

Most enterprise-wide software solutions consist of several million lines of source code and a high number of interactions between various modules. Curtis *et al.* (1988) argued that exceptional system analysts on large software development projects were considered to be essential, but were a scarce resource. He argued that these individuals possessed superior application knowledge and communicated well with both clients and the development team. They could effectively translate user requirements into

technology, identify unstated requirements, and mentally simulate interactions between various parts of the system (Wynekoop and Walz, 2000).

Strong system analysts have also been found to generate and evaluate more alternative solutions to problems, drawing on an experiential base that spans their careers (Curtis *et al.*, 1988; Guindon *et al.*, 1987). Therefore, given the discussion above, we can hypothesize that:

H5. The higher the number of developers than can translate customer needs into programming, the higher the performance of the firm.

The training and education of employees is critical in growing the knowledge base of companies. Various scholars suggest that training contributes to building human capital and improving the performance of organizations (Hassen, 1995; Ashour, 1997; Bontis and Fitz-enz, 2002). Courses in network and system infrastructure, project management, network administration or engineering, application development, and server administration are among the most frequently offered to IT staff members.

Project management is essential to the success of every aspect of software projects. It helps in planning projects, estimating work and cost, building a schedule and spending plan, staffing, and risk estimation. Without project management, software development can be delayed, cost too much, and often never reach completion. Moreover, McCreery (2003) argues that project management training improves participant knowledge levels as well as the ability of participants to apply that knowledge. Therefore, given the discussion above, we can hypothesize that:

H6a. The higher the number of developers in the firm who receive project management training, the higher the performance of the firm.

H6b. The higher the number of training hours for developers in the firm, the higher the performance of the firm.

Individuals who have a longer tenure with a firm or in a particular industry tend to have an historical perspective that cannot be easily replicated. The value of experience in business is always appreciated, especially in recruitment and selection. Horowitz and Sherman (1980) found experience, schooling, and on-the-job training to be important influences on performance. Pena (2002) reviewed research studies and indicated that an entrepreneur's level of experience is positively associated with firm survival and growth. In the software sector in particular, developers with a strong base of experience are highly sought after and contribute significantly to the firm's overall successes.

H7. The higher the number of years of experience for developers in the firm, the higher the performance of the firm.

Methodology

The present study involved two groups of variables:

(1) the independent variables related to human capital; and

(2) the dependent variables related to the performance of the firm.

Due to the limitations of collecting sensitive financial data from the private sector in Egypt, firm performance in this study was defined as the ratio of export business to total production. There were other outcome measures that were considered, such as

lines of code and function points analysis, but the Egyptian government's initial investment in training was targeted at developing the capabilities of domestic firms to compete in an international marketplace. For this reason, an export density measure of firm performance made most sense.

The population for this study was all software firms registered as members of the Software Industry Chamber in Egypt. The Software Industry Chamber is a sub-group of the Federation of Egyptian Industries (www.fei.org.eg) and includes 107 firms in total. After closer examination of the annual reports of these firms, 17 were removed from the list because their focus was more on marketing and feasibility studies as opposed to actual software development. In total, completed responses were collected from 38 firms for a response rate of 42 percent (see Table I for descriptive statistics).

The survey instrument was first tested on six professionals in the software sector as well as a faculty member from Alexandria University who has substantial experience in the field of software development. After minor edits were made, a letter was sent by fax, e-mail, and regular mail to the head of each company in the sampling frame accompanied by a recommendation letter from the head of the Management Department at Alexandria University to encourage each company to participate in the study. Some of them requested a copy of the questionnaire before deciding to participate. Other firms refused to participate in the study because of the confidentiality of the required data. The companies that agreed to participate in the study made an appointment for the researcher to visit the company. The original intent was to calculate the selected items from data and information that could be obtained from public annual reports, balance sheets and other sources. Unfortunately, due to the

Table I.
Sample descriptive statistics

	Number of firms	Percentage
Firm size (number of employees)		
<10	5	13
10-50	16	42
51-100	12	32
101-200	3	8
201-300	1	3
>300	1	3
Firm age (number of years)		
<3	1	3
3-5	17	45
6-10	12	32
>10	8	21
Type of firm		
Individual ownership	14	37
Corporation	20	53
Branch for international firm	3	8
Type of ownership		
Egyptian capital	26	68
Foreign capital	4	11
Joint capital	8	21

confidentiality of some of the required items, some measures were collected through the self-reported questionnaire completed by the CEO. The questionnaire asked the CEO or one of their knowledgeable representatives in the participating firms to provide his or her estimation about the elements of intellectual capital included in the study. The questionnaire and interviews were conducted in Arabic. The whole interview process took between two and four hours to complete.

Results

Table II depicts the results of the data collected. Pearson correlations were used to test each of the seven research hypotheses. Stepwise regression was used to analyze the proposition of human capital and its positive association on organizational performance. Table III outlines the hypotheses testing results and Table IV describes the stepwise regression results.

	Mean	SD	Minimum	Maximum
Human capital				
Certified developers	5.89	5.88	0	25
Superstar developers	7.60	7.10	1	30
Star developers	8.94	10.26	0	40
Leaving developers	2.65	2.35	0	10
Developers who have the ability to work in a team	17.63	16.98	2	70
Developers translate customer needs into programming	6.39	5.84	1	30
Developers attended project management training program	5.21	9.39	0	55
Training hours for developers	111.86	55.82	30	240
Years of experience	6.39	3.66	2	20
Organizational performance				
Export intensity	0.45	0.36	1	0

Table II.
Description of intellectual capital indicators

	Human capital indicators	Correlation with export intensity
H1	Certified developers	0.280 (0.890)
H2a	Superstar developers	0.662^{**} (0.000)
H2b	Star developers	0.489^{**} (0.002)
H3	Leaving developers	0.357^{*} (0.028)
H4	Developers who have the ability to work in a team	0.540^{***} (0.000)
H5	Developers able to translate customer needs into programming	0.479^{*} (0.002)
H6a	Developers attended project management training program	0.396^{*} (0.014)
H6b	Training hours for developers	−0.056 (0.737)
H7	Years of experience	−0.030 (0.858)

Note: Significance levels $^{*}p < 0.05$; $^{**}p < 0.01$, $^{***}p < 0.001$

Table III.
Hypothesis testing and correlations

Based on the findings presented in Table III, the statistical tests revealed a positive but non-significant correlation between certified developers and firm performance ($r = 0.280$, $p = 0.89$). *H1* was therefore rejected. Although the government invested heavily in certification training and many employers look for it when recruiting, the results of this study do not support a statistically significant relationship with export density. It seems that as an outcome of this research, the Egyptian government will need to wait a little longer to realize an economic benefit from its initial investment.

Regarding *H2a* and *H2b*, the results show a significant and positive correlation between the number of superstar developers and firm performance ($r = 0.662$ and $p = 0.05$) and the number of star developers and firm performance ($r = 0.489$ and $p = 0.002$). These results show that higher quality software developers make a big difference. These star performers were more productive than their counterparts and that increased productivity translated directly to export density. This corresponds with Dooley (2000) who found a significant positive correlation between the quality of developers and market share.

The results of testing *H3* indicate a significant and positive correlation between the number of departing developers and firm performance ($r = 0.357$ and $p = 0.028$). This result is in the opposite direction of what was original hypothesized. In this case, as turnover increases, so does export density. Although this result was not expected, there may be an intuitive explanation. Employee turnover sometimes achieves positive outcomes by reducing stagnation, improving innovation (Abelson and Baysinger, 1984), and separating self-selected poor performers (Dalton and Todor, 1979). In the software industry, turnover seems to drive innovation because there are advantages in hiring new developers who bring fresh new perspectives with them. Unfortunately, turnover still yields negative outcomes such as loss of organizational memory. Ultimately, there seems to be a fine balance that needs to be achieved.

The results of testing *H4* indicate a significant and positive correlation between developers who are able to be part of a team and firm performance ($r = 0.540$ and $p = 0.000$). Significant benefits can be gained from adopting a teamwork approach to software development. It is an effective mechanism for collective learning, which can lead to overall increases in intellectual capital. This result corroborates with prior research (e.g. Clifford and Sohal, 1998) which showed teamwork leading to reduced operational expenses, reduced administration costs, and improved communication of firm objectives and results. Clifford and Sohal (1998) have also shown how teamwork leads to improved productivity, increased customer satisfaction and increased profitability.

The results of testing *H5* indicate a significant and positive correlation between developers who are able to translate customer needs into programming structure and

	Beta	Standard error	*t*-stat	Significance
Constant	0.200	0.067	3.000	0.005
Superstar developer	0.662	0.006	5.301	0.000

Table IV.
Stepwise regression

Notes: Dependent variable: export intensity; independent indicator: superstar developer; $R^2 = 43.8$ percent; standard error = 0.2786

firm performance ($r = 0.479$, $p = 0.002$). This means that the ability to understand customer needs is an important human capital element. It enables software firms to create and enhance systems that can be used and appreciated because customers will actually benefit from their use.

The results of testing *H6a* indicate a significant and positive correlation between the number of developers who received training in project management and firm performance ($r = 0.396$, $p = 0.014$). Results from testing *H6b* indicate a negative but non-significant correlation between the numbers of training hours and firm performance ($r = -0.056$, $p = 0.737$). Therefore, *H6a* is accepted and *H6b* is rejected. These results show that project management training is more important for software developers than total training. Project management helps to deliver software solutions on time and under budget. Techniques such as PERT and GANT charts provide guidance to developers so they can plan, monitor, control, report, and deliver to client needs.

The results of testing *H7* indicate a negative but non-significant correlation between the average numbers of years of experience and firm performance ($r = -0.030$, $p = 0.858$). This result does not support previous studies that confirm the importance of experience (Madsen *et al.*, 2002). For example, Wynekoop and Walz (2000) found that years of experience as a proxy for high-level technical and business knowledge was the most important predictor of success in software firms. The explanation here might be that the software industry itself in Egypt is relatively young and that there is very little variance among the firms.

Results of a stepwise regression indicate that the superstar developer indicator contributed 43.8 percent of the variance in the export intensity dimension. Superstar developers typically have distinct capabilities such as a high level of intelligence, creativity, and ambition. Recall that superstar developers are those individuals whose productivity equals four times that of the other developers and two times that of the star developers. These findings corroborate the results of Miller and Shamsie (1996) who studied the role of "superstars" as a predictive indicator of success in Hollywood studios.

The aforementioned results generally confirm what previous studies have found when examining the positive relationship between human capital and firm performance. However, there are some unique insights. The most important determinant for firm performance in the software industry is the presence of super star developers. This poses some big challenges for software firms when recruiting. What is the best resource to attract super star developers? How does a firm retain and train these software developers?

In light of the results of this study, software firms have to devote dedicated effort and time to the recruitment process to be able to secure super star developers. It is no surprise that Microsoft interviews hundreds of highly qualified people from the top universities in the world for each software designer it hires. Their gruelling selection process tests not only for cognitive knowledge, but also for the capability to think about problems in new and innovative ways under high pressure (Quinn *et al.*, 1996).

Conclusions

This research has contributed to the field of intellectual capital by focusing on a knowledge-intensive sector (software development) in a unique international setting

(Egypt). Quantitative data was collected to empirically test a variety of hypotheses. The results provided evidence that certain types of human capital indicators showed a positive and statistically significant relationship with firm performance.

Furthermore, findings suggest that organizational performance in terms of export intensity in software firms is most influenced by superstar developers who have some distinct capabilities such as a high level of intelligence, creative ideas, initiation, ambition, and inimitability. Superstar developers in software firms are able to introduce unique and smart software products and services that achieve attraction, satisfaction, and retention of customers locally and internationally. They also possess the skills, knowledge, and talent to meet the international standard for efficiency and design. Moreover, superstar software developers help in the creation of various other new products that may not have been planned by the firm initially. These findings recognize that not all employees possess knowledge and skills that are of equal strategic importance (Lepak and Snell, 1999). Therefore, software firms should strive to select the best and brightest software developers available.

The main limitation of this study is that due to the confidentiality of some of the required items, the data provided were calculated based on CEOs who self-reported on their own firms. Therefore, measures were not based on raw data. A further limitation is that the study focused on only one country, and one sector and one point in time. Thus, the ability to generalize is limited to that context.

However, we are excited about several opportunities for future research. We recommend that this study be replicated in different Egyptian industries such as communications and education as well as capital-intensive industries that have a long history in Egypt, such as furniture, carpet, and textile manufacturing. Such attempts would allow for more widespread generalizations to be made. This study may also be extended to different software development markets that are burgeoning but considered not fully developed such as India, Ireland, Brazil and Greece.

Finally, it would be interesting to see whether the compensation structure of software developers plays a role in their productivity and therefore overall firm performance. In other words, do software developers who get paid flat salaries, or by stock options, or by lines of code perform better?

References

Abelson, M.A. and Baysinger, B.D. (1984), "Optimal and dysfunctional turnover: toward an organizational level model", *Academy of Management Review*, Vol. 9, pp. 331-41.

Ancona, D.G. (1990), "Outward bound: strategies for team survival in an organization", *Academy of Management Journal*, Vol. 33, pp. 334-65.

Arab Human Development Report (2002), United Nations Development Program, Regional Bureau for Arab States, Amman (Arabic version).

Ashour, A.S. (1997), "Building intellectual and emotional capital of organizations: reinventing human resources development in organizations", Keynote Speech to Conference on Training in the Middle East: Achievement and Challenges, El Bahrain, December.

Ashour, A.S. (2000), "Knowledge capital management. Reinventing management paradigm in the 21st century", *Proceedings of the 12th International Conference on Training and Management Development towards Arab Learning Organizations, Cairo, April 25-27.*

Barney, J.B. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17, pp. 99-120.

Bontis, N. (1996), "There's a price on your head: managing intellectual capital strategically", *Ivey Business Journal – Business Quarterly*, Summer, pp. 40-7.

Bontis, N. (1998), "Intellectual capital: an exploratory study that develops measures and models", *Management Decision*, Vol. 36, pp. 63-76.

Bontis, N. (1999), "Managing organizational knowledge by diagnosing intellectual capital: framing and advancing the state of the field", *International Journal of Technology Management*, Vol. 18 Nos 5-8, pp. 433-62.

Bontis, N. (2001), "Assessing knowledge assets: a review of the models used to measure intellectual capital", *International Journal of Management Reviews*, Vol. 3 No. 1, pp. 41-60.

Bontis, N. (2002), *World Congress of Intellectual Capital Readings*, Elsevier Butterworth-Heinemann KMCI Press, Boston, MA.

Bontis, N. (2003), "Intellectual capital disclosure in Canadian corporations", *Journal of Human Resource Costing and Accounting*, Vol. 7 Nos 1/2, pp. 9-20.

Bontis, N. (2004), "National Intellectual Capital Index: a United Nations initiative for the Arab region", *Journal of Intellectual Capital*, Vol. 5 No. 1, pp. 13-39.

Bontis, N. and Fitz-enz, J. (2002), "Intellectual capital ROI: a current map of human capital antecedents and consequents", *Journal of Intellectual Capital*, Vol. 3 No. 3, pp. 223-47.

Bontis, N., Crossan, M. and Hulland, J. (2002), "Managing an organizational learning system by aligning stocks and flows", *Journal of Management Studies*, Vol. 39 No. 4, pp. 437-69.

Bontis, N., Keow, W.C.C. and Richardson, S. (2000), "Intellectual capital and business performance in Malaysian industries", *Journal of Intellectual Capital*, Vol. 1 No. 1, pp. 85-100.

Bontis, N., Dragonetti, N., Jacobsen, K. and Roos, G. (1999), "The knowledge toolbox: a review of the tools available to measure and manage intangible resources", *European Management Journal*, Vol. 17 No. 4, pp. 391-402.

Brooking, A. (1997), "Management of intellectual capital", *Long Range Planning*, Vol. 30, pp. 364-5.

Brooks, F.P. (1987), "No silver bullet: essence and accidents of software engineering", *Computer*, Vol. 20, pp. 10-19.

Campion, M.A., Papper, E.M. and Medsker, G.J. (1996), "Relations between work team characteristics and effectiveness: a replication and extension", *Personnel Psychology*, Vol. 49, pp. 429-52.

Choo, C.W. and Bontis, N. (2002), *The Strategic Management of Intellectual Capital and Organizational Knowledge*, Oxford University Press, New York, NY.

Clifford, G.P. and Sohal, A.S. (1998), "Developing self-directed work teams", *Management Decision*, Vol. 36, pp. 77-84.

Curtis, B., Kranser, H. and Iscoe, N. (1988), "A field study of the software design process for large systems", *Communications of the ACM*, Vol. 31, pp. 1268-87.

Dalton, D.R. and Todor, W.D. (1979), "Turnover turned over: an expanded and positive perspective", *Academy Management Review*, Vol. 4 No. 2, pp. 225-35.

Davenport, T.H. and Prusak, L. (1998), *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, MA.

Dess, G. and Shaw, J.D. (2001), "Voluntary turnover, social capital, and organizational performance", *The Academy of Management Review*, Vol. 26, pp. 446-57.

Dooley, E. (2000), "Intellectual capital in the software industry: an empirical test", PhD dissertation, College of Business Administration, University of Washington, Tacoma, WA.

Droege, S. and Hoobler, J.M. (2003), "Employee turnover and tacit knowledge diffusion: a network perspective", *Journal of Managerial Issues*, Vol. 15, pp. 50-64.

Ducharme, L. (1998), *Measuring Intangible Investment: Main Theories and Concepts*, OECD, Paris.

Edvinsson, L. and Malone, M.S. (1997), *Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower*, HarperBusiness, New York, NY.

El-Rashidi, Y. (2002), "Silicon Valley, silicon pyramids", *Al-Ahram Weekly*, 31 January-6 February.

Grant, R.M. (1996), "Toward a knowledge-based theory of the firm", *Strategic Management Journal*, Vol. 17, pp. 109-22.

Guindon, R., Krasner, H. and Curtis, B. (1987), "Breakdowns and processes during the early activities of software design by professionals", in Sheppard, S. and Soloway, E. (Eds), *Empirical Studies of Programmers Second Workshop*, Ablex, Norwood, NJ, pp. 65-82.

Guthrie, J. and Petty, R. (2000), "Intellectual capital: Australian annual reporting practices", *Journal of Intellectual Capital*, Vol. 1, pp. 241-51.

Hackman, J.R. and Oldham, G.R. (1980), *Work Redesign*, Addison-Wesley, Reading, MA.

Harrison, S. and Sullivan, P.H. (2000), "Profiting from intellectual capital: learning from leading companies", *Journal of Intellectual Capital*, Vol. 1, pp. 33-46.

Hassen, R. (1995), "Factors correlated with trainees' turnover and human capital investment: suggested model and applied study", PhD dissertation, Faculty of Commerce, Alexandria University, Alexandria (in Arabic).

Heeks, R.B. (1999), "Software strategies in developing countries", *Communications of the ACM*, Vol. 42 No. 6, pp. 15-20.

Henderson, J.C. and Lee, S. (1992), "Managing I/S design teams: a control theories perspective", *Management Science*, Vol. 6, pp. 757-77.

Henderson, R. and Cockburn, I. (1994), "Measuring competence? Exploring firm effects in pharmaceutical research", *Strategic Management Journal*, Vol. 15, pp. 63-84.

Horowitz, S.A. and Sherman, A. (1980), "A direct measure of the relationship between human capital and productivity", *Journal of Human Resources*, Vol. 15, pp. 67-76.

Hussi, J. and Ahonen, G. (2002), "Managing intangible assets – a question of integration and delicate balance", *Journal of Intellectual Capital*, Vol. 3, pp. 277-86.

Kennedy, F. (1998), "Intellectual capital in valuing intangible assets", *Team Performance Management*, Vol. 4, pp. 121-37.

Lepak, D.P. and Snell, S. (1999), "The human resource architecture: toward a theory of human capital allocation and development", *Academy of Management Review*, Vol. 24, pp. 31-48.

McCreery, J. (2003), "Assessing the value of a project management simulation training exercise", *International Journal of Project Management*, Vol. 21, pp. 233-42.

Madsen, T.L., Mosakowski, E. and Zaheer, S. (2002), "The dynamics of knowledge flows: human capital mobility, knowledge retention and change", *Journal of Knowledge Management*, Vol. 6, pp. 164-88.

Miller, D. and Shamsie, J. (1996), "The resources-based view of the firm in two environments: the Hollywood film studios from 1936-1965", *Academy of Management Journal*, Vol. 39, pp. 519-43.

Nahapiet, J. and Ghoshal, S. (1998), "Social capital, intellectual capital, and the organizational advantage", *Academy of Management Review*, Vol. 23, pp. 242-66.

Pena, I. (2002), "Intellectual capital and business start-up success", *Journal of Intellectual Capital*, Vol. 2, pp. 180-98.

Petty, R. and Guthrie, J. (2000), "Intellectual capital literature review: measurement, reporting and management", *Journal of Intellectual Capital*, Vol. 1, pp. 155-76.

Quinn, J.B., Anderson, P. and Finkelstein, S. (1996), "Managing professional intellect: making the most of the best", *Harvard Business Review*, Vol. 74, pp. 71-80.

Ranney, J. and Deck, M. (1995), "Making teams work: lessons from the leaders in new product development", *Planning Review*, Vol. 23, pp. 6-13.

Roberts, J. (2002), "Certifications that pay", *Computerworld*, No. 1008, August, pp. 62-4.

Ross, J., Roos, G., Dragonetti, N.C. and Edvinsson, L. (1997), *Intellectual Capital: Navigating the New Business Landscape*, Macmillan, New York, NY.

Schultz, T.W. (1961), "Investment in human capital", *American Economic Review*, Vol. 51, pp. 1-17.

Seleim, A., Ashour, A. and Bontis, N. (2004), "Intellectual capital in Egyptian software firms", *The Learning Organization*, Vol. 11 Nos 4/5, pp. 332-46.

Seleim, A., Ashour, A. and Khalil, O. (2005), "Knowledge acquisition and transfer in Egyptian software firms", *International Journal of Knowledge Management*, Vol. 1 No. 4, pp. 43-72.

Senn, J.A. (1996), "Creating and sustaining a business edge using information technology", *Data Base*, Vol. 27, pp. 32-5.

Spender, J.C. (1996), "Making knowledge the basis of dynamic theory of the firm", *Strategic Management Journal*, Vol. 17, pp. 45-62.

Starbuck, W.H. (1992), "Learning by knowledge-intensive firms", *Journal of Management Studies*, Vol. 29, pp. 713-40.

Stewart, T.A. (1997), *Intellectual Capital: The New Wealth of Organizations*, Doubleday Currency, New York, NY.

Stovel, M. and Bontis, N. (2002), "Voluntary turnover: knowledge management friend or foe?", *Journal of Intellectual Capital*, Vol. 3 No. 3, pp. 303-22.

Sullivan, P.H. (1999), "Profiting from intellectual capital", *Journal of Knowledge Management*, Vol. 3, pp. 132-42.

Sundstrom, E., DeMeuse, K.P. and Futrell, D. (1990), "Work teams: applications and effectiveness", *American Psychologist*, Vol. 45, pp. 120-33.

Sveiby, K.E. (1997), "The intangible asset monitor", *Journal of Human Resource Costing and Accounting*, Vol. 2, pp. 73-97.

Tjosvold, D. and Tjosvold, M.M. (1995), "Cross-functional teamwork: the challenge of involving professionals", in Beyerlein, M.M., Johnson, D.A. and Beyerlein, S.T. (Eds), *Advances in Interdisciplinary Studies of Work Teams*, JAI Press, Greenwich, CT.

Wynekoop, J. and Walz, D. (2000), "Investigating traits of top performing software developers", *Information Technology & People*, Vol. 13, pp. 186-95.

Corresponding author
Nick Bontis can be contacted at: nbontis@mcmaster.ca