The Digital Economy and the "Rise of Knowledge Workers"

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Abstract — *With the advent of high speed computing, the internet, the integrated networks and the wide bandwidth through optical networking, new opportunities are being created in the "Digital Economy". These opportunities are opening the next frontiers of job markets and giving rise to a creative workforce called the "Knowledge Workers". But just as the bedrock notions of technology have changed in recent years, so have the tricks and skills of the technical workforce who are urgently needed to sustain the market needs and serve the changing face of the digital economy.*

In this paper, the emergence of an information based global society will be acutely examined and the characteristics of the knowledge workers will be presented. The paper will focus upon:

- *Information Technology (IT) and its impact upon the 21st century work environment.*
- *Next frontiers of job market and career trends in a changing digital economy.*
- *Areas of engineering education, technical training and "skill sets" to meet the shifting demands of the high technology workplace.*

The paper will conclude with the development of a model engineering education curriculum designed to address the "skill gap" of the current workforce.

Index Terms *– Information Technology, Digital Divide, Productivity, Computers, Globalization*

THE NEW ECONOMY

The millennia of efforts to overcome the accelerated rate of production and consumption eventually lead to agriculture, mass manufacturing, power and energy space and automation era. The resulting specialization of work, economies of scale and novel technologies define our modern world. Relying on the advances of our skills, power of human ingenuity, discovery, invention and innovation, we have pushed the frontiers of knowledge in defining a new economy … the digital economy.

The Industrial Age has come to an end, and the Era of Knowledge is being heralded in [see attachment 1].
The move from the industrial to the information era … began in the years following World War II and has continued to grow ever since; especially in the 1980s and 1990s. Throughout this period, industries which moved towards the center of the economy are producing and distributing knowledge and information rather than goods. In addition, the tradition industries which succeeded in developing are those which were able to reorganize and restructure themselves around knowledge and information [1].

Instead of the world's economy being driven by machinery, it is now an economy driven by people and their accumulated knowledge; thus, this new economy has been dubbed the Knowledge Economy. In the knowledge Economy, people's "knowledge of the basic form of capital [and] economic growth is driven by the accumulation of knowledge" [2].

In the past, automated machinery replaced people on production lines and computers made other workers' jobs obsolete. Today, machinery and computers are still important components, but without workers who know how to program, repair, and operate them, these devices are worthless. The ability to work on and with these machines is a vital component in the Knowledge Economy along with a general knowledge and understanding of fundamental skills such as reading, writing, mathematics, and the basic sciences. As the world progresses in this Era of Knowledge, the spotlight will be on peoples' knowledge with a special focus on the educational system and learning, innovation, communication, competition, entrepreneurship, business structures, and the government's involvement.

INFORMATION TECHNOLOGY (IT) AND ITS IMPACT ON THE 21ST CENTURY WORK ENVIRONMENT

Since the invention of the first computer "ENIAC" in 1945, the silicon chips provided a rapid processing power through over a million transistors on a chip. It is expected that a common personal computer (PC) by 2005 will run on 1,000 Mhz, contain one gigabyte (one thousand million bytes) of RAM and have large enough storage capacity to hold one person's entire life information including voice conversations [3]. A range of emerging "computer imaging technologies" is also changing the way we learn, work and play. Virtual Reality and Artificial Intelligence are providing knowledge-based applications, which also have enhanced productivity in business, science, engineering and medicine. Recognizing the impact of information on our technological society, Peter F. Drucker stated: "Increasingly, the true investment in the knowledge society is not machines and tools … it is the knowledge worker! Without it, the machines, no matter how advanced and sophisticated, are unproductive"[4]. The 21st Century knowledge based society has given rise to knowledge workers with the following characteristics:

- By 2010, knowledge workers will amount to 70% of the workforce in the USA and 50% worldwide.
- New jobs will require life-long learning with scientific, practical and analytical knowledge and high-technology skills.
- The central workforce in the knowledge society will consist of highly specialized people.
- Productivity of the work environment will become the economic challenge of the knowledge society.
- The knowledge society will be a society of organizations, whose central and distinctive task is to establish information architecture and knowledge management.

FRONTIERS OF JOB MARKET AND CAREER TRENDS IN A CHANGING DIGITAL ECONOMY

As scientific progress and technology innovation continues to march one, the emerging knowledge economy will create a new frontier of opportunities impacting new job market and career trends [5]. Newsweek Magazine [6] and World Future Society Millennium forecast the following emerging economy:

- Information technology will define a new global culture.
- NanoTechnology – The micro manipulation of materials at the molecular level will radically transform the physical sciences.
- Electronic immigrants will make up the emerging workforce of the digital economy.
- Virtual Reality will simulate the future environment for work, leisure, education and research.
- Information Management Systems and the Computer Aided infrastructure will define the evolution of intelligence.
- Computer Aided customization will aid from design to prototype to production (i.e.: factory of the future).
- Bio-technology and genetic engineering will extend the human life span.
- Distance Education and inter-active multi-media will create a new freedom of life long learning.
- The new atomic age through thermo-nuclear fusion will provide unlimited energy needs.
- The new space age will provide alternative resources for sustaining human life on earth.

AREAS OF ENGINEERING EDUCATION, TECHNICAL TRAINING AND SKILL SETS TO MEET THE SHIFTING DEMANDS OF THE DIGITAL ECONOMY

Students graduating from colleges and universities do not possess the necessary skills to succeed in the business and industrial world. It has been stated by many in industry that there "is a persistent shortage of people who combine strong technical abilities with essential skills (e.g.: communications and teamwork) and management skills (e.g.: cost control and budgeting), and executives reported that finding technically competent people who can work in teams, communicate effectively and apply their technical knowledge to real world business problems, is a significant challenge"[7].

Staying current with the emerging technologies is difficult because technology is changing and advancing at an incredible rate. As the level of technology increases, new skill sets and knowledge will be required for its utilization. Because of this, the Knowledge Economy recognizes that lifetime learning is a necessity. In this context, lifetime learning refers to educating individuals, either formally or informally, about new technologies such as new computer programming languages as well as the emerging sciences such as biotechnology and nanotechnology. First, many people are already informally educated lifetime learners studying subjects of interest to them. These individuals are learning primarily for their personal enjoyment and satisfaction. One company researching e-learning found that "while many of these people [engaged in lifetime learning] are currently participating in informal learning experiences on the Internet, we believe that some lifelong learners are turning to more formal learning experiences in the form of courses as these types of resources become more abundant and sophisticated. Whether people want to learn how to cook, get a refresher on Shakespearean literature, or read a

primer on wildlife in a particular region, the Internet is likely to have a multitude of offerings. We believe that as broadband Internet connections become more prevalent in households, enabling more interactive learning experiences, this type of recreational learning will become more commonplace" [8].

Second, for the new technologies, many colleges and universities are beginning to offer an accelerated program for the current workforce. These programs allow adults with full-time jobs and families an opportunity to earn an undergraduate degree in a shorter period of time than it would take in a standard program. In addition, several schools now offer courses on the internet, so individuals can study and learn when they have available time. Third, with regards to the emerging technologies, new discoveries are being made almost daily. Understanding and studying these fields requires one to first possess a strong knowledge of advanced mathematics and the sciences such as physics and chemistry. This means, therefore, that an individual must have previously earned an undergraduate or post-graduate degree to comprehend the information presented. Finally, for those individuals currently employed, their employers may provide technical training or require that they obtain it on their own. This training is necessary because "new technologies are progressing and circulating so fast that it is necessary for workers to constantly update their skills"[1]. If a worker is to remain employable in the new economy, he must adapt to the new technologies and have the necessary skills and knowledge to work with them. In the Knowledge Economy, it is vital to remain informed about new technologies, and lifetime learning is the best way to achieve this whether it involves reading technology magazines or taking courses at a college or university.

To survive in the Knowledge Economy, business and industry will need to focus on new and innovative products. As a result, many companies are heavily investing in research and development (R & D) and are beginning joint ventures with colleges and universities. First, new companies can be created based on knowledge and products developed at secondary education R & D facilities.

In the United States and the United Kingdom, as in a very small number of Canadian locations, there is a history of success arising from investing in enterprise incubators and their associated supports, housed on university and college campuses. The start-up companies are physically located on campus, where they have access to scientific and technical assistance and can benefit from a variety of business services [7].

Second, excellent results can also be obtained by collaborating with higher education R & D facilities. This would require companies to sub-contract their R & D work to these institutes thus saving them from having to create and staff their own R & D facilities. The companies would have access to some of the most knowledgeable minds in the research community and a staff that is already trained in laboratory procedures. This collaboration also has the potential to allow students working at the R & D facility to transfer to the company once they have obtained their degrees since they have a thorough knowledge of the products. Another benefit of this collaboration is that companies can "learn from the experience of universities with strong track records of commercial exploitation"[9] to help them develop their own products. Innovative products will be vital to a company's survival in the Knowledge Economy.

Competition will help stimulate the economy in this new Era of Knowledge. "It is not enough just to strengthen competition in the domestic market. We also need to ensure competition is effective in international markets"[6] because the world is now a global marketplace. First, e-commerce is the shopping method of the future. Since many consumers and businesses now have access to the Internet, they can research, compare prices, and shop for foreign and domestic products in the comfort of their homes. This has resulted in an increase in competition between companies producing similar products. Second, in order to compete effectively, companies must first look to their workforce. Those companies that have highly skilled and knowledgeable employees will fare better than companies that do not. A proficient workforce has the potential to be more innovative, and in the Knowledge Economy, innovation places a company in a good position to be competitive. Third, businesses must keep track of their competitors so that they are able to adapt quickly to any changes in the market. This has always been important, but thanks to technology, it is easier to accomplish.

SKILL SETS FOR THE KNOWLEDGE ECONOMY

The digital economy and the knowledge-based society are experiencing a significant skill gap. Our educational institutions are preparing too few students to meet world-class standards in core academic subjects and too many students are leaving colleges and universities unprepared for productive work in a changing technological society. The skill sets reflecting the core requirements are:

- Applied Mathematics: Skill in applying mathematical reasoning to a variety of work-related problems.
- Reading for Information: Skill in reading and understanding written work-related instructions and policies.
- Applied Technology: Skills in solving problems of a technological nature, such as applying principles of mechanics, electricity and electronics, thermodynamics, computer technology, or fluid dynamics, networking and integration to machines and systems.
- Locating Information: Skill in interpreting and using workplace graphics, such as diagrams, floor plans, tables, forms, graphs, charts, and instrument gauges.

- Basic Skills: Read, write, calculate and operate basic computer applications.
- Communication Skills: Use verbal, written, and presentation skills for the purposes of negotiation, persuasion, facilitation, coaching, mentoring.
- Analytical Skills: Think, analyze and solve problems, assess situations, evaluate and implement suggestions.
- Human and Behavioral Skills: Cooperates with others, and works in teams.
- Information – Literacy Skills: Locate, gather, analyze and organize information.
- Learning Skills: Adapt to a range of situations, take risks, formulate and champion a vision, learn independently, exercise responsibility, innovate (generate and use knowledge)

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ATTACHMENT 1

Keys to the Old and New Economics[8]		
ISSUE	OLD ECONOMY	NEW ECONOMY
Economy – Wide Characteristics:		
Markets	Stable	Dynamics
Scope of Competition	National	Global
Organizational Form	Hierarchical, Bureaucratic	Networked
Industry:		
Organization of Production	Mass Production	Flexible Production
Key Drivers of Growth	Capital/Labor	Innovation/Knowledge
Key Technology Driver	Mechanization	Digitization
Source of Competitive Advantage	Lowering Cost Through Economics of Scale	Innovation, Quality, Time-To-Market, and Cost
Importance of Research/Innovation	Low-Moderate	High
Relations With Other Firms	Go It Alone	Alliances and Collaboration
Workforce:		
Policy Goal	Full Employment	Higher Real Wages and Incomes
Skills	Job-Specific Skill	Broad Skills and Cross-Training
Requisite Education	A Skill or Degree	Lifelong Learning
Labor-Management Relations	Adversarial	Collaborative
Nature of Employment	Stable	Marked by Risk and Opportunity
Government:		
Business-Government Relations	Impose Requirements	Encourage Growth Opportunities
Regulation	Command and Control	Market Tools, Flexibility

8. A similar set of Old and New Economy characteristics has also been developed by John Doer, of Kleiner, Perkins, Caulfield & Byers (Menlo Park, California).

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