Engineers as agents of social change ?

Trends in the 21st century point to an ever-increasing rate and volume of change, with technology penetrating every aspect of life. Engineers are rarely thought of as agents of social change but they are key in developing the technologies that can change how business is conducted, the nature of social institutions and human behaviour. The proliferation of high speed internet access has revolutionized business and personal communications, changing the norms for social interaction in society. Businesses can find it costly to maintain multiple interfaces to accomodate users at different levels of technological acceptance. Witness the continuation of telephone banking alongside the more advanced computer banking. Newer technologies come along that can benefit more individuals, but older technologies do not always disappear.

"Managing the problems associated with technology adoption is critical to the economic and social well being of any society" (The Social and Economic Costs of Technology Resistance)

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Education / *Éducation*

The Social and Economic Costs of Technology Resistance

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The increasing penetration of technology into all aspects of our lives means that the ability to adopt new technologies will be critical to the success of businesses and individuals in the 21st century. High levels of technology resistance in the society as a whole suggest that substantial numbers of people will have difficulty keeping up with the volume and rate of change. Failure to resolve these competing forces threatens to disenfranchise large numbers of people both economically and socially, and substantially increase the costs for the businesses, governments and institutions that need to introduce new technologies to stay competitive, but at the same time need to provide access to people who cannot use the new interfaces. Meeting the challenge of how to migrate individuals and groups from technology resistance to technology acceptance and, then, from one generation of technology to another will require a substantial investment in research on how to effectively introduce new technologies.

La pénétration croissante de la technologie dans tous les aspects de nos vies signifie que la capacité d'adopter de nouvelles technologies sera critique au succès des entreprises et des individus au 21ème siècle. Les niveaux élevés de la résistance de technologie dans la société dans l' ensemble suggèrent qu'un nombre important de personnes auront de la difficulté a suivre le volume et la cadence du changement. Un échec de la résolution de ces forces concurrencielles menace de disenfranchiser un grand nombre de personnes économiquement et socialement, et d'augmenter substantiellement le coût pour les entreprises, les gouvernements et les institutions qui ont besoin d'introduire ces nouvelles technologies pour rester concurrentiel, et en même temps ont besoin de fournir l'accès aux personnes qui ne peuvent pas utiliser les nouvelles interfaces. Le défi de comment aider les individus et les groupes qui sont résistant a la technologie a faire la transition a l'acceptation de la technologie et puis d'une génération de technologie a une autre exigera un investissement monétaire important pour étudier le meilleur moyen d'introduire les nouvelles technologies.

1. Introduction

One rarely discussed aspect of technology is the role engineers play as agents of economic and social change. In most cases, this is an indirect role as designers and developers of new technologies that will change our behaviour, the way we conduct business and the nature of our social institutions. However, as McLeod et al. state in their article on integrated media systems "current and future scientists and engineers need the ability to understand and synthesise solutions to problems for which they were never trained" [1].

Technology drives economic and social change. However, the success of a technology is determined by the ability of businesses, governments and individuals to adopt that technology. The rate of technology adoption is important. The impact of new technologies in areas including work, transportation, communication, health, education, merchandising and recreation is extensive and growing as technology becomes the dominant element in our on economic and social lives.

This article explores two themes: the factors influencing the rate and degree of technology adoption and the social and economic costs associated with introducing new technologies. In exploring these two themes, we will address two important questions: How is society affected by new technologies? How can we mitigate the impact of new technologies on society?

The literature on 21st century technology trends and issues [2,3] forecasts major changes in technology interfaces that will transform the way we act and interact. In particular, the widespread diffusion of multi-modal interfaces incorporating visualization (including animation, 2D and 3D representation), hearing, movement and touch will complete the transition from specialized to consumer-ready technologies. This is potentially a reoccurrence of the trends, which catapulted multimedia and the Internet to their current level of acceptance [4].

The capacity or willingness of individuals to use these new technologies will affect all segments of society. Businesses and governmental agencies are under continuous pressure to use technology regardless of whether individuals want to or are able to do so. Consequently, individuals who cannot or will not use the technologies are at risk of being left out economically and socially. Companies whose market success depends on technology adoption by individuals or other organizations may see their growth rates reduced or eliminated. Organizations whose success depends on the ability of their own staff to use technology will need to ensure that their entire staff is capable of using the latest generation of technology. Finally, the cost of maintaining multi-channel interfaces to support both the technologically capable and technologically resistant segments of the population will increase due to the need to upgrade each of the interfaces as the technology itself evolves.

However, the increasing penetration of technology into all aspects of human activity coupled with large numbers of technology resistors, suggests that problems associated with technology adoption will increase irrespective of the design of the interfaces. Managing the problems associated with technology adoption is critical to the economic and social well being of the society. Enabling society to capture the benefits of technology advances will require a shift in the way companies and institutions introduce technology, as well as the way they train and support technology users. The rapid rate of change and evolution of technologies also means that organizations will need to find ways to reduce the large number of interface channels as they strive to manage their infrastructure and support costs.

The article is arranged as follows. Section 2 reviews the technological and sociological factors affecting the ability of individuals and organizations to introduce and adopt new technology. Section 3 describes the social and economic costs of having large numbers of people who are not able to use new technologies. Section 4 identifies some of the additional factors that need to be addressed in migrating people from technology resistance to technology acceptance and from one generation of technology to the next. Section 5 concludes the article.

2. Factors Affecting Adoption Of New Technologies

Many factors impact people's ability to adopt new technologies. However, the two which stand out as major challenges to the timely adoption of new technologies by the society as a whole are high levels of technology resistance and the penetration of technology into all aspects of contemporary life.

A. High Levels Of Resistance To Technology Throughout The Society

A recent book by Weil and Rosen [5] divides technology users into

three groups based on their psychological response to new technology (see Figure 1). The three groups differ in their response to the use of new technology and the amount of support they require to adopt a new technology. Moore defines technology adopters in a very similar way from a marketing perspective [6].

Early adopters (estimated to be 10% to 15% of the population) are willing to teach themselves how to use new technologies. Members of this group will accept the frustrations of trying to make the technology work as part of the challenge and joy of working with technology. This group corresponds to the innovators and early adopters defined in marketing terms.

Hesitant users (estimated to be 50% to 60% of the population) are willing to use technology, but only if given some degree of support in learning and/or using the products and systems. This group corresponds to the early majority pragmatists and some of the late majority conservatives defined in marketing terms.

Technology resistors (estimated to be 30% to 40% of the population) are highly resistant to technology. Members of this group are not risk takers and interpret problems with technology as a reflection on their own abilities (or lack thereof). This group corresponds to the laggards defined in marketing terms. It is very difficult to migrate them to a new technology.

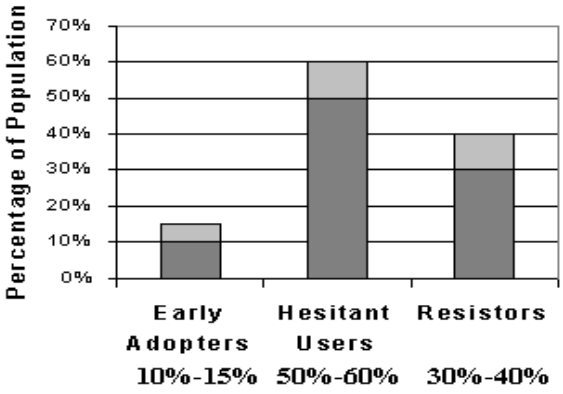

Figure 1: Categories of technology adopters [5]

Only 10% to 20% of the population, buy or adopt technology because of novelty or performance [6]. The remainder waits until the technologies are simple enough for them to use. In other words, most late adopters want convenience, ease of use and reliability and will not adopt until the technology is at this level [7]. It has taken decades for large numbers of late adopters to accept technologies such as the television, telephones, microwaves, VCRs, computers, and ATMs (Automatic Teller Machines). The short lifespan of new technologies and new interfaces does not allow us the luxury of long time periods to migrate late adopters to new generations of technology.

The implications for organizations introducing new technology are clear. Only a certain segment of the society is willing (or has the skills) to keep up with the technology change. For others, the change is forced on them. Will technology resistors ever ask for the changes? Probably not. This group will require high levels of support and maintenance to avoid non-use or misuse of the technology. Will this change over time? Again, probably not.

B. The Increasing Penetration Of Technology Into All Aspects Of Life

The rate and extent of technology introductions has reached the point where technology is penetrating all aspects of our lives. For example, teller transactions can be replaced by ABMs, computer banking, and telephone banking. Telecommunications options include telephone answering systems, cellular phones, call forward and messaging options, and the use of menu based telephone systems to screen and direct incoming calls for many businesses and governmental agencies. New wireless technologies promise to dramatically increase the number of devices, applications, and opportunities for use available to individuals.

The penetration of technology, including the requirement that individuals communicate with businesses and institutions via technology, puts people who cannot or will not use technology in a difficult position. In many cases, they need to pay additional fees (e.g. today in North America most banks charge higher fees for simple transactions processed by a teller rather than through an automatic banking machine). The continuing push towards automation as a means of reducing costs and improving competitiveness means that people will increasingly need to be technologically literate to participate in the society.

Companies face the same challenges for their own employees as they introduce new technology. While some segments of the workforce may be technologically able, even organizations that develop technology have large numbers of support workers who fall into the hesitant user and resistor categories.

3. *The High Costs Of Technology Resistance*

One of the critical issues facing society is the need to ensure that as many participants as possible can share the benefits that new technologies bring. Failure to help migrate as many people as possible to the use of new technologies will affect the well being of both individuals and society as a whole.

The social and economic costs of people not being able to use technologies are substantial. For individuals, the costs can be measured in lower incomes, fewer employment opportunities and potential social isolation. While some groups (e.g., technical professionals, people in companies that have a strong technology infrastructure, and people who are young enough to have grown up with technology) can readily adapt to newer generations of technology, other groups have more difficulty. For example, substantial numbers of people only use technology for specialized work-related functions or only use computers on an occasional basis. Older workers may have had only limited exposure to technology during their careers, much of it with older generation technology. Many people adapt to one generation of technology and find it difficult to move to another interface (hence, all the training courses offered each time a new generation of office suite software is released). Research in the area of ageing and technical adoption shows that older adults are interested in and able to adopt new technologies, but need additional support to do so [8].

The intersection of the ageing baby boomer generation, increasing rate of technology change and increasing penetration of technology into all aspects of our lives suggests that the need for additional support for older persons will grow substantially over the next 15-25 years (see Figure 2). Similar data from other industrialized countries (US, Japan, Western Europe show that up to 19% of the population will be over 65 years of age by the year 2015 [9].

Technology resistors present many serious problems for businesses and institutions. The current trend to offering multi-channel delivery systems (e.g., user choice of bank teller, ATM, telephone banking or Internet banking) is attractive because of the cost savings as human tellers are displaced by technology. However, the overheads associated with maintaining multiple channels will rise over time as the technology underlying each channel evolves and businesses have to pay the price for upgrading and maintaining each channel [10].

Companies trying to increase the penetration rate for their technology products or to move consumers from one generation of technology to the next will need to find ways to move beyond selling products to motivated and capable people if they are to overcome competition and market saturation.

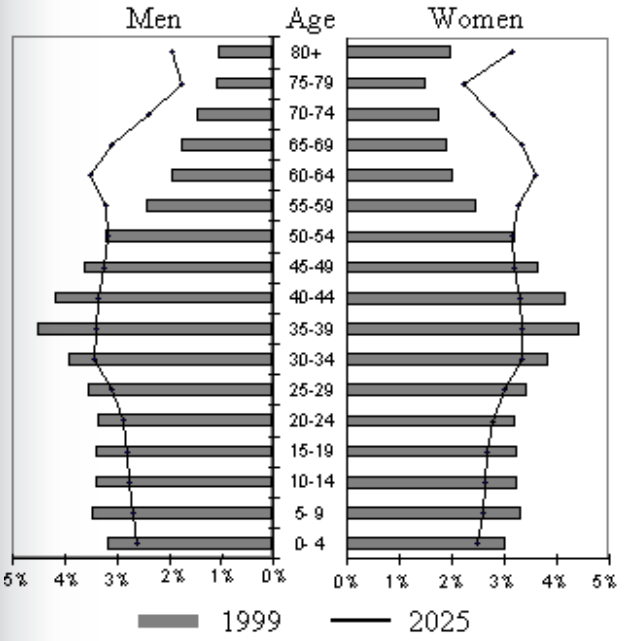

Figure 2: Canadian population distribution by age and sex, 1999 and 2025 [9].

Governments will bear the social costs of non-participants in terms of welfare and other service costs. Governments, like businesses and institutions, will have to bear the expense of introducing and maintaining multi-generational, multi-channel interfaces. Finally, all organizations need to upgrade their internal systems and train their staff. But this will be difficult for employees who are themselves hesitant users or technology resistors.

4. Meeting The Challenges Of The 21st Century

As our society approaches the 21st century, the authors anticipate that one of the key challenges that individuals, businesses, institutions and governments will face in the next century will be how to migrate technology resistors and individuals with low technology capability to being technologically capable and then from one generation of technology interface to the next. Among the factors that need to be managed are the following:

- Rapid changes in interfaces and mode of interaction: Technology is evolving from single mode interfaces to increasingly visual, multi-dimensional, multi-modal interfaces that require people to be equally competent in managing words, images, and sound [1,11].
- An ageing population: Data show that over 32% of the US population will be over 50 years of age by the year 2010, compared to today's figure of 27%. Comparable data for Japan for the year 2010 show 40% of the population will be over 50 [9].
- Cultural differences and preferences within increasingly multi-cultural societies: 1996 Canadian Census Data show that more than 10% of the population uses a language other than English or French at home [9]. Cultural differences, expectations for face to face contact, social niceties, literacy, language of communication, and cultural aesthetics, as well as previous experience with automation and technology will all affect the rate of adoption of new technology.
- The increasing complexity of technology: Technologies seem to be increasing in complexity as can be seen with new software, the increasing presence of self-service options such as kiosks, on-line banking, shopping and airline reservations.
- The need to interact with technology as a precondition to contacting other persons: Companies use technology to screen and direct people, as for example, with some voice messaging systems, and individuals have to interact with technology whether they like it or not.
- The need to migrate users to new generations of technology as a precondition to abandoning legacy systems: New technologies enable a wider range of people to share the benefits that technology brings. However, the older technologies are not disappearing [10].

5. Conclusion

The continued advancement of technology carries with it the potential to raise the standard of living and quality of life for everyone. Our challenge is to enable those people who are hesitant or resistant to make the transition from low technology environments to technology rich ones. Because many of the factors that make people hesitant or resistant are psychological, sociological or economic, making the interfaces more accessible, affordable or easy to use will not be sufficient to accomplish this goal. Future research needs to answer the questions: Do we have the capability to migrate people, particularly technology resistors, from low technology environments to the current generations of technology and beyond? How will businesses and governments pay for and manage technology resistors? The social and economic costs of not resolving the issues around who can share the benefits of technological advancements are too high to ignore.

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IEEE Canada News

At the recent IEEE Sections' Congress 1996 in Denver, two members of IEEE Canada were honored for their contributions to Region 7 activities. In the photo right, receiving their awards from Dr. Ray Findlay (Vice-President, Regional Activities Board) are Jacek Chrostowski and Ibrahim Gedeon.

Jacek received his award for "Leadership in developing new electronic ser- vices for IEEE Canada". Ibrahim received his award for "Outstanding contributions in promoting IEEE/Industry relations". We offer our congratulations to both winners.

Photo: (from left to right),]. Chrostowski, R. Findlay and I. Gedeon

Subject: Moral of the week

One day an expert in time management was speaking to a group of busi- ness students and, to drive home a point, used an illustration those students will never forget.

As he stood in front of the group of high powered overachievers he said, "Okay, time for a quiz."

Then he pulled out a one-gallon, wide-mouth Mason jar and set it on the table in front of him. He then produced about a dozen fist-sized rocks and carefully placed them, one at a time, into the jar. When the jar was filled to the top and no more rocks would fit inside, he asked, "Is this jar full?"

Everyone in the class said, "Yes."

The expert said, "Really?"

He reached under the table and pulled out a bucket of gravel. Then he dumped some gravel in and shook the jar causing pieces of gravel to work themselves down into the space between the big rocks. He asked the group once more, "Is the jar full?"

By this time the class was on to him. "Probably not," one of them answered. "Good!" he replied.

He reached under the table and brought out a bucket of sand. He started dumping the sand in the jar and it went into all of the spaces left between the rocks and the gravel. Once more he asked the question, "Is this jar full?"

"No!" the class shouted.

Once again he said, "Good."

Then he grabbed a pitcher of water and began to pour it in until the jar was filled to the brim. Then he looked at the class and asked, "What is the point of this illustration?"

One eager beaver raised his hand and said, "The point is, no matter how full your schedule is, if you try really hard you can always fit some more things in it!"

"No," the speaker replied, "that's not the point. The truth this illustra- tion teaches us is: If you don't put the big rocks in first, you'll never get them in at all."

What are the 'big rocks' in your life? Your children....Your loved ones.... Your education....Your dreams....A worthy cause... Teaching or mentor- ing others... Doing things that you love....Time for yourself.....Your health....Your significant other.

Remember to put these BIG ROCKS in first or you'll never get them in at all. If you sweat the little stuff (the gravel, the sand) then you'll fill your life with little things you worry about that don't really matter, and you'll never have the real quality time you need to spend on the big, important stuff (the big rocks). So, tonight, or in the morning, when you are reflecting on this short story, ask yourself this question: What are the 'big rocks' in my life?

Then, put those in your jar first.

Bob Mcleod
Markham, ON