# *A New Approach in a New Context for Retraining Engineers in Information and Software Engineering*

by *Ahmed Seffah*
*Computer Research Institute of Montreal*

Dans le présent article, nous présentons le contexte et les principes directeurs de notre réflexion sur les nouveaux défis dans la formation continue des ingénieurs. Notre travail est mené, entre autres, dans le cadre du projet PRISE (Programme de Réorientation des Ingénieurs Sans Emploi) mis en place par le Centre de recherche informatique de Montréal (CRIM) en collaboration avec l'ordre des ingénieurs du Québec (OIQ). PRISE vise à «transformer» des ingénieurs en informaticiens afin de répondre aux défis suivants:

- diminuer la pénurie de main-d'œuvre qualifiée qui touche (ou touchera d'ici l'an 2000) plus de 80% des entreprises du secteur des technologies de l'information au Canada,
- maximiser les retombées de l'investissement consenti pour la formation continue à l'heure des coupures budgétaires et de la remise en question de la relation augmentation de productivité/ informatisation des organisations,
- pallier aux difficultés, voire à l'incapacité, d'adaptation rapide de l'enseignement universitaire particulièrement dans un contexte où les technologies de l'information évoluent d'une façon rapide, continue et perpétuelle.

In this article, the context and the conceptual framework of our work on continuing education in software and information engineering is discussed. Our work has partly been undertaken within the project PRISE (Programme de Réorientation des Ingénieurs Sans Emploi) developed by the Computer Research Institute of Montreal (CRIM) in collaboration with several organizations. The objective of PRISE is to retrain engineers into software and information engineering in order to respond to the following industry challenges and needs:

- Decrease the shortage of skilled labour which affects or will affect by 2000 more than 80% of the companies in the information technology industry in Canada,
- Maximise the benefits of approved investments for continuing education at a time of financial cutbacks and questioning over the correlation between improved productivity and investments in tools;
- overcome the problems, indeed the inability, of universities to rapidly adapt to the rapid, continuous, and continuing changes in the field of information technology.

## *1. Challenge: A shortage of skilled labour, sharp growth in ITs, unemployment among engineers and the limitations of conventional teaching institutions*

The social and economic context of Information Technologies (ITs) in Québec, throughout the rest of Canada and in North America in general can be summed up as follows. Information technology is the sector that has recorded the greatest growth, has been the most affected by the lack of qualified workers and for which classic teaching institutions (universities, training centres, etc.) have been unable, in the very short term, to supply the manpower on which its growth depends.

### A. Sharp growth in the Information Technology industry

In 1995, the IT sector employed 415,217 Canadians 3% of the labour force in Canada. With a 15% employment growth rate between 1990 and 1995, ITs have been doing extremely well in the various economic sectors in Canada (Table 1). Two sub-sectors have especially contributed to the high growth rate: the telecommunications equipment industry, with an employment growth rate of 48.1%, and the software development and services sector, with a phenomenal growth rate of 72.1%. It is important to note that in 1994-1995 alone (the latest period for which statistics are available) the employment growth rate reached 24.5%.

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TABLE 1. Employment Growth Rate in Canada

| ECONOMIC SECTOR | 1990-95 | 1994-95 |
|---|---|---|
| Telecommunications equipment industry | 48,1% | 14,1% |
| Software development and services | 72,1% | 24,5% |
| TOTAL FOR THE IT INDUSTRY (all sub-sectors) | 15% | 13,8% |

Software development and services is therefore by far the economic sector that has recorded the sharpest growth in employment. In this sector, the job growth in Quebec from 1990 to 1995 shows the same trend as for the whole of Canada. According to all economic experts and observers, the trend towards sharp employment growth is here to stay for a number of years yet.

### B. Workforce shortage in information and software technologies and engineering

A number of economic indicators point to the fact that the shortage of qualified workers in these sectors is both critical and far-reaching, and is not going to be naturally reduced over the next few years unless something is done to counter it. Below are just a few examples that illustrate the extent of the shortage of skilled labour:

- A recent analysis of the main job-market problems on the Island of Montreal, sponsored by Human Resources Development Canada [1], revealed that there is a serious shortage of computer engineers, EDP systems analysts and programmers. These are professions that are experiencing recruiting problems and require freshly trained workers; it is therefore possible to intervene by training unemployed workers who have the necessary prerequisites. The Quebec-based Société québécoise de développement de la main-d'œuvre (SQDM) has confirmed the results of the study.
- A 1995 study carried out by the Software Human Resource Council showed that 173,000 Canadians were working in the software and consulting services sector alone in 1995. According to SHRC estimates, this same sector will require some 325,000 qualified workers by the turn of the century in order to maintain its present growth rate [2].
- A recent Angus-Reid survey conducted for the Canadian Advanced Technology Association (CATA) revealed that the vast majority (88%) of its corporate members foresee a shortage of skilled IT labour in the near future, while 54% say that they presently have positions that they are unable to fill [3]. According to CATA, there are presently some 16,000 IT jobs available in Canada. This figure can be compared to estimates of the Information Technology Association of America (ITAA) that there are presently 190,000 unfilled IT positions in large and medium-sized companies in the United States.

- The job market is in a state of turmoil, not to say a state of war. One just has to browse through the career pages in the newspaper or job banks on the Internet to realize the extent and variety of demand in the IT field. Corporate recruiting services must go to extreme lengths in their search for candidates to fill the thousands of positions that are presently available, including both raiding competitive firms and setting up international partnerships, which ultimately exports jobs to other countries.

One of the measures taken by organizations confronted with the lack of qualified labour consists of recruiting in foreign countries. But in this world-wide search for skilled labour, Canada is at a definite disadvantage. The value of the Canadian dollar and the salary level offered makes it difficult to compete with our neighbour to the south. To make things worse, young Canadian university graduates, lured by career opportunities in the United States, leave Canada, aggravating the manpower situation here at home.

### C. The inability of traditional continuing education centres to alleviate the shortage of IT workers

Without going into a detailed discussion of the causes of the shortage of IT manpower, it is, however, important to note that the globalization of markets and dereglementation (in the area of communications, for example) have been important contributory factors.

Even in the face of such a shortage and such rapid growth in the industry, the number of students graduating from IT-related university programmes in Canada has remained stable. Quebec universities train from 700 to 750 students per year, whereas according to CATA estimates some 4,000 IT jobs are available at the present time in Quebec. Over the past decade, a dramatic decrease in registrations for computer science programs in the United States has created enormous pressure not only on the American market, but on the Canadian market as well.

Even more at the root of the problem is the clearly negative image that young people have of working in the IT field. Furthermore, this image seems to be symptomatic of a more generalized feeling of alienation on the part of students towards the sciences and technology. It would appear that in those areas colleges and universities are having an extremely hard time filling their classrooms.

Furthermore, companies are increasingly looking for manpower that is both specialized and multidisciplinary. For example, they would like software developers to be capable of designing applications that require not only advanced technical skills but also extensive knowledge of the field involved (medicine, chemistry, etc.) and even marketing and management skills [5, 6].

We believe that no continuing education approach and/or framework is capable of coming up with a rapid, effective and efficient solution to this deadlock. The newest trends in education (just-in-time training, learning tasks, education without frontiers, learning organization, knowledge society) are elements that are forcing us to rethink the way we teach, learn and share knowledge.

## *2. Approach: A customizable curriculum, skills-based training methods, a training environment that makes the most of new communication and information technologies*

The PRISE project undertaken by the Computer Research Institute of Montreal in collaboration with the Ordre des ingénieurs du Québec (the Quebec Order of Engineers) uses such an approach. The main aim of the program is to train engineers to become computer professionals. Participants in the program are engineers who are unemployed and/or come from fields with diminishing career opportunities (civil and architectural engineering, etc.). Training must take place over a maximum period of one year. The first group began in the fall of 1998.

More than a training challenge, the program requires the participation of researchers whose task is to find and implement a new training approach that is capable of responding to the challenge. The project relies on the following elements to reach its objectives:

1. A curriculum that focuses on new information technologies,
2. Co-operative programs that alternate practical internships and intensive theoretical courses,
3. A skills-based training approach,
4. The Internet as a means of communication and distribution of training courses.

The curriculum makes use of the wide range of NICTs, particularly the Internet, as support aids for its customized and customizable training system. The aim is that each intern be able to proceed with the curriculum in an individual manner and therefore adapt it to his/her own objectives and pace of learning.

Below is a brief look at the basic concepts underlying such an approach.

#### A. A curriculum centred on new information technologies

A closed “fixed-menu” type of curriculum would not stand a chance in the training context we have presented here. The students, according to their personal engineering background and theoretical knowledge, must be able to customize the curriculum by choosing among a wide range of courses that will eventually enable them to perform the jobs involved in one of the following two areas:

- **Communication network administrator**, which can lead, for example, to jobs involving the installation and configuration of computer systems, computer maintenance and technical support, and the administration of distributed systems and networks.
- **Software developer**, which can lead, for example, to jobs relating to the designing, analysis, programming, testing, technical writing, and implementation of software.

This alone is a considerable challenge, in terms of the means and logistics required in order to provide students with the pedagogical support they need in such a wide-open curriculum and that aim at such a diversity of career opportunities. For example, the curriculum for a software developer can prepare students for jobs such as analyst programmer, software tester, graphic interface designer, telecommunications network programmer, etc. In the PRISE project, the à-la-carte curriculum is made possible partly because of a huge catalogue of courses that have been offered over the past ten years by the training division of CRIM (http://www.crim.ca/formation). These courses are organized into two semesters (Fall, Winter) with several sessions for each course (a minimum of three) during each semester. This enables students to take the courses they need when they need them.

#### B. A system where students alternate between practical internships and intensive courses at CRIM

The training program consists of a six-month internship in a company, which provides students with both on-the-job training and integration into the labour market. This type of program, where students alternate between internships and courses, has proven successful in faculties of engineering throughout North America.

Over the course of the internship, students continue taking intensive courses at CRIM. The problem then arises as to:

- identifying the needs that justify a student following a particular form of training.
- evaluating what the students have learned, since officially there are no exams in the curriculum.
- having the program accredited by government and/or private bodies.

The teaching team put together by CRIM, in collaboration with their business partners, supervises the trainees and monitors them on an individual basis. The Ordre des ingénieurs du Québec contacts its participating members periodically to ensure that the training program is responding adequately to their actual needs. Furthermore, the program has to include information and preparatory sessions in view of the certification exams required by:

- companies (MICROSOFT, ORACLE, etc.)
- associations such as the Ordre des ingénieurs du Québec and the Institute for Certification of Computer Professionals (http://www.iccp.org)

This type of certification process strengthens the credibility of the program.

**C. A skills-based training approach**

The PRISE program's dynamic systems engineering approach ensures that the skills and various types of knowledge required in a given situation or context will be developed:

- theoretical knowledge (how to understand and interpret information)
- procedural and operational skills
- experimental skills
- social skills (how to conduct oneself)
- cognitive skills (how to process information, how to reason, how to put a name to what is being performed, how to learn)

Skill is defined as a series of co-ordinated actions that are usually effective in carrying out one's objectives. But today the term "skill" has come to mean any ability that has been acquired through experience and the assimilation of relevant information. It consists of expertise or qualification that is recognized and enables a person to define and solve specific problems relating to a particular field. This is precisely the approach used in the PRISE program. It is reflected in the following manner when determining the training curriculum:

A - A careful analysis is carried out of the job that the future professionals will have to fulfill and the environment in which they will be working. This is done with the close collaboration of our business partners in the actual workplace.

B - The skills that are required (knowledge, abilities, attitudes and behaviours) in order to perform the particular job are determined.

C - These skills are considered as the operational goals that the curriculum must enable the students to reach.

The skills-based approach is closely intertwined with a teaching method that promotes the students' acquisition of practical skills. In this type of approach, case studies, problem solving and working on projects that are comparable to those that would be encountered in the workplace are at the heart of the learning process.

In order for this teaching approach to succeed, two prior requirements must be met:

1 - Those participating in the program must have the personal aptitudes and qualities that are necessary for a harmonious integration into the world of ITs.

2 - Training instructors recruited from the university milieu must have had previous experience in the workplace. The PRISE project includes "training the training instructors" so that they have a complete understanding of the philosophy of the program and can therefore incorporate it into their teaching approach.

**D. Extensive use of the Internet as a medium for communicating and for the dissemination of training courses**

Basically, the Internet serves as a medium for providing valuable information to the students. This is done, for example, by making information available concerning:

- the schedule, course lists, syllabuses
- events and seminars
- bibliographical references
- self-serve support resources (on-line training manuals, multi-media presentations, etc.)

The Internet also facilitates communication between students and/or professors. A mailing list makes it possible for:

- students registered in the same program, but who do not necessarily know each other (because they may have attended different course sessions), to share their experience and knowledge.
- professors to quickly send personalized messages to students and vice versa.

Using the Internet therefore offers tremendous advantages. Table 2 shows a brief comparison between courses given in a classroom and those given on the Internet.

TABLE 2. Contrasts between conventional and virtual courses

| Conventional Courses | Virtual Courses |
|---|---|
| - Speaking and listening<br>- Generally the professor speaks and the students listen (in theory...). | - Typing and reading<br>- Several students can express themselves at the same time, using a group discussion format, for example. |
| -The entire group of students is supposed to learn at the same pace. | - The students can go at their own pace and according to their goals. |
| - Specific time and place for each course | - The student chooses where and when to take each course |
| - Assignments are done mainly on an individual basis. | - Most of the exercises and assignments are done in groups. |
| - Students must take notes | - Lecture notes are sent automatically and are available in review mode. |
| - Generally speaking, very little resource material is available besides the lecture notes. | - Students benefit from a large library of resource materials available on the Web. These resources are added to as the on-line course is used. Even students can contribute to the library. |

**E. A far-reaching view of the Internet as a training and working aide for students**

Beyond its basic uses, the Internet is an innovative and cost-effective environment that integrates various applications. It is dynamic, open, distributed and accessible. It combines various training media (distributed classes, multimedia, etc.), Internet tools (electronic messaging, browsers, Internet-based software, etc.) and intelligent computer-based training systems (intelligent tutorials, advisory systems, add-ins and critical systems). These tools are designed to aid both students in their assignments and professors in the follow-up of their students.

Both students and professors are able to adapt Internet tools and content to their own preferences and needs, thanks to a configuration tool that is part of the environment. Access to the environment is provided via a unique interface, which in turn gives users access to:

- tools for the distribution and consultation of course content
- tools for communicating and sharing knowledge
- a system to aid in evaluating the students' knowledge and following their progress.
- a virtual library that will provide all the query and lookup services available for virtual libraries and documentation centres.
- tools that the students or professors would normally use in their job (programming languages, software libraries). Several current products and ongoing projects are examples of this trend, such as OLA (Oracle Learning Architecture) developed by Oracle to support its training activities. More than 150 on-line courses on various aspects of IT engineering are available in OLA and accessible via an extranet (http://ola.oracle.com).

We must take this opportunity to mention the LEARNSHARE project (http:\\www.learnshare.com) that was started up in the United States and was designed to pool the learning resources of large American companies. The LEARNSHARE project is aimed at building a virtual environment in which learning resources can be shared in order to maximize performance and minimize cost.

## 3. R & D Challenges and Projects

In this article we have looked at the situation in Canada and, generally speaking, North America with respect to the training of computer specialists and this is only the beginning of NICTs. We have seen that, as they presently stand, the traditional training institutions are not capable of providing sufficient workers fast enough to keep up with the sharp growth in the IT industry, nor are they succeeding in reducing the unemployment numbers seen in other fields of engineering. We then described the main aspects of the approach used in the PRISE project, which is based on and benefits from our research into training and the use of NICTs as a training platform. Below are only a few examples of research being carried out:

- SAGE-ISO: a system aimed at the dissemination of information on ISO standards, the just-in-time distribution of training resources and job aids. It is, in fact being used by CRIM to support its ISO 9001 certification and quality assurance procedure.
- A number of studies carried out on the training practices used in software development companies and on the architecture of Internet-based training environments.
- Experiments involving offering courses on-line, mainly those designed by the training division of the Computer Research Institute of Montreal, particularly the following courses: creating Web pages, designing new-generation Web sites, ergonomic design workshops for the Web and developing an intranet/extranet.

However, in order to profit from the advantages that are anticipated in Internet-based training, several issues must be addressed. Table 3 sums up the main questions to which a logical overall answer will have to be found.

TABLE 3. Crucial questions at the heart of developing an Internet-based training infrastructure.

| | |
|---|---|
| 1 | For what type of training needs is the Internet most appropriate? |
| 2 | What is the most appropriate teaching strategy for on-line training? Has, in fact, an on-line training strategy been developed? |
| 3 | What factors are used to measure the a posteriori cost/benefits of an Internet-based training environment and its content (learning resources)? |
| 4 | What is the most appropriate technological architecture for implementation of the environment? |
| 5 | What can be done to facilitate the transition toward this new type of environment and encourage students to use it? |
| 6 | How do we promote the integration of that environment into the information and training system? |

## 4. References


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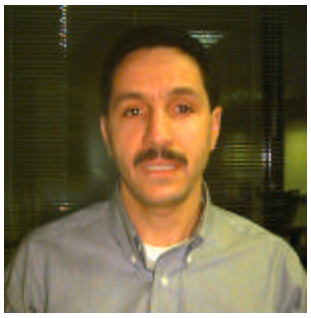
## About the author



**Ahmed Seffah** holds a Ph.D in software engineering from the École centrale de Lyon in France. He is presently an adjunct professor at the University of Quebec in Montreal (UQAM) and research leader of the software development group at the Computer Research Institute of Montreal (CRIM). Ahmed Seffah's research expertise is at the frontiers of software engineering and human-computer interaction. His current investigations concern the human factors in software engineering. His work on software processes is centered on human factors in software development, developer performance support and continuing education approaches to software engineering, particularly the powerful advantages of using the Internet to focus the training on the learner and promote the exchange of knowledge and process skills. For more information, visit the following URL (http:\\www.crim.ca~aseffah).

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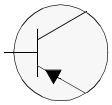

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