The use of state of the art E-Learning technology in support of education and professional development for GeoEngineers

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ABSTRACT
It has become readily apparent that geotechnical and geological engineers working in their respective fields are faced with a more demanding operational environment, an environment that is multi-dimensional and one that requires a highly educated and a situationally aware core of geo-professionals. In support of this mandate, the educational and professional development framework associated with the undergraduate degrees must also morph in order to support these current and future realities. Within the context of life-long learning, a niche role for a university is to keep up with the technological trends by incorporating e-learning education faculty within its organizational structure. Also highlighted are the potential advantages of using such technologies to improve enrolment of woman in engineering. This paper focuses on the various technologies that can be employed at the university level in support and continuing education within the geoengineering disciple.

RÉSUMÉ
Il est devenu évident que des ingénieurs géotechniques et géologiques qui travaillant dans leurs domaines respectifs sont confrontés à un environnement opérationnel plus exigeant, un environnement qui est multidimensionnel et un qui demandent que les geo-professionnels ont des skills technologique très élèves. À l'appui de ce mandat, l'entraînement, le cadre éducatif et de développement professionnel associant avec les degrés de premier siècle, doit aussi changer afin de soutenir ces réalités actuelles et futures. Dans le contexte de « l'étude pour toute la vie », un rôle pour une université est de suivre les tendances technologiques et incorporant les stratégies de « e-étude » dans sa structure d'organisation. En outre accentués sont les avantages potentiels d'employer les technologies relevant pour améliorer l'inscription des femmes dans les programmes de génie. Cet article se concentre sur les diverses technologies qui peuvent être utilisées au niveau d'université et soutenant l'éducation continuelle dans le disciple de génie.

1 INTRODUCTION

It is quite evident in today's society that the technological advances are moving at an unprecedented rate; so much so, that the doctrine or pedagogy to incorporate the use of such technologies in the university classroom cannot keep up. As well, it is quite difficult to realize institutional change, diverting from traditional methods of delivering an undergraduate engineering program of study.

A degree in the geotechnical and geological engineering field is quite demanding and there is a very real requirement for the students to be exposed to laboratory sessions and field-related exercises. The selected technologies introduced in this paper can surely compliment and augment such requirements for these degree programs. Also incorporated in this paper are the lessons learned through area-wide studies within the geoenvironmental field and professional development realm that highlight the unique requirement of distance learning / training and the proficient use of current and dynamic technology and adaptive educational techniques.

Using a web-based platform has many benefits for geoengineers, consultants and members of the Canadian Forces (CF): Base personnel can view their instructor / consultant and colleagues through video connections, talk to each other using phone or VOIP (voice-over-internet-protocol), communicate using instant messaging, work with others or privately in their own online room and share files and desktop applications with consultants or their colleagues to complete their assigned tasks.

With respect to higher education institutions, the arguments for technology enhanced learning have been discussed in current literature (Csanyi et al., 2007). Participants are independent of time and space constraints. Learning resources and communication between students and teachers are available and accessible always and everywhere. Courses may include work-related experiences and problem situations as well as the knowledge and valuable input of international experts and local practitioners. An important advantage at the organizational level is the enhancement of teaching practices, even for large course groups by utilizing certain aspects of modern learning management systems, i.e. communication and feedback tools, student administration tools or testing and assessment tools.

Current literature has also indicated that women tend to outnumber men in online courses, including undergraduate and continuing education engineering programs (Muller, 2008). Despite their strong motivation to complete degrees, and appreciation for the convenience of an online degree-completion option, multiple responsibilities, insufficient interaction with faculty, technology, and coursework ranked highest as barriers to women's persistence. This may be the result of instructional design practices having been rooted in a domain constructed in, and reflecting, androcentric values (Campbell, 2000). This often becomes an obstacle in women's career opportunities and professional development, especially a female engineer, as there is a rapidly increasing impact of modern educational technologies on society, and lack of relevant skill sets would not make a person very competitive. Further, it excludes the female perspective from future technological innovations and, thus, reduces the quality of the results. As our dependence on educational technology augments, more highly qualified female specialists (engineers) are needed. Taking into account the growing need for competitive, well-educated employees in the future, it becomes clear that women are expected to play an active role in technological matters, especially in distance education, and must be privy to being included in such domains (George, 2000; Dahlmann et al., 2006).

2 STATUS QUO IN ENGINEERING EDUCATION

The demands placed by the workplace for professionals in engineering and science show that universities may not fulfil the expectations of a rapidly developing society. It has been seen that technological advances in the educational field have not been endorsed adequately by academics in today's higher education institutions (Csanyi, et al., 2007). More studies must be conducted in order to determine the role and impact of technologically enhanced teaching strategies in engineering schools as well as in continuing education programmes for engineers.

The majority of academic institutions have so far resisted adjusting their programmes according to the current needs of the workforce (Campbell, 2000). Their educational strategies are also outdated, as they focus on knowledge transmission rather than encouraging their students to develop a sense of ownership for the learning process and their personal development. Clear incentives for engineering students to expand on their originality, social and economic responsibility, political thinking and social skills are not included in many of the current engineering study programmes. As a direct result of these issues, educational quality is unquestionably affected. As such, technology enhanced learning and teaching practices can promote the improvement of educational quality. Highly structured technological support structures that envelop all educational activities of an academic institution are essential to create in order to expand modern educational tools and establish their usage by teachers as well as learners.

The Canadian Academy of Engineering (1999) cited this fact years ago, stating that:

> *Engineering faculties should reach out beyond their own students and help in providing a modern liberal education for all university students. They should also help in improving the technological literacy of all university graduates as well as the general public. In a society which is so profoundly influenced by technology, the technological literacy of many university graduates is open to question. Engineering professors regularly deal with the interface between science and society and are well-qualified to contribute to the liberal education of students and the public at large.*

Academic discussions have circled their way around this subject for years. In theory, universities know what has to be accomplished, however, in practice there are many obstacles due budgetary constraints, administrative barriers, strong traditions and rigid attitudes towards academic teaching widely spread among university professors. Therefore, there is a unique requirement to bridge this gap.

3 WHAT IS E-LEARNING?

E-Learning (or technology enhanced learning) is the learning process created by interaction with digitally delivered content, services and support. It can be any learning that utilizes a network (LAN, WAN or Internet) for delivery, interaction, or facilitation. This includes (but is not limited to) distributed learning, distance learning (other than pure correspondence), computer-based training delivered over a network, and Web-based Training. E-learning can be synchronous (i.e. live), asynchronous, instructor-led or computer-based or a combination of any of the above-mentioned delivery platforms. As can be seen, the diversity of the technological delivery combined with the flexibility of delivery platforms make the e-learning option a very viable and powerful force multiplier for professors and learners alike. Distance education has far surpassed the days when large packages of books and reference materials were sent to students via traditional mail. The on-line community and the use of specific technology and software have made e-learning a viable and effective alternative.

3.1 Technologies Combined with E-learning

There are many hardware peripherals and software packages that are commercially available that have been specifically produced in order to support technology enhanced learning. These produces can also be modified in order to suite the specific needs and requirements of the administrator or user. Selected technologies that can be used for this purpose are cited below: (Note that the authors do not endorse or solicit the use of these software packages).

a. Web Collaboration & Virtual Classroom Software for Online Teaching;
    1. WebEx (Cisco Systems)(Figure 1);
    2. Elluminate *Live; and,*
    3. eLecta *Live;*
b. Videoconferencing;
c. WebCT; and,
d. Skype.

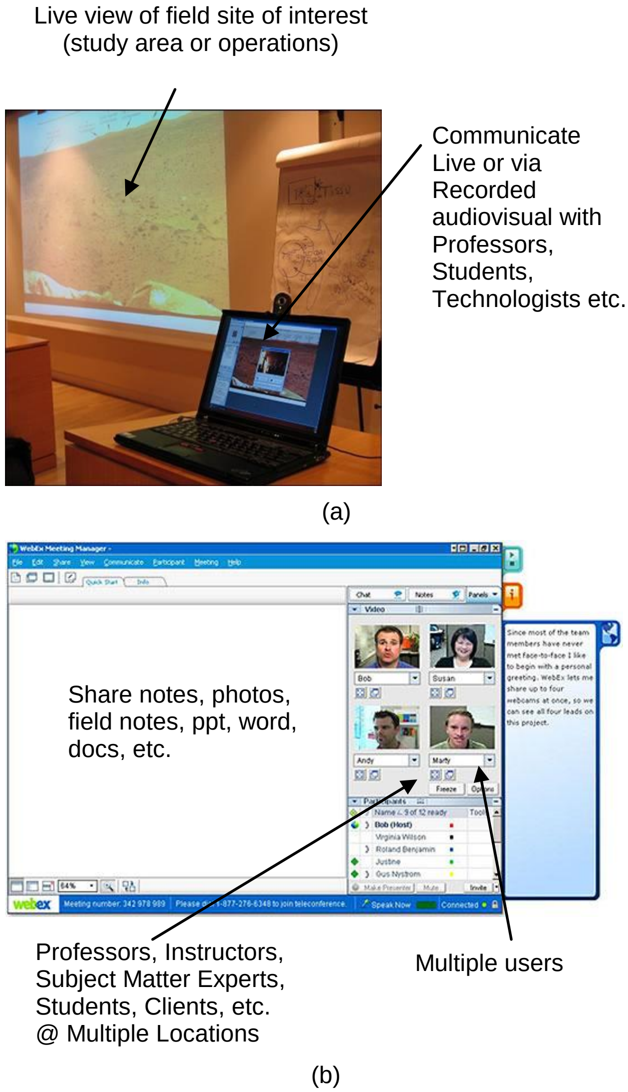

Figure 1. Example of virtual learning environment using WebEx (for example); (a) e-learning in a traditional classroom environment, (b) interface of software.

All of these technologies can be used in order to enhance the on-line learning environment. Cited in Figure 1, is the use of WebEx (for example). The figure depicts the screen arrangement and selected capabilities of the software. Of note, is that this interface has:

a. Live, audiovisual communication;

b. The ability to record sessions for future usage;

c. The ability to share notes, desktops, internet resources synchronously; and,

d. Specially designed tablets that allow for handwritten notes to be shared digitally among multiple participants.

4 BRIDGING THE GAP WITH E-LEARNING

Technologically advanced learning tools exhibit a number of advantages for the teacher and the learner. Distance education programmes offer time and space independence. Communication and feedback methods as well as distance education assessment techniques can be employed in order to accommodate large groups. In addition, continuing education courses for working professionals can be tailored to the needs of the learners who bring a wealth of experience and *real* workplace insight.

As technology enhanced learning continues to establish itself in higher education institutes, it has become apparent that educational theories and methodologies need to be revised accordingly. It is crucial that teachers' as well as students' attitudes about traditional knowledge transmission (or skill transfer) be re-evaluated. Regarding the students' aspect, self-directed learning follows different patterns and requires other measures and resources than traditional teacher-centred education. Distance education methodologies require learners with substantial self-directed learning skills, motivation and working discipline. Similarly, the educators' function has to transform considerably. Professors need to endorse and develop new competencies, such as facilitator's skills rather than teacher-centred, "spoon feeding" type of instruction techniques. Most importantly, teachers should focus on instilling self-reflective learning skills and a sense of ownership of the educational process in their students.

Not only does the pedagogy need to change, the teacher is required to master the use of the ever-changing and evolving technologies; not an easy task for professors that may be set in their ways and concentrating on research, institutional service as well as teaching. Although there is a considerable number of educators who appreciate the value of incorporating technology in their teaching practices, developing new competencies and acquiring solid expertise in using distance learning methodologies requires a substantial amount of time. Hence, only a few innovative and motivated teachers employ technology enhanced teaching practices. This causes a gap of knowledge to occur between undergraduate students in applied science programmes and professional engineers, as limited information is transmitted between the academic world and the real workplace. Also, for professional development programmes, people seeking continuing education are faced with the dilemma of dealing with time and space limitations of traditional academic environments or investing in distance education courses of questionable quality.

When employing distance education techniques specifically for engineers, complex real life scenarios can be reproduced. This allows for practical learning to occur, as students are able to participate in problem-solving situations that are similar to real workplace environment. For example, engineers who are geographically separated, report to senior management and need to collaborate in order to address a task as one team, they would need to employ technology enhanced methodologies (such as those provided by virtual environment programmes) in order to exchange ideas and information.

In addition, e-Learning can be employed as a means for the provision of continuous learning opportunities. These solutions empower employees to be equipped with lifelong learning skills inclusive of effective (and crucial) learning-with-technology skills. An educational institution must, therefore, equip their learners/students with these skills so that they enter industries ready to learn and use technology for learning (Anthonysamy, P., 2003)

5 CASE STUDY – RMC GREEN TEAM

The Royal Military College (RMC) Green Team is a research organization that resides within the Civil Engineering Department at the Royal Military College of Canada. The Green Team's function is to provide multidisciplinary assistance and research in support of the (geo)environmental needs of the Department of National Defence (DND) and the Canadian Forces (CF). Within DND, the RMC Green Team has conducted programs that are strategic in nature and area-wide in scope.

A specific example of a project that benefited from the use of e-technology aided expertise was the Sewage and Water Treatment Plant Optimization Program (ST/WTPOP). The goal of this optimization program was to provide DND staff with the skills, knowledge, training and experience to achieve and sustain optimized performance from existing sewage treatment plant infrastructure in an economical manner. In all, seven sewage treatment facilities and fourteen water treatment facilities were evaluated, spanning nine provinces within Canada. The scope, magnitude, time & space constraints warranted an innovative approach. The efforts at the Bases and Wings resulted in improved performance and brought effluents better into compliance with federal, provincial and local guidelines and objectives. The program saved an estimated $12M in capital costs and $385K in annual operating costs.

It was evident from the beginning of such projects that one of the critical components was skill transfer and open lines of communication with all of the facilities spanning the entire country. Computer and software aided technology allowed for:

a. The transmission of treatment plant performance data to the central office – including the data analysis feedback response as well;

b. Direct communication with the sponsors, plant operators, relevant personnel, consultants, stakeholders, other plant operators etc. (synchronous)

c. Skills transfer sessions in order to augment the skill set of operators and relevant staff members;

d. Reduced travel to locations to conduct the same activities mentioned above;

e. On-line data bank of references, training and relevant documentation (asynchronous) that was accessible to all interested parties;

Organizing and executing such a system was not without its challenges. The level of computer literacy of selected plant operators was minimal, access to particular software suites by certain sites was limited, and security/network firewalls were also an impediment in the implementation of such a system. There is a certain amount of up-front effort, buy-in, and cost that must be negotiated prior to the implementation of such a structure.

Also noted was the eagerness, pro-activeness and technological ability of the young engineers that have been and are currently being employed by the RMC Green Team. This generation of engineers have been exposed to many technological devices and software tools. As such, the proper training (internally), they have a certain amount of confidence in using such technologies.

Selected members of the RMC Green Team are not co-located with the main office in Kingston. As such, computer and software aided packages facilitate with the ongoing communication, training and professional development of these skilled employees. The team has worked at over 80 locations across the country working on various projects and at any moment, each member may initiate directly communication with other team members or with the head office.

5.1 Lessons Learned

The use of technology for research and professional development purposes has facilitated the operations of the research team as well as the day-to-day operations of DND and CF members alike. This experience and lessons learned is directly applicable to certain aspects of incorporating such frameworks within the context of undergraduate engineering curriculum. The following are selected lessons that have been learned through the utilization of such an on-line approach:

a. It is difficult to obtain buy-in in the initial stages of a program;

b. It is challenging to augment and provide training to those that are not computer literate;

c. Time and space will always provide challenges that will have to be overcome; either by the on-line community or more traditional methods;

d. There needs to be a balance between site visits and on-line communication, therefore, one does not alleviate the need to travel in certain instances;

e. One should not underestimate the time, cost and efforts required to initiate such a program;

f. There is a real cost saving that can be obtained and realized within a limited pay-back timeframe;

g. Recently graduated engineers are "tech-savvy" and easily grasp such concepts. They are also more likely to favour working off-site, preferring to communicate with the head office remotely.

h. Not all employees can work off-site and require a particular management approach;

i. One should rely on subject matter experts in order to set-up the technological framework (hardware and software requirements);

j. Input from educative experts with respect to pedagogy should be obtained for on-line training courses.

6 THE VIRTUAL CLASSROOM

In an e-learning experiment carried out by Dobrzañski et al. (2007), students in an undergraduate engineering program were introduced to e-learning methodologies and expected to perform within a virtual classroom. Online delivery techniques of the learning material combined with on-line discussion forums as well as distance education assessment tools were employed as part of the cited study. In addition, the formation of the virtual laboratory focused on enabling the students to improve their skills on using real devices.

According to the results obtained by the research study, the educational outcome for the students who participated in the distance education program compared to the students in the traditional classroom/laboratory environment was analogous (Table 1). The research study included 270 undergraduate engineering students who were divided into two equal groups: one group was taught using traditional methods and the other group was delivered the program online one. Both groups had access to internet resources and were tested on the same teaching subjects. Their final exam scores demonstrated that the performance of the students from both groups was similar. The online students were grateful to be given the opportunity to develop new competencies in e-learning and welcomed the change. It is promising them that technology enhanced teaching practices can be as effective (if not richer) as traditional methods.

Table 1 Statistical tab description of final exam results (after Dobrzañski et al., 2007)

Statistic description	Traditional group	Online group	Total result
Average	11.90	11.99	11.94
Middle result	12	12	12
The highest result	21	21	19
The lowest result	4	5	4
Standard deviation	3.04	3.30	3.16

6.1 Potential Applications for the GeoEngineering Curriculum

The outcomes based accreditation criteria (2010) set out by the Canadian Engineering Accreditation Board, does not preclude the use of e-technologies for accreditation purposes. All of the accreditation criteria can be met with the successful implementation of these technologies paired with suitable pedagogical frameworks.

Given that universities and educational organizations have to face challenges such as budget cutbacks, insufficient funding or other restrictions that make it difficult to survive, many Canadian universities have explored the option of employing such e-methods into their engineering curriculum. The use of the virtual classroom can also augment the number of students within a program, drawing from remote regions of the country (or world).

There are already a variety of virtual laboratories that are commercially available or that have been developed by academics that have been employed by universities as part of their engineering curriculum. For instance, a triaxial test virtual model (Figure 2) has been used in order to perform virtual triaxial experiments as part of the engineering curriculum/ccourse component related to soil strength and behavior (Penumandu et al., 2004). These simulated/virtual experiments are being used at the University of Tennessee.

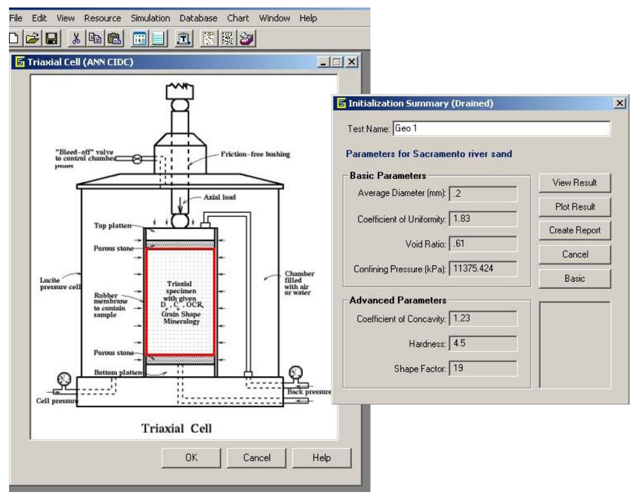

Figure 2. Geo-Sim interactive triaxial virtual module with specimen and test parameter display (after Penumandu et al., 2004).

These virtual experiments do have their merit, however, the authors believe that these tools can be used in addition to real, physical experiments and fieldwork. By exposing engineering students to real-life construction sites and practices, they can better relate to the engineering challenges and actualities associated with design and construction. They can also begin to relate the theoretical concepts introduced in the classroom environment to applied concepts being utilized by modern industry.

Therefore, a combination of “brick” and “click” may be the answer to the employment of such techniques to the Canadian engineering curriculum; i.e. a balance of traditional classroom (brick) instruction and on-line (click) instruction.

Many on-line courses and programs (such as those at Athabasca University) use the on-line method of teaching as the primary learning environment. However, in the first week of the program, students are asked to visit the university campus in order to conduct an on-site orientation that involves meeting with professors, and being exposed the on-line technologies, research communities and resources that will be critical to the successful completion of their degree program.

The implementation / augmentation of these technologies into a geoengineering program is non-trivial, however. A major challenge for faculty is integration and application of knowledge, in a global sense. There is a unique requirement to have within the curriculum structure such that the major components of the program are addressed on mass. The pedagogy (i.e. effective teaching methods and strategies of studies) and engineering subject knowledge need to be complimentary (Pan et al., 2010).

As such, an undergrad engineering program can incorporate the use of on-line strategies and technologies as the primary method of instruction / learning while also allocating a limited timeframe for on-site (or satellite site facilities) laboratory and field activities but must ensure that the correct pedagogy is employed..

7 GENDER AND ENGINEERING

It is a well known fact that woman are under-represented in the engineering profession and that the trend is that of a more declining number of female enrolment in engineering programs across Canada (Frize, M., 2010). Perhaps, here too, e-learning can be used to increase woman enrolment.

In order to enhance women's participation in the technical fields (to include distance education) several aspects are involved:

a. the importance of women embracing technology and distance learning, the current characteristics of the computer science domain and why it has been exclusive to women;

b. the female learner needs;

c. the existing design of technology enhanced educational material and how it could be informed by female learner qualities, and,

b. the technological tools that could help young female students develop new competencies.

Female professionals in advanced societies, with a desire to improve their career perspectives, may also choose distance learning technologies in order to benefit from continuing education and lifelong learning programs. In fact, due to increasing demands on female working professionals to improve their educational and skills profile, undergraduate and continuing education programmes that are delivered online have become popular with women. Computer-based learning offers time and space flexibility to adult students. In addition, it affords privacy not available in a classroom setting, as well as affording "control of the learning environment" (Burge, 1990; Massoud, 1991). Moreover, a woman many not feel intimidated in a "male dominated" classroom environment. These virtues allow many women to broaden their career perspectives while fulfilling other demands in their lives (i.e. family).

A research study conducted by May (1994) on distance education for women had promising results that could help extend the educational opportunities of adult females and overcome major barriers that have historically turned women away from personal and professional development venues. May (1994) did point out that the students experienced some difficulties getting accustomed to using technology. Regardless, the participants in the above-mentioned research welcomed the opportunity to receive education by using communication technologies in the comfort of their own homes, and contribute at the times that were most convenient according to their personal schedules.

As technological innovations progress and new media are introduced in today's professional spheres, the low participation of women in technical fields is even more noticeable. Sound computer skills and strong abilities in the area of information technology have become an important requirement for a meaningful professional and social life. Ironically, even though the current societal values are advantageous for women in most advanced societies, the lack of interest in new technologies may result in further marginalisation of females from technology related fields.

'Modern' women have endorsed and extensively use most tools related to cooperation and communication on the Internet, especially those that allow for creativity, such as Wikis, blogs or podcasts. Today, there is a large female presence on the web in the form of female communities, networking areas or blogs. This shows that women *do* use modern technology if it fulfills their needs for expression, ability to connect and collaboration (Dahlmann et al., 2006).

There also may be reasons, however, that may hinder woman from using technology. The reasons for this partial female absence from technology (as mentioned previously) appear to be complex. Many women supporters criticize technology for its male-oriented design, reproducing and reinforcing sexist gender ideologies. Female computer anxiety, which was identified by researchers two decades ago, may still be a social construct. Often, at home and in school, young females experience less support than males in computer related activities. Adult women often enter technology-based learning activities with low self-esteem. This tendency could be compounded by the possible problems associated with networks, software and equipment. Hence, female marginalisation is reinforced by male dominance of computer media and technical professions. In general, the parameters that have negatively influenced the participation of women in technology related fields may include access to computer technology, relationship with instructor, social preconceptions, experience gap between males and females, and design of learning material.

As computers are often used as an auxiliary to science/technology courses, where male population may be dominant, few females have access to them. Men-filled computer rooms can feel unwelcome to female students. Further, regarding their relationship with the instructor, females are 'expected' to perform lower than men, thus they may receive less attention. Social stereotypes interfere with academic achievement, discouraging women from engaging in computer-related educational activities. As a result, an experience gap in technology is often observed between men and women (May, 1994; Campbell, 2000). Males presuppose lower technical abilities from their female peers. This attitude towards women may lead to computer anxiety issues, rendering an educational activity a stressful and potentially an unsuccessful experience. If women had more access to computers, thus, more practice and experimentation with technology, perhaps this inequality in technical issues could be eliminated.

Another aspect of the computer science domain that turns women off is the design of the learning software. Learning material involves examples that are often offensive to women. Simulations are likely to be abstract, whereas females tend to prefer real-life contexts with a social focus (Campbell, 2000; Nett et al., 2002).

If distance education and e-learning strategies can accommodate the unique learning needs of woman within the context of an engineering degree program (as well as life-long learning and professional development programs) this may ultimately increase the number of woman enrolled in engineering.

8 RECOMMENDATIONS AND CONCLUSIONS

It is recommended that the following measures be followed by academic institutions (also supported by Csanyi et al. 2007), in order to enhance the usage of technology in teaching:

a. Technology and financial support structures;

b. Quality management; and,

c. Change management.

While support structures can promote innovation in teaching methodologies, quality management would provide ground-breaking teaching research and application with adequate support. By acknowledging the efforts of its educators, especially in the field of distance education methodologies, an academic institution with solid quality management structure can rely on educational research and further expand its undergraduate or continuing education programmes. Lastly, change management would facilitate the transition processes from traditional instruction to self-directed learning.

While technology does not offer instant solutions to every didactic problem, it can certainly benefit both the professor and the learner; the former by providing experiences of success through pioneering work and thus, increasing job satisfaction; the latter by having current educational needs being met, developing autonomy, ownership of the learning practice and responsibility skills.

Most of the cited literature and experiences cited in this paper indicate the need to incorporate and support the development of distance education methodologies in modern academic programs, equally in undergraduate and continuing education. There are no limitations regarding teaching subjects (theoretical or applied) in employing e-learning practices. E-learning systems are already essential in higher education teaching and it is only a matter of time, when such systems become an integral part of all future academic institutions.

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