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Attitudes of engineering faculty towards technology-assisted instruction - a polemic

Malgorzata S. Zywno

Ryerson University
Toronto, Canada

ABSTRACT: Technology has changed all aspects of our lives, including business, industry, communication and entertainment. Yet despite all the innovations and research showing the beneficial effects of technology on learning when it is well integrated into the educational process, today's academics are generally reluctant to incorporate digital technology in their teaching. In this paper, the author suggests that the roots of this reluctance lie in the low knowledge of educational theories and in the lack of instructional design skills, and that voluntary bottom-up faculty initiatives cannot change the prevailing culture of our campuses. The author concludes that an institutional top-down approach is the only effective enabler of systemic change that will allow the universities, and particularly their engineering departments, to meet challenges of the future.

INTRODUCTION

British Prime Minister, Tony Blair, said in the foreword to a recent book that the *Information Age is transforming business, commerce and our working lives … we live in a Global Information Society* [1]. This simple truth will have a profound impact on higher education. Future university students are growing up with digital technologies and accept them to be a natural part of their wired, increasingly interactive world that does not stop at the gates of educational institutions [2].

The question is no longer whether we should use digital technology in education, but rather how we should use it. Advances in Information Technology (IT) have made computers essential tools for university students and faculty alike. Applications include computer-assisted learning environments (simulation tools, databases, virtual libraries, expert and tutoring systems, etc), and more recent hypermedia-assisted learning environments (interactive CD-ROM and the WWW, online laboratories, etc). The distinction between real and electronic classrooms is expected to blur within the next five to eight years.

Yet despite the saturation with computers and an ever-increasing number of studies and initiatives demonstrating how technology can enhance learning, in the majority of university classrooms business is carried out as usual, untouched not only by technology but by modern educational philosophy as well. To make a successful transition into technology-enriched educational environment, a radical change of mindset is therefore required. Change is always difficult, but it is necessary if we academics are to maintain relevancy as education providers. E-education of the future either will become an integral part of the *bricks and mortar* university, or it will bypass it altogether. Since nature abhors a vacuum, other providers of education will step in, for better or worse.

THE DAWN OF E-LEARNING

We live in the age of life-long learning necessitated by a rapidly changing knowledge base, technology-driven globalisation, unpredictable job markets and rapidly decreasing half-life of a university degree, especially in engineering and commerce. With the growth of e-learning and e-communications the link between on-campus and off-campus can now be seamless [3]. Universities have been traditional providers of continuing and distance education for adult learners. The Internet explosion has brought a promise of a rapid expansion of this market. US Department of Education statistics reveal that distance education enrolments in the USA alone are expected to reach 6.6 million by 2007, up from 1.6 million in 1998.

For corporate providers of IT, education represents a potential multibillion-dollar market. John Chambers, CEO of Cisco Systems announced at the 1999 COMDEX Conference that education was going to be the next big *killer application* for the Internet. Thus, universities will experience competition from non-traditional providers in delivering post-secondary education and training. For universities to successfully compete for future learners, the technology-enriched educational environment has to become not only a part of their distance education delivery, but also an integral part of the on-campus learning as well. Future on-campus, workplace and continuing education need to become a part of the same continuum.

IF WE BUILD IT, WILL THEY COME?

The author recalls attending an educational technology conference sometime in 1996 and listening to a litany of reasons why faculty members were so reluctant to embrace technology in their teaching. The list included a lack of institutional vision, lack of infrastructure, equipment, training, resources, time, etc, etc. Three enablers of change necessary to

create the technology-enriched educational environment were identified: institutional vision, support structures and personal attributes of faculty that would allow them to function effectively in such an environment. The consensus at the conference was that the first two were sorely missing, and were largely to blame for the slow pace of technology adoption. Implicit at that time was the bottom-up model of change, where it is assumed that, as the universities provide infrastructure and technical support, the initiatives originating with individual faculty will eventually create a wave of change which will sweep through campuses and change their culture. This belief in a gradual grass-root change mechanism originates with the acceptance theory [4]. According to it, 12-18% of any group are early adopters in their attitudes towards innovations, and 10-12% will never use the new technology. The majority typically resists change, but as evidence accumulates, eventually they shift their patterns of behaviours. The speed of change depends on how compelling the evidence is and how dramatic the change is required.

The author came away from the conference with a feeling that if only the institutional support and resources materialised, the faculty attitudes would surely follow. Five years later, our campuses have increasingly become networked and wired, with investments into retrofitting classrooms for presentation technology and high speed Internet capability. One would be hard-pressed to find an institution of higher learning that has no long-term plan for IT implementation. Most universities have in place support structures, providing training opportunities, professional assistance in creating courseware, etc [5].

Yet, changes in faculty attitudes have not kept pace with the way that the Internet and the WWW have penetrated our collective consciousness and they lag behind the institutional changes and support structures. Because the number of faculty who, as the early adopters, incorporated technology in their teaching, has been so small, their activities, while attracting praise from administration (and often resentment from their peers, who perceived their activities as *raising the bar for all*), did not transform the culture of the campus. As a result, the expected administrative changes did not follow. By and large, several factors have not been dealt with, including issues of creative copyrights, of crediting the time spent creating and maintaining courseware, of accounting for the 24/7 model of counselling students (for effective online counselling, the instructor has to be available 24 hours a day, seven days a week, as opposed to being physically in his/her office for the set number - typically five per week - of face-to-face counselling hours), and of the team approach to course development.

Thus, the early adopters who hoped that their enthusiasm and positive results of research on benefits of technology-assisted instruction alone will be sufficient to convince their peers to follow suit, are beginning to feel burnt out and disillusioned. The bottom-up approach to change has utterly failed.

At different venues, the same arguments are still used to justify the, by now, very obvious faculty reluctance towards technology-enhanced teaching. The lack of technological know-how, lack of access to hardware and software, lack of technical support and lack of time and incentives still top the list. While the last two items are hard to dispute within the current realities of our campus life, the uneven penetration of technology-enhanced instruction on campuses belie the technology-based source of the problem. Over the years, a clear pattern has emerged - social sciences, humanities, education and creative arts are leaders in technology-instruction initiatives, followed by business, while other professional areas, such as medicine and, especially engineering, lag far behind.

The adoption leaders are areas traditionally considered as *soft science*, where one would reasonably expect relatively more problems with overcoming computer fears and with technology-related resources. On the other hand, in science and engineering, computers have become an indispensable research and day-to-day task tool for both faculty and students over the last 20 years. Computer engineering and computer science is what drives the rapid development of IT and of the Internet. Saturation with the PC technology and the WWW access among the engineering faculty and students is approaching 100%. The faculty who routinely use sophisticated software and electronic communications in their research can hardly claim technophobia as the source of their reluctance to investigate the use of technology in their classrooms.

The author's opinion is that the failure of the voluntary, bottom-up approach to technology adoption has nothing to do with technology, and everything to do with educational thought. The penetration patterns of technology-enhanced instruction roughly correspond to how likely the faculty members are expected to be adherents to progressive or conservative educational paradigms. The dismal rates of technology adoption among academics (and among the engineering faculty in particular) are a direct result of the prevalent traditional, instructor-centred education paradigm, and of the low knowledge of educational theories and of instructional design principles.

EDUCATIONAL PARADIGMS

Teachers in general, and academics in particular, traditionally have been viewed as unresponsive to change. Bray writes that:

> *An eighteenth-century surgeon visiting a modern operating theatre would only have the dimmest understanding of what was going on. Medicines, methods, machines, anaesthetics and antiseptics would all be unfamiliar... A teacher from the eighteenth century, by contrast, would have no difficulty comprehending the pedagogy, technology or purpose of what he or she observed in the typical 1990s' classroom: lectures, pencils, chalkboards, active teachers and passive learners*… [6].

Poor teaching, especially in math, engineering and science programmes (inadequate organisation, ineffective presentation, inaccessible faculty) is the most common student complaint and causes many students to drop out [7]. Leading engineering educators have long recognised that meeting the needs of today's students requires a more effective pedagogy than the prevalent *sage-on-the-stage, chalk and talk* approach. Yet most of college-level teaching, especially in engineering and sciences, adheres to traditional, instructor-centred methods.

Smith and Waller in their comparison of old and new paradigms for college teaching, describe the instructor-centred paradigm as based on transferring faculty's knowledge to passive students [8]. The teaching assumption is that any subject area expert can teach. Teaching takes place in a competitive, individualistic atmosphere where faculty holds and exercises power, authority and control. In contrast, the new

paradigm acknowledges that teaching is complex and requires considerable training and effort. It takes place in collaborative atmosphere and power is shared between students and faculty. In the old paradigm, faculty's purpose is to sort and classify students through norm-based competition. In the new paradigm, it is to develop student competencies and talents [8].

The new paradigm introduces elements of *constructivism*, while retaining the principles of learning objectives that are crucial from the point of view of professional, accredited curricula. Constructivism affirms that learners need to actively construct meaning from knowledge and that learning should be collaborative, discovery-based, context-based and learner-oriented [9]. The new paradigm also reinforces principles of good teaching, summarised by Chickering and Gamson in their meta-analysis of 50 years of educational research [10]. They are: communications with students, teamwork and collaboration, active learning, prompt feedback, time on task, communicating high expectations, and respect for diverse ways of learning.

The fact that most academics are most comfortable with the traditional instructor-centred educational model is not necessarily their conscious choice. Teaching at the tertiary level is unique in the sense that, unlike at all other levels of education, academics are not required to hold teaching certificates and they generally have very low levels of educational knowledge. The problem is compounded by the prevailing research-oriented, individualistic, competitive culture permeating teaching departments. University hiring policies are based on scientific expertise and proven ability to conduct research, and not on teaching ability. Bruffee, an expert in collaborative education, succinctly wrote that most of today's academics have learned what they know under the social conditions of academic alienation and aggression [11]. This creates a vicious cycle where students who do well in such traditional, competitive environment go on to become academics themselves and perpetuate it [8].

Since teaching is not the most important component of faculty evaluations in research-driven departments, it often is not a priority for the academics. Their teaching techniques are more often intuitive than grounded in any factual knowledge of theories of learning or principles of instructional design. Consequently, they mimic the traditional approach to which their professors adhered. As well, what transpires within the four walls of the traditional classroom is of fleeting nature, which can mask many deficiencies. They could include risk aversion; fear of losing control and of the status of an all-knowing expert; lack of confidence; lack of communication skills; fear of showing vulnerability; and most of all, low educational knowledge. The technology-enhanced classroom, especially if it is a virtual one, with no face-to-face contact between the instructor and the students, makes such deficiencies painfully obvious. The skill sets that, in the face-to-face environment, make a difference between less-than-adequate but still tolerated teaching and an excellent one, become critical in the technology-enhanced environment.

In the distance education e-learning environment, its success or failure depends not on the sophistication of the technological platform on which it is offered, but on the pedagogy and instructional design. Furthermore, the WWW and hypermedia have a potential of changing the balance of power in the classroom. They can empower learners and shift the locus of control away from the instructor by encouraging complex interactions between educators, learners and content through technology. As such, they are seen as promoting the constructivist approach to learning, and thus as challenging the conservative status quo.

This may help explain why it is so difficult for the current faculty to take up the challenges of technology-enhanced teaching. It requires effective communication, facilitation, interaction, prompt feedback, willingness to take risks, ability to listen and accept criticism, collaboration with peers and openness to peer review, careful planning and attention to instructional design, and structuring learning as an active pursuit; these are all attributes of the progressive, learner-centred educational model. Research suggests that technology-enhanced teaching is most effective in the context of student-centred education where it has to be grounded firmly in curriculum goals and incorporated into the instructional process [8]. However, the educational technology itself does not produce learning and what matters is how it is used. In other words, while technology is not necessary for good teaching, good teaching is required if an adoption of technology in teaching is to result in increased learning.

SO MUCH HAS HAPPENED, NOT MUCH HAS CHANGED…

The opinion that the lack of educational knowledge is at the root of the problem of low adoption rates of instructional technology among academic is gaining currency [12-14]. In the traditional educational paradigm, university professors are first and foremost content experts. According to Mitterer, they possess content-level knowledge, while the support structures provided by universities tend to supply tool-level knowledge [12]. This includes advice and training on the latest hypermedia creation software, access to facilities, etc. However, the process-level knowledge and the knowledge of mapping process onto tools are missing. The former refers to educational theories and models; the latter refers to principles of instructional design. The bottom-up approach to technology adoption on campuses does not include the mechanisms that would enforce bridging the gap between the content level knowledge and the tool level knowledge. As a result, technology implementation rates are marginal, early adopters are burning out at an alarming rate, and our classrooms still would engender familiarity for any 17th Century visitor.

Perpetuating the current state of affairs is to risk the universities becoming increasingly irrelevant as providers of education. Over the next few years, a radical change of mindset is required to embrace progressive educational models and to develop IT implementations to its full capacity without compromising educational ideals. Proponents of the voluntary approach to change point out that this will occur naturally as the older generation of academics retire and the new generation takes their place. However, in the author's opinion, this is not true. Far from it being a generational issue, conservative attitudes and low levels of educational knowledge are perpetuated through a self-selection mechanism by the current institutional culture, hiring policies, lack of incentives and lack of leadership.

TOP-DOWN MODEL OF SYSTEMIC CHANGE

A much more proactive, top-down approach is therefore required. It has to involve and affect all university stakeholders, including administration, faculty and students. It should give a more serious consideration to faculty development [14], as well

as the scholarship of teaching [15]. Teaching scholars can be enablers of change and leaders in the transformation of our campuses, if they are given institutional support. Only administrative changes (such as hiring policies, merit systems, introduction of faculty development programmes, etc) will accomplish what the voluntary efforts failed to do.

An excellent example of the successful top-down systemic change transforming the campus culture comes from RMIT University, in Melbourne, Australia [16]. The University statement of principles locates firmly the use of the new technologies within the student-centred educational philosophy. The strategy included wide consultation, development of operational plans at the Faculty level and the adoption of the Boyer scholarship model that is less divisive between teaching and research [15]. It also included adoption of the continuous quality improvement philosophy and the development of quality check systems. Directors of Teaching Quality in each Faculty were appointed to provide guidance in development and implementation of the Teaching and Learning Strategy, while Directors of Information Technology advise them on the optimum technology within the learning process, and plan investments in infrastructure, hardware, software, and staff development. Faculty members are required to develop Teaching and Learning Guides, specifying the learning objectives and outcomes, performance criteria, assessments, learning resources, request for feedback on the learning experience, etc, which are peer-critiqued.

Such top-down strategies may soon become more frequent. Pressures are building to reform American engineering education [14]. Not the least of such pressures is the adoption of the new engineering accreditation criteria, EC 2000. The criteria were developed to help students become life-long learners, and to develop not only technical, but also critical thinking, interpersonal, communication and entrepreneurial skills [17]. Similar trends are observed in the UK [3] and Australia [16]. Extensive engineering faculty development is therefore needed to equip engineering graduates with the required skills [14].

CONCLUSIONS

Technology adoption in teaching among university professors, particularly in engineering, has been progressing at a painfully slow rate. In order to enable change and to move forward, it is necessary first to correctly identify the problem at hand. The current bottom-up approach to change incorrectly identifies the lack of technological *know-how* as the source of delay and assumes that the adoption rates will improve voluntarily. This approach, while much less demanding of administrators and of strained university resources, is putting universities at risk of becoming increasingly irrelevant as future providers of education and contributing to an unnecessary burnout of the most ardent faculty proponents of change.

In this polemic, the author suggested that the real problem with the slow adoption rates of teaching/learning technologies lies in low levels of educational knowledge, lack of instructional design skills, as well as with the low priority given by faculty to the scholarship of teaching. The author's opinion is that the direct, top-down approach to systemic change is required to ensure that academics take change seriously and continually work to improve teaching and learning, with more discussion of the educational processes. This is particularly important in the engineering faculties where participation in faculty development has never been part of the prevalent culture [14]. Only pressure coming from the top and appropriate structures and resources for faculty development will affect the change in the culture of departments, provide encouragement for educational innovators and direction for the laggards. This will guarantee that our campuses, and particularly our engineering departments, will be able to meet challenges of the future.

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