Can universities survive the 21st century?
Alastair J. S. Summerlee and Jacqueline Murray

Alastair J. S. Summerlee, President and Vice-Chancellor, University of Guelph
Jacqueline Murray, Department of History, MacKinnon Extension, University of Guelph

Abstract
Universities worldwide are facing a number of contradictory and competing pressures that range from under-funding to the very nature of universities and their roles in society. Pressures of the information explosion, the democratization of information through access to the Internet, and the advent of the knowledge-based economies have changed the educational landscape and universities are under threat.

To survive universities need to reform. We must graduate citizens with a broader, interdisciplinary knowledge and an ability to take responsibility for their own learning. At the University of Guelph, we have turned the telescope around and are offering small group introductory courses during the first year of university. Through interdisciplinary, enquiry-based courses we help students develop critical thinking and research skills at the start of their university careers. We have charted the impact of this approach and document significant improvements in motivation, academic achievement, critical thinking, library and other resources use, and personal development. Contact time with faculty is reduced and students have a deeper and more sophisticated approach to learning. The presentation will explore how this approach can be used to create a different type of university education that is more relevant to our complex world.

Introduction
Universities worldwide are facing a number of apparently contradictory and competing pressures ranging from under funding and increased demand to the very nature of universities and their roles in society. Once, universities were the rightful bastion of ideas and knowledge. They served as the repository of all known knowledge, created an environment conducive to discovery and stood as beacons for ethical and social debate on contentious and difficult issues. Now, the pressures of the information explosion, the democratization of information through access to the Internet and the advent of knowledge-based economies have changed the educational landscape and universities are under siege. Moreover, in response to increasing financial pressures, universities have literally hunkered down and let the venue for public debate pass to the mass media, which sensationalizes and distorts information in ways that are inflammatory and counterproductive. To survive, universities must reform.

Ironically, much of the pressure for change can be traced back to universities themselves. The Internet, the child of university inventiveness, poses the greatest threat to university education, discovery and autonomy. Universities are no longer the sole repositories and archives of knowledge. We can no longer control the sequential and incremental release of knowledge to educate the citizens of tomorrow because information is readily accessible to people worldwide. Almost without exception, students and members of the public can consult the Internet and find an answer to any question. Blindly used, this kind of faux knowledge can construct answers, and worse, serve as a surrogate for understanding, on virtually any subject. Free and ready access to information, without an appreciation of the limits of such information, undermines and obviates the ability to think critically and to explore, in detail, issues that should lie at the heart of the important questions facing every society.

Responding to societal pressures
Universities need to change. We need to adapt to the changing circumstances in which we find ourselves. Most especially, we need to change to meet the demands of the information age.

Sadly, with few exceptions, universities are not responding to this challenge by revolution. We are not demonstrating the very wit that invented the Internet in the first place. Most institutions are responding to today's pressures by abrogating our responsibilities and blaming funding agencies, governments and the public for lack of understanding and lack of funding. We are being herded into seeing the mission of universities as being training grounds to fulfill specific and particular roles in society. Wittingly or unwittingly, we are adopting immediate and short-sighted actions in response to the pressures. We are falling into the commercial metaphor that "*to create more product you simply have to streamline the process*". The consequence is the dismantling of education. We reduce knowledge to bite-size pieces of information that can be clearly identified and standardized. We can then define the minimum amount of information that has to be learned (memorized) and then we create standards that can be used to claim mastery of a particular subject. We blindly trust that developing these individual building blocks of information, and stacking them on top of one another, will somehow create an overall level of understanding and knowledge. Too little attention is paid to education, to learning in context, to learning for the sake of learning, and there is too little belief that in-depth learning ultimately results in understanding. If we, as a society, want to create problem-solvers, entrepreneurs and critical, deep thinkers, then universities must be proactive in developing minds that use information and integrate knowledge from the Internet, and the variety of other available sources and resources, into multi-dimensional constructs rather than linear pathways. Such people will have the tools to address the complex problems that face the world. They need to have learning and problem-solving skills that actually mirror the non-linear nature of the Internet itself, and in doing so will change the very face of our world.

Instead of facing up to and dealing with the challenges, universities are responding to the pressures of addressing the laudable and vital goals of accessibility to education, by thoughtlessly joining the pack of lemmings hurtling towards the cliff edge of training at the expense of education. And we all know what happens to the lemmings when they reach the edge of the cliff. Universities are failing to withstand the pressure to train students. We must insist on **educating**, not simply training, students across disciplines. We should have a crucial role in broadening the boundaries of education, a role in developing the young person as an inquisitive and energetic thinker and, above all, a role in stemming the tide of standardization which leads to mediocrity. At the tertiary level, education should be about the process of learning, and students should be encouraged to see the learning process as akin to research and to take responsibility for that research. As universities struggle to adapt to the increasingly interconnected world in which students (and the rest of the world) live, there is a tendency to cling to a vestige of hope that perhaps learning can occur through structured classes, through the hierarchical presentation of information and through the rote learning of content.

Enough of this rhetoric. There are two fundamental questions that need to be addressed: first, should universities even continue to exist? Do they have a meaningful and effective role in today's and tomorrow's society? And second, if they should continue, what should universities do to change their approach to education and regain the moral high ground as vital institutions essential to society?

Universities, as institutions, have withstood the test of centuries but historical longevity alone is not sufficient reason for our continuation. There must be palpable and important reasons for remaining at the centre of our society, even if some of the functions that were once the purview of tertiary education are hived off to other venues. For example, in some jurisdictions research has been peeled off into private and publicly-funded research institutes or training has been

centred in vocational colleges and polytechnics. The principal argument for universities' continued existence should be the centrality of our commitment to civil society and to the pursuit of that old academic "chestnut"--truth: truth in the context of the multi-dimensional interdisciplinary problems that face the world. In a world that is beset by significant challenges, there is an absolute need to have a haven for debate and discussion to further understanding. In fact, arguably, the imperative for an essential role for universities has never been stronger. Societies need a place for reasoned debate to foster and promote understanding, and that place needs to be free from bias and influence from government, business and, most importantly, the media. In creating these safe spaces, universities should also be committed to the development of students' minds so that they will readily engage in finding solutions to complex problems. This requires them to take responsibility for their own learning because they have the capacity to research and synthesize information, and have the motivation to be engaged in the communities and societies around them.

Concentrating on teaching and learning

We need a period of reformation and renaissance in higher education. We need to restore enlightenment to higher education—to make it a place of contemplation and reasoning. We need to regenerate our approach to, and understanding of, teaching and learning, accept the vital need to integrate knowledge across and among disciplines and demonstrate a willingness, even a passion, to participate in civil and civic engagement. All three of these drive a pressing need to reform the undergraduate experience in universities worldwide.

First and foremost, teaching and learning needs to be focused on the process of learning and helping the learner understand exactly how learning occurs. For human beings, learning is as innate as the presence of finger prints but, like those prints, each person has a unique approach, a pattern of learning that is individual. It is important for each of us to understand the broad patterns and concepts of the learning paradigm, to be able to understand our own unique approaches and to capitalize on our individual strengths and work on our individual weaknesses. It is also necessary to be able to understand and use the strengths and weaknesses of others. To drive learning, students should be motivated and that means setting the learning in the context of problems that are relevant or have an intrigue or immediacy that makes investigating them and understanding them an absolute challenge for the student. Inherent in these suggestions are a number of principles about university education that challenge our current approaches and systems. For example, these opportunities should be open to all—regardless of gender, creed, race or age. Universities should not be places for the elite but rather places for an elite-ness of thinking that is accessible to all. They should present problems and issues as complex and integrated, not reduced to readily digestible units (often referred to as disciplinary courses). Finally, they should concentrate on innovation, relevance and applicability and should emphasize skills related to employability and an ability to function in global polities, economies and cultures. In other words, university education should be about process not content; it should be about teaching people how to learn rather than memorizing facts; it should be centred on problems not disciplines so as to create a context in which to learn more; it should marry theoretical and the applied knowledge to help the learner understand why it is necessary to understand the material; it should be involved in, and not isolated from, the communities where students and faculty live and work; it should be about working together in teams and in real-life situations; and it should be relevant to international issues, not limited to the local or national context.

A new approach to teaching and learning

Following the innovations in medical education in the 1960s at McMaster University (Ontario, Canada), there was a slow recognition that medical education needed to change. It has taken almost 50 years but the waves of the experiment at McMaster have rippled across the world and problem- or enquiry-based education has surfaced in many professional schools around the world. And in a number of baccalaureate degree programs, pockets of experimentation with enquiry-based education are beginning to emerge. The fundamental challenge is the need for universities worldwide to engage in serious discussion and debate about how to change university education in the arts, sciences, commerce and social sciences and to foster pedagogical innovation in an environment where fiscal challenges are the predominant consideration. However, the very tenet of enquiry-based learning is working in small groups. In a fiscally restrained postsecondary system this seems to render the idea impossible to implement. Put bluntly, to talk of small group work in a university system that is over-populated and fiscally-constrained might appear to some to be utterly demented.

At the University of Guelph, we have engaged in an experiment in undergraduate education and have produced evidence that would suggest that not only is it possible to think differently about how to approach education but that, with sufficient attention to structures, course weightings, timetabling and the support mechanisms for learning, it is possible to change the form of undergraduate education in disciplines across the arts, sciences, social sciences and commerce. Such changes do make a difference in the overall educational experience of students, in both qualitative and quantitative terms, and could address many areas of lingering dissatisfaction with how universities currently organize undergraduate education and the culture that surrounds it.

As part of broader educational initiatives, the University of Guelph has introduced a program of first-year seminars that literally turns the approach to university education on its head. The first tenet of this approach is small group learning in the first year. Based on literature from the United States that argues that academic engagement is the most important factor to motivate students to take responsibility for their own learning, we have reversed the concept that a university curriculum should begin with larger foundation classes while in the final year teaching should occur in small groups. We have experimented with the idea that first-year university students, across the full array of disciplines, should have a small class experience and work with senior academics, researchers and administrators. Academic faculty and staff were invited to participate in these courses—the criteria for participation were simple: courses had to be truly interdisciplinary (across the arts, social sciences, commerce and the sciences); engage students in active learning; and, be centred on problems or issues. Among these classes, a small number were taught in an enquiry-based format based on the original model described by Barrows (1986; 1996) and Schmidt (1983) and modified by the Bowman Gray Medical School (North Carolina, USA). There are a number of accounts of the subjective outcomes of problem-based learning but there is a lack of empirical evidence, particularly about teaching and learning outside medically-based curricula. At the University of Guelph, we set up a series of problem-based courses which were specifically designed not only to teach students about content but, more importantly, to teach them about their own processing and reasoning skills. The fundamental tenets of this approach were that learning should be about the process of learning, and students should take responsibility for their own learning.

An important change in the discourse
Whilst the literature is replete with views on problem-based learning, it is clear that there is no consistent understanding of the term. This type of learning is based on the study of problems or issues and that gave rise to the name. But this creates three significant challenges: first, there are remarkable differences in the way so-called "problem-based learning" is used and implemented, so rigorous comparisons between approaches are difficult; second, the use of the word "problem" leads people to misunderstand the intent and to assume that there is a problem that the students are supposed to solve, when the pedagogical rationale for this approach is to use problems to stimulate and motivate thinking about the factors and issues that underlie the "problem" —in the best cases (problems) there may be no answer at all or at least not one simple solution; finally, the use of the term problem-based learning is frequently confused with the use of problems in classes to illustrate principles: many faculty will say "*I use problem-based learning*" when they use problems to illustrate subject matter.

In an attempt to resolve this confusion, we (the authors) have started to use the term "**enquiry-based learning**" because it more accurately reflects the rationale for the approach. Students and facilitators are presented with problems or issues that motivate learning. They have no prior formal training in the issue but are expected to make enquiries (do their own research) to understand the principles underlying the problem.

Research on Enquiry-based learning at Guelph
These courses provided an ideal opportunity to carry out objective, empirical research into the impacts of enquiry-based learning. The specific objectives of this research were to explore the students' perceptions of the value of their enquiry-based course in terms of developing their processing and reasoning skills and in meeting their expectations of a university education. We also explored the transferability and persistence of these learning skills over the rest of the students' program of study in two ways: their perception of the persistence of the skills learned in the seminar course, and the actual impact on their marks throughout the rest of their degree program. Finally, we have explored the impact of this approach to teaching and learning on the way students develop their research skills and how they access information through electronic resources, through print media or through fellow students, teachers and librarians. Some of this work is already published (Murray & Summerlee, 2007) and some is in preparation for publication (Murray, Christensen-Hughes and Summerlee).

The observations and performance of a group of students in an enquiry-based first-year seminar were compared with students who had chosen to register for a different first-year seminar (i.e., a small group interdisciplinary experience but one that did not have the explicit objective of teaching and developing processing and reasoning skills) and students who did not choose to participate in the first-year seminar program. The students were matched for entering grades at the start of the research. The observations have been repeated for more than one class.

First, it is important to be clear about the specifics of the particular approach to enquiry-based learning used in these. The seminars were conducted as closed-loop reiterative sessions. Almost all other accounts in the literature describe so-called problem-based learning that is really a hybrid including content delivery, problem-solving and testing. In closed-loop reiterative, enquiry-based learning, students work in a small group with one, or possibly two, facilitators. There are no more than nine students in a group. They are presented with a scenario that poses a problem or a conundrum and are required to discuss it and explore issues that arise. The fundamental task for the students is to identify issues and learn the context that underpins the

scenario through their own independent research. They are not provided with any additional information or explanation before or during the discussion, and the role of the facilitator(s) is to guide the students to identify the issues presented. The students' task is not to "solve" the problem but rather to use the scenario as the starting point to generate learning issues that they will chose to research, so they can come to an understanding of the issues behind the problem. As the students discuss the case, they develop a series of ideas and questions that they will then research.

Perhaps this is best illustrated with an example. Students in a course on Politics, Science and the Environment were given the following problem:

> *You are working for the Minister of Agriculture in the province of Saskatchewan. There is a report in the Regina-Leader Post about the apparent absence of Monarch butterflies in the province during August and September this year. A member of the opposition has indicated that he will pose questions to the Minister during question period in two days.*
> *You are asked to prepare a brief for the Minister on the issue and provide some advice on the possible questions that may be asked and suggest answers that might be appropriate.*

The students are provided with an article from the Regina-Leader Post that describes a scientific conference on the apparent disappearance of the butterflies and quotes environmental groups who claim that the disappearance is caused by pollen from genetically-modified corn killing the caterpillars of the Monarch butterfly. During the course of their discussion, students are expected to identify issues that they do not understand. These are likely to include: issues related to politics and policy development; the science of genetic modification and its known impacts or not; environmental issues including the impact of environmental change on the migratory pattern of the Monarch; and, a host of other issues. No help is provided in finding resources but students are encouraged to search for answers in the library as well as on the Internet and come back to the group to present their learning and discuss the impact of that information on their understanding. The value of this approach is that it slows down the thinking process. Students externalize their thinking and begin to articulate and understand the various stages of the learning. The students are able to focus, at the sophisticated levels, on learning within Bloom's taxonomy of educational objectives (Bloom, 1956). When presented with a scenario, they are encouraged to ask three fundamental questions: (1) what do I know; (2) what do I not know; and, (3) where is the best place to get the information I need. The facilitators serve simply to keep the students on track, to guide them through the thinking process, to role model thinking and processing but not to serve as the purveyors of knowledge. This last point is absolutely vital. For example; the facilitators role-model asking questions that provoke the students into identifying information that is known and ask questions that uncover a lack of understanding. They also help to keep the students on task. At the second (or subsequent) meeting, each student presents a short discussion on their particular learning issue(s). By agreeing with their colleagues to undertake the research, they make a contract, an un-written bond with their peers, to engage in this research. This un-written contract is a vital part of the learning process because it motivates the students to perform in front of their peers. Effort is made by the facilitator(s) to press the students to be specific about their learning issues, to be critical of their sources and to bring reference material to the sessions. Over time, the quality and clarity of these presentations improves and the depth of critical thinking and analysis becomes very sophisticated. The students emulate the facilitator(s) and question each other, probe the

veracity of the sources of information, rapidly come to appreciate differences and areas of contradictory information and ideas, and start to synthesize knowledge and opinions as multi-level attitudes to complex, multi-layered problems. At each stage, the information presented is integrated into the problem and the process of reading through additional pages of the case continues—and more learning issues arise.

Every meeting of the group ends with a period of group processing. This step is absolutely essential to the learning process. Each member of the group, including facilitator(s), provides oral feedback to every other member of the group along with a critique of their own performance. The feedback must be explicit, specific and focused on the behaviours and actions of members of the group that helped or hindered process. The role of the facilitator(s) is to ensure that this feedback is completed at every session, to model the approach and to ensure that the comments are honest, accurate and respectful. It is vital that the facilitator(s) create and maintain a space that is safe and effective for this process. Inevitably, this part of the learning process is uncomfortable at first but it is an essential component of the learning process.

Finally, it is crucial that the formal evaluation in this type of a course mirrors the method of learning. Therefore, the evaluation strategy depends on two approaches: a written version of the oral assessments provided in group processing, that is a summative response by each participant about their own performance and that of every other member of the group. The written critique is also completed by the students about the facilitator(s) and v*ice versa*. The second component of the formal evaluation is a written case, presented as a scenario as described above. Whilst students may collaborate to create a list of learning issues, they are asked to research and write an analysis of the case independently.

The results of this pedagogy have been dramatic: the students respond with great warmth and sincerity to the motivation created through the intrigue of the scenarios. They show a genuine desire to learn the background material associated with each scenario. They rapidly learn to use the library and information resources effectively, to integrate their learning with that of the others, and they demonstrate confidence in tackling difficult and complex subjects, show an understanding of processing and reasoning methodology and report an overall level of engagement and satisfaction with the learning process. More importantly, the students in the enquiry-based seminar course scored significantly higher in these (and other) areas compared with the other groups of students studied (Murray & Summerlee, 2007). Perhaps more significant, though, is the lasting impact on the learning capabilities of students. The students in the enquiry-based courses show significantly improved academic grades in their subsequent courses compared with their matched peers in the other groups (Murray & Summerlee, in preparation). By the time they graduate, the difference is an average of 10 grade points higher (range 8-12 percentage points) which is significantly different from both the comparator groups (Figure 1). There is no difference between the students in other small group seminars and students who chose to remain in traditional classes: in both cases the performance of students in these two types of groups is below that of the enquiry-based students. These data suggest that it is not the act of choosing a small group class that results in the grade difference, but the approach to teaching and learning in the enquiry-based classes.

Figure 1. The impact of one first-year course using enquiry based learning (EBL) on the average grades during the remainder of the course of study compared with a control group of students in a self-selected seminar taught in a more traditional mode (Non-EBL) and a control group of students (Control) taught in standard didactic lectures.
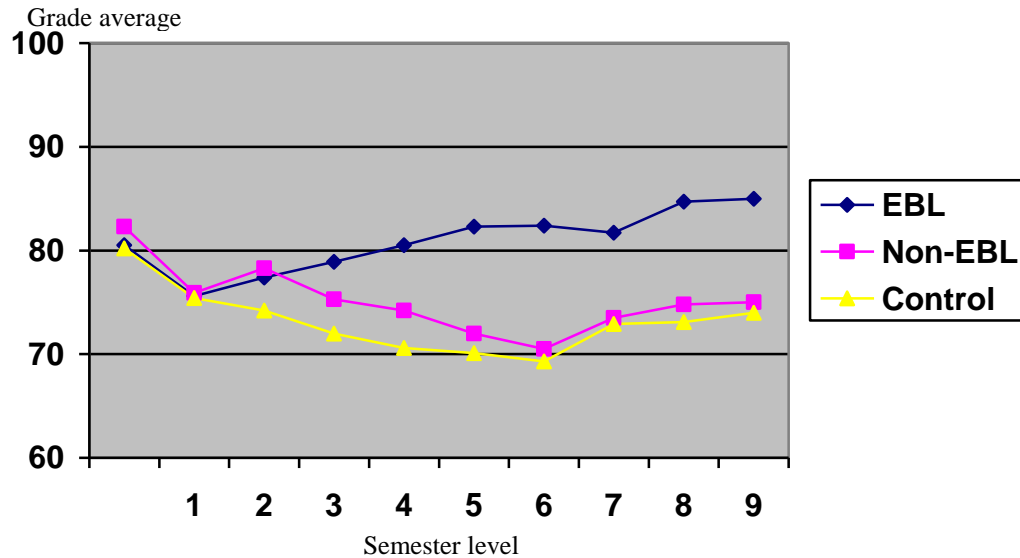
The students in the enquiry-based group also provide interesting reflective comments on their experiences and abilities. These include comments like: *"I developed a passion for learning"* and *"I developed life-long skills about how to learn"*. Whilst these comments are simple reflections on the experience, some made more considered comments about the impact. For example: *"The most important skill that I learned was to believe that no problem, no issue was beyond my comprehension."* And, if this were not sufficient, the same student wrote *"I arrived at University to do business because I did not believe I could learn science and was not interested in history and the arts. This course made me realize that learning is a passion and every subject, every aspect of learning about anything is not only exciting but fun"*. The students also recognized that the skills were transferable *"This skills that I learned* [in this course] *have been at the heart of my success at University"*. At the same time, most students recognized that they had learned to use the library effectively and had developed analytical skills that served them well in other courses and activities at the university. In the study that is currently being prepared for publication, we document the changes in the use of resources and the degree to which students rapidly become both familiar with information resources and critical of resources that are popularly accessed (Wikipedia and the Internet in most cases) but they are also able to integrate and use such resources effectively and reliably in their research. Preferentially, students in the enquiry-based courses changed their research habits to access original articles and scholarly publications, and specialized encyclopedias and institutional research databases (Table I). They reduced their reliance on Wikipedia and more rudimentary search engines. The students report that they also engaged reference librarians proactively in their research and relied less on teachers and especially other students for advice (Table I). Anecdotally, reference librarians at the university comment positively on the enthusiasm and commitment of the students in the enquiry-based learning seminars.

Table I: Changes in the access and use of resources reported by students before and after an EBL course.

Access to resources	Significance
Internet search engine	NS
Wikipedia	Less $p < 0.05$
On-line databases	More $p < 0.05$
Specialized research institution websites	More $p < 0.01$
Generalized encyclopedias	More $p < 0.05$
Specialized encyclopedias	More $p < 0.01$
Reference librarians	More $p < 0.01$
Professors and teaching assistants	Less $p < 0.05$

Finally, we have charted the time students spend in learning and researching in the enquiry-based course compared with students in traditional courses. In general, students at the University of Guelph are registered for five courses a semester and spend three to five hours in contact with faculty in a classroom/seminar/laboratory setting per week per course – a total of 15-25 hours per week. In a survey of students, most report that they spend an additional five hours per week per course on learning outside the classroom. It is perhaps pertinent to point out that this means that students in a traditional curriculum (at least in Canada) are spending 40-50 hours per week on their academic studies. Students in the enquiry-based class spent three to four hours per week in the classroom settings and they estimate that they spent 10-15 hours per week on learning time outside the class researching their learning issues. In other words, this one course occupied almost half the amount of time normally taken to complete five courses in the semester. The amount of time per week varied with the problem and the complexity of the learning issues, but students overwhelmingly commented that they were *"motivated to learn and to learn more"*. Many reported that they would have liked to do more, but had to complete work in other courses. This raises the possibility of reducing the number of courses per semester to allow students to focus their efforts on the enquiry-based course alone. Given the demonstrated positive impact of this approach to learning on the academic achievement of students and the monumental shift in how they approach learning, researching and analyzing information, and their willingness to engage fully with this approach, it raises the possibility of changing the nature of undergraduate university education in ways that could revolutionize learning. Moreover, this could be done with fewer resources.

One question that arises with these data is whether enquiry-based learning is equally effective with students who have previously demonstrated a high level of academic achievement and those toward the bottom of the entering class. It is obvious, as each class progresses, that there are some students who adapt quickly to this approach to learning and some who take longer to become accustomed to working in this fashion. But, regardless of their entering average or disciplinary major, students show a similar overall percentage improvement in academic achievement by the end of their degree, irrespective of their starting point (Figure 2). In fact, although not statistically significant, there was a clear trend that the weaker students (in terms of admission grades) demonstrated a greater increase in performance compared with those entering with higher average grades.

Figure 2: Comparison of the average change in grades for students who took one EBL seminar in their first year on their final grades at graduation. The data are analyzed by the admission average of students entering the university. The classes were split into four quartiles based on admission average. In each case there is an 8-12 percentage point increase in grade.
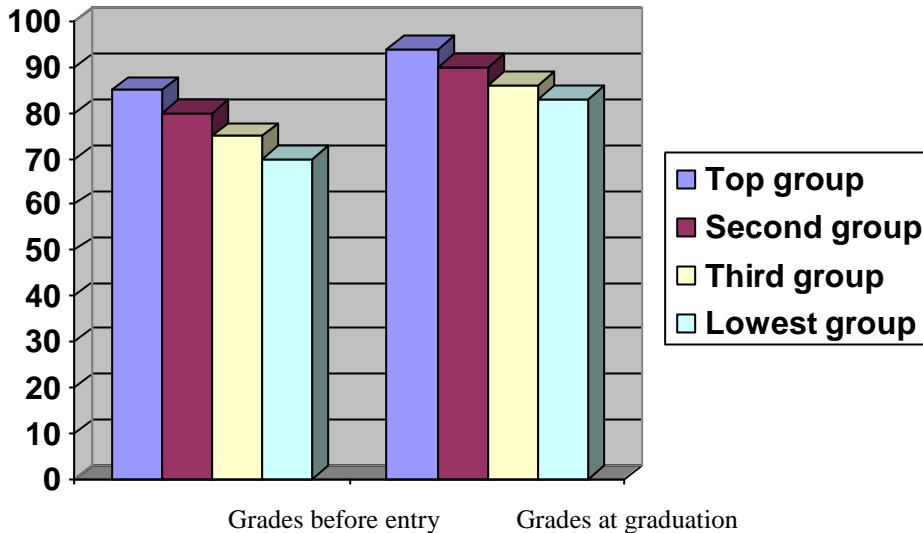
In a world that is increasingly complex, where information is becoming ubiquitous and overwhelming, where we need students to be able to think critically and independently **and** where there is an overwhelming pressure to educate people, we need to change the way of teaching and learning for our students.

Think for a minute about the impact of changing the face of education for university students. If one course using an enquiry-based approach can have such a profound impact on the learning experiences and abilities and accomplishments of students, what could a succession of these do over the course of an undergraduate degree, or even part of a degree? If one course can be delivered with less student:faculty contact time, but incite more independent and more effective learning, imagine the impact overall on faculty time. If faculty were spending less time in the classroom, whilst at the same time the students were more extensively engaged in their own self-driven research and learning, there would genuinely be more time available for faculty-based research and for the supervision of graduate/postgraduate students. Perhaps this could be the revolution that would change the face of higher education and create the kind of efficiencies sought from political masters and mistresses? Finally, imagine the process of developing the "problems" or "cases" that the students would study. It would be possible to involve industry and business leaders and representatives of the voluntary sector and civil society in the design of cases. This process could result in a unique type of private-public partnership that would transform education. At the same time, we could preserve and restore some of the very tenets of higher education that have been treasured by academia over the millennia, and we could foster genuine intellectual curiosity in our students.

Universities need to change. We need to adapt to the changing circumstances in which we find ourselves. Most especially, we need to change to meet the demands of the information age. And there is a way to do it. We can change without forsaking the fundamental pillars of an open and autonomous approach to learning and the generation/synthesis of knowledge. Just as we

have revolutionized communication throughout the world, we have the ability to revolutionize and modernize higher education. Indeed, we have a duty to do so.

References:

Barrows H (1986). A taxonomy of problem-based learning methods. *Medical Education* **20.6:** 481-486.

Barrows H (1996). Problem-based learning in medicine and beyond: a brief overview. In L. Wilkerson and W. Gijselaers (Eds.), *New directions for teaching and learning.* **68:** pp 3-12. San Francisco: Jossy-Boss.

Murray J, Summerlee AJS (2007). The impact of problem-based learning in an interdisciplinary first-year program on student learning behaviour. *Canadian Journal of Higher Education* **37:** 85-105.

Murray J, Christensen-Hughes J, Summerlee AJS. (in preparation). Enquiry-based learning and the link to empowerment. *Canadian Journal of Higher Education* (to be submitted September 2008)

Murray J, Summerlee AJS (in preparation). The quantitative impact of enquiry-based learning on performance and research skills. *Canadian Journal of Higher Education* (to be September 2008)

Schmidt H (1983). Problem-based learning: Rationale and description. *Medical Education* **62:** 305-315.