Introduction

The Alan Blizzard Award was created by the Society for Teaching and Learning in Higher Education (STLHE) to honour its former President (1987-1995) Alan Blizzard, on his retirement, for his significant contributions to the society. Designed to stimulate and reward collaborative efforts to enhance the effectiveness of university teaching and learning, the Award encourages and disseminates scholarship and effectiveness in teaching and learning. Each year the Blizzard Award winners present the Blizzard Plenary address at the Society's annual conference, and a monograph describing the project is circulated to all Canadian universities.

The concept for the Blizzard Award was developed by a committee including Chris Knapper (President 1982-1987), Alan Blizzard (President 1987-1997), Pat Rogers (President 1995-2000) and Dale Roy (Coordinator, 3M Teaching Fellowship Programme). The Alan Blizzard Award is sponsored by McGraw Hill Ryerson (Higher Education Division) and *University Affairs*, Canada's higher education magazine. The Society is particularly grateful to Petra Cooper and Joe Saundercook of McGraw-Hill Ryerson, for their advice in the conceptual stages of the design of the Award, and for their ongoing support of this project. McGraw-Hill Ryerson supports this Award as part of their focus on student success and faculty support. For more information go to www.mcgrawhill.ca/highereducation.

This year, seventeen applications were received from fifteen Canadian universities. This monograph contains papers summarizing the two winning projects. Readers who are intrigued by the possibility of adapting these projects to their own institutions are encouraged to contact the authors directly. For more information and guidelines for submitting a nomination for the 2003 Blizzard Awards, visit the STLHE website at www.tss.uoguelph.ca/stlhe/.

Ron Marken, Director
The Gwenna Moss Teaching & Learning Centre
University of Saskatchewan
October 2002

An application to the Society for Teaching and Learning in Higher Education:

Alan Blizzard Award

for Collaborative Projects that Improve Student Learning

Section A: Information

1. Developing critical thinking skills in a multidisciplinary context: meeting the challenges of collaborative teaching in the McGill School of Environment

2. An ongoing project begun in 1997-98

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4. 18 February 2002

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Terry Wheeler, Associate Professor, Natural Resource Sciences

Section B: Precise nature of the collaboration

Seven professors from six departments in two faculties actively collaborate to design and deliver an interdisciplinary course integrating material from the natural sciences. Our course, The Evolving Earth, is part of the introductory core curriculum in the McGill School of Environment. This core curriculum was created during 1997-98 through discussions initially involving an even wider range of professors; the teaching team contributed to and continues the process of refining the content and approach to teaching and assessment in this core course. The Evolving Earth addresses the roles of chance, necessity and history in shaping the Earth and its biota, with an emphasis on patterns in biodiversity through time and the nature of the physical and biological processes that underlie these patterns. We give the course every winter semester to ~175 students, about evenly split between B.A.(Environment) and B.Sc.(Environment) programs.

We are committed to: 1) having most lectures given by at least two professors offering different perspectives on a topic, 2) promoting student discussion during lectures, 3) having professors attend all lectures, joining class discussions as apropos, and 4) using essay assignments and on-line discussion groups to help students work through and understand concepts and be able to apply the course themes. We give each lecture twice, once on each McGill campus, with travel time between lectures devoted to discussions of student response to the lecture and how it might be improved. We meet for workshops in spring and fall to adjust lectures and discuss ways to improve learning in assignments. We exchange readings and ideas throughout the year that carry well beyond the course and flow back into its cross-disciplinary integration. We are convinced that our own learning at the interfaces among our disciplinary specialties has led to the creation of an unusually effective teaching and learning environment.

Section C. Project abstract

We are seven professors from six departments in two faculties who teach one of four introductory core courses in the McGill School of Environment. Our course, The Evolving Earth, addresses the history of the Earth with an emphasis on the patterns in biodiversity through time and the nature of the physical and biological processes that underlie these patterns. The course demands a rich, cross-disciplinary perspective rooted in the natural sciences combined with a sensitivity to the roles of chance and historical contingency. Our collaborative efforts to develop the course fall in three phases: 1) initial creation of the course concept, content and teaching methods 2) implementation and refinement of the course, and 3) discovering ways to sustain the founding spirit of the course. The latter two are ongoing. We give the course every winter semester to ~175 students, about evenly split between B.A. (Environment) and B.Sc. (Environment) programs. Weaving together the individual threads of our training and experience to effectively teach this comprehensive perspective on the history of the Earth and its biota has been our major challenge and our major achievement.

We want our students to recognize the multidisciplinary nature of environmental problems, and to learn how to think across disciplines in creative and useful ways. We want them to be able to find and analyze information relevant to an environmental problem, to know how to critically assess ideas in environmental discourse. Toward these ends, we juxtapose alternative views in our lectures and encourage student interventions to explore ideas. We emphasize the nature of scientific inference and the strength and weakness of different lines of evidence. We design our assessments of student learning to encourage and strengthen critical thinking. Midterm and final exams are essay format, emphasizing reasoning and broad ideas over simple recall of facts. Students are called on to apply what they have learned to situations not covered in lectures. We annotate the midterm with detailed advice on how the essays might have been improved in content and clarity of argument. We break the students into groups to carry on an online discussion on an assigned topic throughout the semester. This assignment begins the first week with each student searching the primary literature for a relevant publication, which s/he then summarizes and critiques for the group. We provide support systems (various documents, personal interventions, library and web resources) to facilitate their search and evaluation of articles. These individual contributions lay the foundation for a discussion of the topic in the course learning space (WebCT) to which the professors also contribute. Finally, a thematic essay assignment demands thoughtful synthesis of key ideas in the course using information gleaned from library and web research. A first draft is edited and returned for revision, with the final mark contingent on both the overall quality of the work and the degree to which the final draft responds effectively to editorial advice. Overall, we strive to challenge every student, from the weakest to the strongest, and we provide the different sorts of help that each individual needs to learn and improve their abilities.

Section D: Project description

Institutional Context

Teaching in the McGill School of Environment (MSE) began in September, 1998. The MSE seeks to provide a unified undergraduate curriculum in all aspects of environmental studies including ethics, economics, the social sciences, and the natural sciences. The curriculum rests on four introductory core courses taken by all students earning either a B.A. (Environment) or a B.Sc. (Environment). These are MSE 200: The Global Environment, MSE 201: Society and Environment, MSE 202: The Evolving Earth, and MSE 203: Knowledge, Ethics and Environment. In a given year about 175-200 students take each course, mostly MSE students but also some students in engineering, business, agriculture and other programs who take the courses as electives.

The primary purpose of the core is to prepare students in the MSE for upper level study in a specific Domain: for example, Environment and Development, Biodiversity and Conservation, Water Environments and Ecosystems, and Environmetrics. Courses from several departments across Faculties cooperating with the MSE make up these domains. The MSE requires that all Domains involve staff and courses from more than one department, thus reinforcing the well-grounded, cross-disciplinary synthesis that the school promotes in its overall program. The emphasis on interdisciplinary and synthetic approaches to environmental issues culminates in two advanced core courses in the senior year: Environmental Thought and Environmental Research. These bring together students from different Domains who can apply their diverse training and experience to specific environmental problems or issues as part of an interdisciplinary team.

Goals of the Project

Curriculum Goals

The challenge in designing The Evolving Earth was to find ways for students with diverse backgrounds in arts and science to begin to develop the analytic and synthetic skills needed throughout the later stages of the MSE program. On one hand, we need to provide students an essential compendium of concepts from the biological and physical sciences that are critical to discourse in environment. On the other, we need to teach students how to move fluently across disciplinary boundaries and bring multidimensional perspectives to bear in discussion and analysis of environmental issues. If we strike the balance wrong, we may tilt students too much toward one discipline or another. That is not in itself a bad thing, but too early specialization in a single discipline can later inhibit the ability to work through intrinsically multidisciplinary environmental issues and problems. Students may become so adept at thinking about an environmental issue from the perspective of one particular discipline that they lose the ability to work productively with people bringing alternative perspectives to a problem. Conversely, a second risk is that we will train students good at talking about different views about an environmental issue, but in fact unable to do so in a well-informed and critical way. Their knowledge may be broad, but facile. An important goal of our course is to steer between these two poles. We seek to train students who in the end will appreciate the views of experts in various disciplines, be able to critically evaluate their points of view on a problem, and thus be able to facilitate creative, cross-disciplinary solutions to environmental problems. The Evolving Earth strives to achieve this balance between information and perspective across a range of allied disciplines in the biological and earth sciences.

Learning Goals

Level I: Mastery of a basic set of concepts, processes and patterns that bear on understanding and interpretation of landscapes and their associated biota.

> Focal Concepts: Equilibrium, stability, feedback and dynamic control, stochasticity, spatial and temporal scale, habitat and niche, tolerance and stress, acclimation and adaptation, population and species, life cycles and life history, landscape diversity, genetic diversity, and species diversity.
>
> Key Processes: Tectonics and volcanism, weathering and erosion, transport and deposition, glaciation, pedogenesis, replication and mutation, sex and meiosis, reassortment and recombination, selection and adaptation, dispersal and migration, fragmentation and isolation, evolution and diversification, speciation and extinction, coevolution.
>
> Principal Patterns: Stratigraphy, landforms, organismal diversity, phylogeny.

Level II: Learn analytic, synthetic and research skills required to develop independent thought about environmental issues

- Learn to use databases to find relevant information, not just in the secondary and tertiary sources but also in the primary literature
- Learn to evaluate the quality of information in terms of its source and the relationship between evidence and conclusions
- Develop analytic and interpretive skills suited to complex, multiple interactions that bear on species diversity, habitat diversity, extinction and related issues.
- Develop the ability to analyze an environment: evaluate the present landscape and biota as a particular outcome of chance, necessity and history.
- Learn the basic elements of predicting future states of an environment: modelling dynamic interactions between biotic and abiotic factors, appreciating and allowing for the nature of uncertainty and contingency in determining future landscapes and biota.

Course Development

The project of developing the Evolving Earth as an effective core course within the MSE falls in three phases, the latter two still ongoing: 1) initial creation of the course concept, content and teaching methods 2) implementation and refinement of the course in response to student feedback, and 3) discovering ways to sustain the founding spirit and purpose of the course. The first phase occurred in the 1997/98 academic year when the course and the MSE itself were being created. The second phase began in winter 1999 when the course was first taught. The third phase began in winter 2001 when we first had to deal with sabbatical replacements and the integration of new staff into the teaching team. Each phase posed challenges and taught us lessons about interdisciplinary collaboration and the nature of student learning that are detailed in the sections that follow.

Phase I: Creation of the Course Concept

The 1997/98 academic year at McGill was an exciting, if tumultuous, experience for many of us. About 50 professors had committed to trying to create the McGill School of Environment by drawing together

resources from the Faculties of Arts, Science and Agricultural & Environmental Sciences. During a workshop in January 1997, we had agreed to a set of four introductory core courses that would comprise a unified base in this new curriculum, but each core course was described only in broad and rather vague outline. We chose not to dictate teaching teams responsible for developing each core course, but rather to let individuals coalesce by choice in working groups to create the course that most interested them. Each working group did have a chair appointed by the MSE Steering Committee. These working groups began meeting in September 1997 and their work continued through the academic year and into summer 1998.

The group that gathered to create what would become The Evolving Earth was much larger than the eventual teaching team. At its core were individuals who hoped to teach in the course, although not all ended up as members of the teaching team. Some individuals were attending more than one working group, partly out of uncertainty as to their ultimate commitment and partly to ensure some integration of discussions across the four working groups. Department chairs attended discussions to decide what departmental resources could be seconded to MSE teaching, and to assess if MSE students taking upper level courses in their departments would be well prepared. Some individuals came to the meetings with serious concern for the impact of the MSE on their departmental curriculum, and were often determined to infuse the course with material that would attract students to their discipline. Others came with a broad commitment to building a course that drew on many disciplines in the natural sciences, but with widely disparate views on how that might best be done. At the outset, it is fair to say that everyone saw the problem from the perspective of the discipline in which they were trained and worked. The challenge was to move the discussion forward in a rational and coherent way.

Early discussions focused on treating the course as a survey of earth history, the sort of course that might use a text like Steven Stanley's *Earth System History*. In this view the course would trace a chronology of key abiotic and biotic events in earth history. Some professors even came with fully prepared “modules” of two to several lectures in their discipline that they would give as their contribution to the course. This approach raised two serious problems. First, there was little agreement on how to balance the material. Individuals argued that this or that information in their discipline just <u>had</u> to be in the course, and often that teaching the topic just <u>had</u> to allow time for some background lectures as well. It became clear that all the "essential material" from the four or five disciplines represented in the discussions was not going to fit into our 39 hours of lectures! Secondly, we gradually began to realize that a chronological and historical approach was not by itself going to be an effective way for students to learn what they needed to do well in the MSE curriculum. We wanted to teach not just earth history, but also the nature of the <u>interactions</u> between biotic and abiotic processes that underlay this history. That realization, and an inspired suggestion from one individual, moved the discussion to another level.

The inspiration came from Jacques Monod's 1970 book entitled *Le hasard et la nécessité*, which opens with an epigraph attributed to Democritus "Everything existing in the Universe is the fruit of chance and of necessity". We adopted this view as a theme for organizing the course, while adding a third element: history. This let us change the focus of our discussions from trying to condense everyone's favorite topics into a course on earth history to instead selecting examples in earth history that would let us bring illustrate and explore this tripartite perspective. In other words, we shifted from a focus on factual content to a focus on an organizing idea. We abandoned the notion that we had to teach all the basic background in all the disciplines represented within the working group. The focus shifted to what background material should be selected, not only to provide the more essential elements in any contributing discipline, but also to best illustrate the workings of chance, necessity and history in structuring our world. This emphasis on an idea changed the tone of our discussions significantly.

Some individuals were unable to accept and work within this developing conceptual framework, and they gradually dropped out of the working group.

Those of us who stayed on struggled to understand one another's points of view in this new framework. The working group now was smaller; we had come to know one another better; and the discussions were increasingly free-wheeling. We also had slowly begun to listen more closely to one another, and insist on getting past jargon to the core ideas associated with a topic. We realized that some apparently shared words and concepts did not carry the same meanings across disciplines (…even evolution itself!). We realized some topics of central interest in our disciplines did not necessarily stimulate much interest in related disciplines, while other topics had everyone contributing connections to their own discipline. Overall, two characteristics of our best discussions began to emerge. First, discussions made most sense when we explicitly identified the spatial and temporal scales associated with a topic or concept. Second, we realized that we all shared an interest in the relationships between patterns in nature and the processes that created the patterns. Some of us emphasized pattern, others process, but all of us recognized and respected the connection. Our discussion took another major step forward at this point. We decided to incorporate these two insights into the learning goals of the course itself -- we would teach students about the importance of scale in framing problems, and about the nature of the relationships between pattern and process.

That decided, we recognized the need to create a list of key concepts and processes that would be the knowledge base for our course; only then could we turn back to discussions of which patterns in nature provide the best examples to illustrate these concepts and processes. At this point, we sought the help of Cynthia Weston and Terry Gandell from the Centre for University Teaching and Learning to facilitate our discussions. They convened two workshops that helped us achieve some important goals. First, we settled on a list of key concepts and processes that remains part of the foundation of the course. Second, and perhaps more important, they helped us identify an innovative and coherent framework to organize the sequence of 26 lectures. The framework centered the lectures around three specific time periods in earth history. The emerging framework did not serve the personal or departmental goals of everyone and some individuals left the working group at this juncture. Those who stayed were individuals comfortable with the frank give and take of discussions and who were attracted to the emerging blend of disciplinary perspectives. We had begun to realize how much we were learning from one another and how exciting it could be to teach this material to our students.

Phase II: Teaching and Improving the Course

By early summer 1998, the four introductory core courses in the MSE had all taken form and the MSE Executive had to take some decisions on who would actually teach each course. This involved negotiations with department chairs to approve secondments, and a good deal of juggling of possibilities to achieve balance across the core courses taught on each of the two McGill campuses. The initial teaching team for The Evolving Earth was Don Baker, Martin Lechowicz (coordinator on downtown campus), Jeanne Paquette, Wayne Pollard, Marcia Waterway (coordinator on Macdonald campus) and Terry Wheeler. All of these individuals had been involved with the working group. We would have two teaching assistants and would begin teaching in January 1999. This teaching team now picked up the discussions from the working group and carried them forward from concept to implementation.

We agreed that, unlike the other core courses, we would not break up and teach separate courses on the two McGill campuses. We would all six teach the course together, travelling between the campuses and giving the lecture twice each class day. We wanted to be able to watch student reactions during colleagues' lectures and try to gauge how students heard the lecture. We committed to developing our

lectures cooperatively, and giving them jointly to the degree that was feasible and appropriate. We consciously decided not to let the course fall into the carousel style of team teaching with one professor following another every few weeks of lectures. We wanted to continue to work together to refine the ideas and the teaching in our course. We had bonded as a team in the working group and had learned so much from our interactions that we wanted to keep that spirit alive in the course and communicate our growing insights to the students.

By fall 1998, we had arrived at a reasonable series of team-taught lectures, but we needed to sort out assignments and assessment strategies in the course. We turned our discussions to those points, looking especially for ways to generate an interplay between the class discussions and the individual or group efforts of students to work through the ideas given in lecture. We settled on three forms of assessment: 1) essay exams, 2) a thematic essay, and 3) an online discussion of a specific topic for each of several subgroups of the class. All three approaches were purposely designed to ensure explicit feedback to the students so they could evaluate and improve their progressive mastery of the concepts and approaches we were teaching.

Essay Exams: We agreed on essay examinations from the start to encourage students to learn how to think and reason about the nature of environment and biotic diversity. In 1999 we set a comprehensive final exam, but no midterm – that was a mistake. The students need an early encounter with an essay exam to appreciate how to approach the course material. When we introduced the midterm in winter 2000, we therefore made it a low percentage of the course mark and used it as a learning experience. We invested a significant part of the available TA time in providing detailed comments on the midterm essays. We purposely set questions that required a manageable degree of synthesis of ideas from different lectures, and that touched on abiotic and biotic patterns and processes in a balanced way. We provided detailed scenarios of possible answers to the TAs, emphasized they should critique the student reasoning not "count points" in the answers, spot-checked and discussed their initial efforts, and finally checked their overall marking for consistency. We hoped that the students' experience of doing the midterm and the feedback given them would yield better performance in the course and especially on the essay final exam.

Thematic essay: We set out to design an essay topic that respected the content and goals of the course and that was more or less immune to plagiarism from stock papers available on the Web or from students who had taken the course before. This precluded any simple topics that merely reviewed a concept, pattern or process. Instead we required students to choose one of the processes discussed in the course, identify a pattern generated by the process and illustrate how the interplay between pattern and process is affected in this instance by chance, necessity and history. We wanted the students to struggle to apply the concepts they had learned in class and develop their own synthesis, rather than review a lot of facts. We encouraged students to discuss potential topics with the professors. Assessment involved two stages: TA's made a detailed critique of the submitted essays, which were then returned for revision and resubmitted for marking by a professor. The TA's gave comments not only on content and style, but also on adherence to the themes of chance, necessity and history and on how well the interaction between abiotic and biotic factors was considered. The students had one week to revise the paper, after which they handed in both drafts. The final assessment by a professor was determined both by the quality of the final product and the way in which the student responded to the TA's critique.

Online discussion: Most students in this introductory course are unfamiliar with literature research, ignorant of distinctions between primary, secondary and tertiary literature, and tend to read things very uncritically. They have little idea how to search for information except in textbooks, encyclopedias and similar tertiary formats. We strongly believe that the sooner students learn how to find and assess

primary literature, the more likely they are not to fall prey to the many specious arguments that dog discussions of environmental problems. We therefore set out to create a component in the course that would immediately begin to help them find and critically evaluate information. We hoped this would also encourage them to listen critically and intervene in lectures, and to be better able to handle the essay exams and assignment. We create a series of subgroups in the class, taking care to mix students of differing backgrounds and interests based on biographies they submitted online in the first week of class. This submission forces every student to get online right away; we provide support systems to help them do that in the learning space the university has adopted (WebCT). Each subgroup is led by a professor and has a specific topic to research and discuss; the topics are selected based on our expertise and our sense of contemporary issues. Each student has to find an article in the primary literature on the assigned topic, seek approval from the professor for their selected article, and then write a short summary and critique of the article to be posted to the group web space. The TAs help students search, and the professors engage in an email dialog with each student to help focus in on a suitable paper. We provide detailed guidelines and advice on preparing a useful summary and critique, and we mark this assignment promptly to provide encouragement and feedback. These student postings then became the basis for an online discussion by each group in which the professor plays a significant role throughout the semester. Near the end of the semester each group has to create a 5-page synopsis of their discussion and five selected readings; these are carried into the next year as a basis for restarting and extending the discussion.

Phase III: Sustaining our Founding Spirit and Purpose

This winter is the fourth that we have taught the course. We have identified some of the key challenges to its continued improvement and indeed to its sustainability. First, the course is inevitably disrupted by sabbatic leaves and other causes for staff turnover, so it is essential to develop methods to integrate new staff into the teaching team. Newcomers need to be found who can catch the spirit of the enterprise. Second, the online discussion takes more time and energy than the professors and TAs alone can manage if it is to attain its full potential. We address each of these topics below, emphasizing their impacts on student learning.

Turnover in the teaching team: All the applicants are founding members of the teaching team except Michel Lapointe. He came onto the team when Wayne Pollard was on sabbatic in winter 2001 and decided to stay involved with the course this year while Don Baker is on sabbatic leave. Since all our lectures are given as Powerpoint presentations and archived on CD, Michel was able to review the course in entirety during fall and to use Wayne's lectures as the basis for his own. He sat in on and participated in every lecture, thus having a better feel for the course and the class when he was involved in a lecture himself. He also brought a fresh insight to the course as a whole that resulted in our substantial reordering and revision of some material this year. We take Michel's smooth blending into the teaching team as a promising indication that the course need not suffer through staff turnover, and indeed will often be improved by the infusion of new ideas and energy. It is, however, important to identify new team members well in advance so that they can be attracted to the course and arrange release from departmental teaching obligations.

Sustaining the online discussion: There is no denying this assignment is the biggest drain on the professors' time; it can cause problems if pressing departmental or other professional obligations coincide with the assignment. An ancillary problem also has emerged: many students are shy to ask the professor or TA directly for help. Some think this will adversely influence their mark, others are just hesitant to “bother” a busy professor. Many seek help from friends instead and end up getting bad advice. Consequently, we sought and won support from a Royal Bank Teaching Innovation Award this winter that let us create a cadre of peer mentors to advise students during this online discussion. This

initiative is described in detail later in the application.

Impact on student learning

We seek not only to teach the main elements that must be considered in assessing any environmental situation, but also to emphasize their application to evaluating interactions between organisms and environments. We would like to bring students to a fairly advanced level of learning even in this introductory course. All arrive with reasonable facility in the initial stages of cognitive learning: knowledge acquisition, comprehension and to a lesser degree application. Most students are far weaker in analysis and synthesis, which are especially difficult tasks in an area like environment where so many factors come to bear. We therefore strive in each lecture and each assignment to confront students with more than “just the facts” about a topic, to emphasize the diverse nature of evidence and inference that can be brought to bear on a given topic. We try to draw the students into thinking about the material being presented, not just listening "for the facts". All lectures are presented using Powerpoint and then placed online in WebCT so that students can download and review them as they wish. We encourage interruptions and class discussion and we use essay exams to force students to come to grips with the application of ideas to new situations. We involve students in online discussion groups where they can work together to analyze and synthesize information themselves. We provide Web links and reserve readings to help students review topics about which they may be poorly prepared; in winter 2002, responding to student feedback, we have created a course pack of background readings. We place a significant burden on the students to actively learn at their own pace and to draw on the support systems we provide, as they need them. These support systems include optional conferences and tutorials by the professors and teaching assistants. Because of the disparate backgrounds of the students taking this core course, it is important that the material be available at various levels so that students can find the level they wish to work from and advance their understanding from there as far as their time and energy allow. We have designed the support systems to help students find their working level quickly so that all can keep up with the base level of the course, but also so that the better prepared students can find challenges in the more advanced, supplementary material and in tutorials.

Many of the students in The Evolving Earth at first actively resist aspects of the learning we seek to encourage. They arrive with a strong, but naïve commitment to the environment. They often have little or no idea what really underlies the science and policy development on environmental issues. Some would like nothing better than to enter into comfortable discussions about current hot-button issues, but are not keen on learning enough population ecology or genetics to carry those discussions beyond the level of popular news magazines. If we succeed only in awakening the need of deeper understanding of issues, we can consider ourselves successful. The breakthrough may come in a single lecture or assignment, but that is enough to count as a success that will be amplified as they proceed through the MSE program. If students learn the basic concepts and get even only a glimmer of the multidisciplinary complexity of an environmental issue, then their effective knowledge as an environmentalist will grow with time.

Evidence of student learning

We can offer three lines of evidence that the course provides an effective learning environment: 1) clear improvement in marks from the midterm through to the final examinations, 2) disproportionate improvements in performance by the initially weaker students, and 3) specific testimonials from 1999 through 2001 by students about their learning experience. Students do respond positively to our teaching and in particular to the feedback we provide on assignments, showing progressive improvement through the course. The average class marks for the comprehensive final exam have

shown consistent improvement over the midterm: for example, 60% to 67% in 2001. We have noticed that this shift in the mean is due mostly to stronger marks on the final from the students who were in the lower and mid-level ranges on the midterm. The nature of the assessments and the support systems for learning in the course seem to make the most difference to students who initially are less able to meet the challenges of the course. The best students show a more stable performance through the course. There is no doubt that the course is challenging for even the best students -- only 14 of 169 students got an A or A- in winter 2001. What is interesting is the degree to which somewhat weaker students improve through the course and how few students in the end actually fail -- only 3 in winter 2001. With regard to testimonial evidence, space constraints force us to be selective. Some of the most satisfying and informative remarks include:

> "I am amazed at how difficult this course has been overall compared to my other courses here. Yet, despite the trouble I have had I am all the more inspired to start my U1 year in the school of the environment next year. I have gotten the impression that the kind of education you are giving us is just what we need to become critical, effective, and revolutionary environmentalists that will know how to make a difference. Though it may be hard today it will pay off tomorrow... thanks again."
>
> "The course was beautifully organized, and incorporated the course goals as no other course I have taken has."
>
> "Awesome! Everything I learned in here, and my motivation to learn it, was exceptional - even though my grades do not reflect it."
>
> "Thanks for teaching us this great class. It was one the most instructive classes I ever had at university level either in Europe or here at McGill. All teachers were great…."
>
> "Learned a lot, not memorized but actually learned to apply knowledge. I will be able to remember it longer."
>
> "I learned a lot in this course - a different way of thinking - I stopped thinking of science as simply hegemonic discourse."
>
> "Overall very happy with this course… it's brain candy."

A broader sample of student evaluations appears in the supplemental material. It is worth noting that the interactions with and responses from the students have played a large role in shaping the development of the course. Sitting in on one another's lectures let's us see first hand how the students respond to the material. We hear the perceptive questions of the best students in the class but also see the puzzled looks of those who are struggling to follow a lecture. Formal and informal feedback on the assignments and the nature of answers on the essay exams show us clearly where we have succeeded and failed in our teaching. The impact of this dynamic interaction with our students is especially apparent in the change in tone of the student comments from 1999 compared to 2000 and 2001. Each year, and especially the first year, we have identified ways to present material more clearly and realized ways that additional support systems for student learning were needed. We as teachers have been able to respond to the pressures for useful change and innovation that the students themselves apply. Our past students have in a real sense become part of the teaching team, allowing us each year to make useful improvements in approach and content.

Present and Future Developments

Creating discussion groups and topics that work well has been a persistent challenge. Students at this early stage in their studies are far less prepared for the demands of this assignment compared even to the essay examinations and thematic essay assignments in this course. This is evident each year in our anonymous online survey about the assignment. In winter 2001 the average response to whether or not the discussions were intellectually worthwhile was 2.76 on a scale from 1 (strongly disagree) to 4 (strongly agree). Asked whether the five learning goals for this discussion assignment were or were not achieved yielded the following average responses (1=not achieved, 2 OK, 3 Very well achieved):

Learn to use electronic communication and information: 2.10
Learn to find and evaluate information: 2.03
Gain experience in formulating and presenting ideas: 1.75
Understand and cope with group dynamics: 1.64
Improve written communication: 1.56

Our problems in achieving the learning potential of the exercise are rooted primarily in the disparate backgrounds of the students in the class, and our inability to create a meaningful role for every student in each group. We need to 1) strengthen the support systems for students less familiar with finding relevant material in the scientific literature, 2) diversify the roles that students can play in the discussion, and 3) explore ways to teach students to evaluate more critically the available sources of information. More generally, the students need to better appreciate how their efforts at the initial phase will determine the quality of subsequent discussion.

In winter 2002 we therefore have involved five peer mentors (PMs) to help us develop a more effective support system for the students. These are students who have taken the course, and who are hired and trained to: 1) counsel students during *ad hoc* group meetings, library help sessions, office hours and in individual emails outside the discussion forum; 2) counsel the professors on ensuring the marking is fair and consistent across groups; and, finally, 3) counsel the professors on ways to improve the discussion assignment. We have three goals in developing the Peer Mentor system. First, we want to improve the ability of the students in the course to find and critically evaluate relevant scientific literature. Second, we want to develop systems for the training and effective use of PMs in the course. We want the PMs themselves to grow and learn in their role. Third, we hope the PMs will strengthen linkages among the year classes in the MSE and contribute to a student appreciation of the unity in the MSE programs. The PMs have the potential to help us connect the 200-level experience in core courses to that in the 400-level core. Finally, we wish to use this year as the basis for developing a sustainable role for PMs in the course. This trial project is funded by the Royal Bank and by the Deans of Arts, Science and Agricultural & Environmental Sciences. If it works, then peer mentoring may become an integral part of The Evolving Earth and perhaps other core courses in the MSE as well.

Epilogue

What general lessons might be drawn from our specific experience in developing and teaching this core course in the McGill School of Environment? First, we are convinced of the value of truly teaching as an integrated team, not a loose tag-team giving a sequence of lectures topic by topic. As an integrated team we are learning more ourselves than any of us ever imagined we would, and this learning among the professors is revealing new ways to teach the students. Second, becoming an integrated team is not a quick and easy exercise, nor is working in such a team possible for every individual. Individuals

must be able to move outside their own training to find a new language and frame of inquiry. In creating a course that integrates material from many disciplines, a great deal of time and effort is required to identify concepts and novel perspectives that cut across and unify narrower disciplinary views. Third, having identified a novel frame of inquiry, the teaching team must continue to work hard to find ways to convey their ideas to students unburdened by narrow disciplinary views but limited in their abilities to synthesize diverse lines of inquiry. No amount of professorial effort *a priori* will "get things entirely right". If the students are to attain the learning goals we set, we need to continually assess student feedback and adjust the course content and approach accordingly. In other words, the students themselves are an integral component of ongoing course development. Fourth, it is becoming increasingly clear to us that students must be actively applying the ideas and perspectives being taught, not simply listening to lectures that neatly lay out the ideas. Developing assignments and assessments that steadily demand application of the ideas and provide tutorial feedback throughout the course is critical. Finally, we are convinced by our experience that this sort of team teaching at the core level is not only possible but also essential in multidisciplinary programs such as those in the McGill School of Environment. This requires that administrators commit the resources necessary to get the job done, that they invest what is required in teaching first-year students. We are fortunate that McGill has been willing to make the investments in our course and in the McGill School of Environment.

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E. Additional documention: 1. Student comments 2. Syllabus 3. Letters of support (2)

1. Student comments on anonymous course evaluations

Comments from winter 1999, our first effort:

This course has the potential to be famous around McGill and elsewhere for its scope and innovation. Clearly it has a long way to go from its first year.

I think in a few years this will be an excellent course. The enthusiasm of the instructors is one of the best aspects of the course and I hope this does not decrease over time.

After taking the course, I am unsure of what its goals and aims are. Some topics seemed quite irrelevant, some quite important. I think it will improve greatly with a little time and polishing of rough edges.

Course goals seem a little ambitious… attempted to cover too much of a span of earth history and ended up presenting vaguely related topics which were quickly skipped over. Mastery of subject was impossible.

The material of this course was very broad, covering many disciplines and was thus a bit difficult to follow for those of us without a background in the topic. The lack of a textbook or course pack was a tremendous handicap as we had to learn and understand a great deal of new material on the spot.

The jumble of information that was given to us was virtually impossible to assimilate as we were never given a clear outline or statement of objectives. The topics dealt with in the course were fascinating, but there was no coherent structure to support it.

The use of different instructors is beneficial, each is an expert in their own field. However, at times, the course did not seem to follow a pattern and I had difficulty understanding which point we were at in earth history.

At times the course seemed a bit disconnected…like it was five courses being taught at once, sometimes it was hard to see the connections.

Seemed a bit scattered at first (first 3-4 weeks), but then came together nicely after this.

The attempt to cover and integrate a broad range of subjects was very impressive – it is very hard but more courses need to be multidisciplinary.

The sequences fit together really nicely. It was well organized and really well taught using professors from different backgrounds.

The organization and presentation of lectures was excellent, [and] the visual aids added greatly to understanding the material

I really enjoyed the course material and the integration of different subjects into one course but I found all of the information overwhelming at times.

I want the professors to know that this was the first time at McGill that I have been so stimulated because of the enthusiasm of the professors. I loved watching the interplay between you all and I really felt that you were putting forth a true effort to help us learn and think in a new way.

It was my favorite class since I am at McGill. Very motivated. The diversity of ideas and presentation and professors make the class different and better than others are.

The professors constantly ask for feedback which I find is really good because it shows they care about what students think and that they want to keep improving the course for future years.

Overall very happy with this course… it's brain candy.

Comments from 2000 and 2001, showing improvement in attaining our goals:

Excellent course, very well organized with interesting new methods of work & studying. It asks a lot though, a lot of very different concepts. It is hard to keep up sometimes!

Thanks for teaching us this great class. It was one the most instructive classes I ever had at university level either in Europe or here at McGill. All teachers were great….

This is the most well organized course I've ever taken! Amazing. Loved the multiple instructors & their obvious devotion to students & course material. Very adequate & appropriate, also very fair. I've learned incredible amounts in a subject somewhat difficult for me. Again, the instructors supersede others I've had in making information available to us readily & willingly.

A lot of material covered. Course goals followed almost exactly to sheet we got in January, so that is good. A little confusing drawing links between the different professors' topics. Good power point slides, but too many. When profs ask us questions, it is good; Dr. Baker's class discussion was really good. Questions good at drawing all our knowledge & applying it. "Second Chance" on term paper is good. Learned a lot, not memorized but actually learned to apply knowledge. I will be able to remember it longer.

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Course very well organized. Interesting concept, well-done. All teachers were good, some exceptional. Visual aids w/computer made class more interesting, also conveniently available on internet. …I really enjoyed this class though I initially didn't think the material would interest me. Though I'm only in first year and don't have much to compare it with, this is the best course I've taken at McGill.

OK, this is, so far, the best course, I have taken at McGill. A+ goes to all the profs. It was obvious that you put a lot of time + heart into organizing the lectures, webct etc. I've never had a course that so clearly + systematically followed thru towards its goals. Profs were all very well spoken + most importantly enthusiastic about their areas if expertise. I was very excited about the class. I feel I've learned a lot. The computer/technology aspects were great. Much better than the usual freshman sci. courses. Very well organized + structured. Being an Arts student - this course could easily be expanded in to a D course. More time would be nice. Use of power point slides was helpful & well done. Teachers were clear & although this was a large group answered questions effectively. Prof. Wheeler - appreciated your send of humour. All profs. Dynamic + enthusiastic. Chance to have feedback on term paper very helpful. Original evaluation ex: on-line discussion. Very interesting. I learned tons of stuff.

All instructors adhered to the outline given every week which were broad but helpful in giving an idea as to what to expect. All instructors used the overheads - power point programs very well for drawings, pres - helpful w/visualizing!

Loved it. The sequence of topics in my opinion was very organized, and chronological. I especially liked prof Don & Terry's lectures. Full of valuable info, and very entertaining. Very cool. Very educational. At first I didn't like it, but after awhile I realized that it is a very effective way of communication. The assignments were hard, but I learned a lot. The exam was a killer!

Awesome! Everything I learned in here, and my motivation to learn it, was exceptional - even though my grades do not reflect it.

The course was beautifully organized, and incorporated the course goals as no other course I have taken has. Please downgrade the amount of knowledge/specifics in the geomorphology sections - it can be a little overwhelming. All instructors were great - Wheeler was awesome, interesting, engaging, especially in his use of teaching aids (the stick & fish are memorable). Instructional method was clear & easy to retain information – great for visual learners. I liked the diversity of marking procedures. Just more time for the midterm — the goal is encourage thought. The two-phase term paper was really helpful. A vast amount of info was covered, but in an integrated manner. Interest was always high. Awesome course! The best of the MSE core courses, by far!

The course was really well planned out and all information was tied in well. However, some lectures contained an overwhelming amount of material. Good use of teaching aids- powerpoint + everything up on web ct. Web discussion groups are a good idea but I didn't participate as much as I would have liked due to limited internet access. Very interesting material.

The course was well organized- course goals were made clear in every class. Sequencing of topics made sense. I felt that all instructors were skillful in communicating to the students the material. Clarity of information was especially great through the power point slides. WEB CT helpful a lot too, since we could go back and review course material. Exam (midterm) was very fair. Assignments were well thought out. I learned a lot in this course - a different way of thinking - I stopped thinking of science as simply hegemonic discourse. I was interested 7/8 of the time and motivated to do well.

The organization of this course is excellent. The profs have coordinated themselves, their lectures, and webct very well. Each instructer gives us well organized, well delivered lecture which is given along with a well-put-together set of slides that are both helpful and informative. I believe the course is divided up well in terms of what our grades our based on, the instructors give feedback and are easily accessible but perhaps could increase feedback on assignments. The course matter was very interesting and did not overlap w/other courses. It allowed for participation and resulted in obtaining a great deal of knowledge.

It links well to switch lecturers in a 1 ½ hour session. Great job. Bulletin board idea was very innovative, a great learning tool. Power point was also great. I liked the way thinking took priority to memorizing!

> Even though I have my complaints with WebCT, I think it is a great idea to have us discussing issues that combine science, ethics, and sociology. I appreciate the work of the professors and TAs. Thank you. This is also my first class that I have taken in the school of the environment and I am amazed at how difficult this course has been overall compared to my other courses here. Yet, despite the trouble I have had I am all the more inspired to start my U1 year in the school of the environment next year. I have gotten the impression that the kind of education you are giving us is just what we need to become critical, effective, and revolutionary environmentalists that will know how to make a difference. Though it may be hard today it will pay off tomorrow... thanks again.

2. Winter 2002 Syllabus in MSE 202: The Evolving Earth

The Evolving Earth addresses the history of the Earth with an emphasis on the patterns in biodiversity through time and the nature of the physical and biological processes that underlie these patterns. Themes of chance, necessity and history run through and unify the course. Simple explanations rooted in the laws of physics and chemistry (necessity) cannot wholly explain patterns that arise in part from historical and stochastic factors. The outcome of past events affects future possibilities. Life in all its wondrous diversity has a rich present that can only be fully appreciated with reference to its past. We strive to bring students to an understanding of the processes that operate in time and space to create and sustain patterns of diversity. This demands a rich, cross-disciplinary perspective rooted in the natural sciences combined with a sensitivity to the roles of chance and history. Our lecture topics range widely in time and space, but are consistently rooted in these three organizing themes. We emphasize evidence and the lines of inference that bear on the interpretation of patterns in nature. We emphasize the interplay of biotic and abiotic processes that affect patterns in nature. We emphasize unifying ideas, not the particular details of examples that illustrate those ideas.

Lecture1	Introduction to the course themes, teaching staff
Lecture 2	Creation and composition of the Earth
Lecture 3	When was Earth fit for life?
Lecture 4	Fundamental attributes of living systems
Lecture 5	The nature of natural selection
Lecture 6	Sex, selection and evolution
Lecture 7	Early evolution and diversification of life
Lecture 8	Forming the Earth's surface: geomorphic processes
Lecture 9	Landform evolution at geological time scales
Lecture 10	Challenges to life on land
Lecture 11	Challenges to reproducing on land
Lecture 12	Speciation and phylogeny
Lecture 13	Plate tectonics
Lecture 14	Biotic/abiotic interactions in coastal systems
Lecture 15	Diversity through Earth history: extinction events
Lecture 16	Adaptive radiation after the K/T event
Lecture 17	Co-evolution: angiosperms and insects
Lecture 18	Physical changes in the Cenozoic era
Lecture 19	Biotic effects of the Isthmus of Panama
Lecture 20	Interplay of geomorphic processes and biodiversity
Lecture 21	Cultural evolution
Lecture 22	Quaternary glaciations and Beringia
Lecture 23	Extinction: pattern & process
Lecture 24	Diversity in ecological communities
Lecture 25	Agriculture
Lecture 26	Human impacts on biodiversity