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## Using Coursework to Enhance Students' Understanding of Research/Scholarship

## A Report from the Inquiry Network

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## Preamble

The integration of research/scholarship into the undergraduate experience is a high priority both at McGill University<sup>1</sup> and worldwide (Beckman & Hensel, 2009; Brew, 2003; Elrod, Husic & Kinzie, 2010; Elton, 2005; Kuh, 2008). In order to achieve this objective, it is essential that we, as an institution, think beyond individual supervision—perhaps the most obvious way in which professors can link teaching and research/scholarship—and promote the use of *coursework* to enhance students’ understanding of how research/scholarship contribute to knowledge production. Many instructors at McGill already expose their undergraduate students to research practices and results and see the benefits firsthand in the development of their students’ critical thinking skills and ability to problem solve. Current literature confirms the value of using coursework to improve students’ understanding of research/scholarship but suggests that for this approach to become more widespread, it must be supported at the departmental, Faculty, and institutional levels (Jenkins & Healey, 2005).

In the present context, the term “research/scholarship” denotes all activities engaged in by professional academics in pursuit of knowledge, regardless of discipline. More than two decades ago, Boyer (1990) argued for a definition of research that went beyond the traditional understanding of research as discovery and included the concepts of integration, application, and teaching. It is with reference to this pivotal work that the term “research” will be used for the remainder of this document (rather than the somewhat cumbersome “research/scholarship”). The term “research” should also be understood to include a professional commitment to upholding standards of academic rigour and integrity.

This report identifies ways in which instructors can use coursework to cultivate students’ understanding of research regardless of discipline, academic level, or class size. It provides information on (1) the Inquiry Network, the group that authored this document; (2) the framework created by the Inquiry Network for designing course content in ways that enhance students’ understanding of research; (3) recommendations for the University on how to promote the integration of research into coursework; and (4) examples from ten instructors in the Inquiry Network who have developed an aspect of an undergraduate course to enhance students’ learning about and engagement in research. While this document is aimed at individual instructors, it will have greater impact if departments, program directors, and Faculties also consult it during curriculum and program planning initiatives.

The remainder of this document provides support for the three main conclusions of the Inquiry Network which are listed on the following page. These conclusions emerged during two years of cross-disciplinary debate and deliberation by the members of the Inquiry Network, who worked together to analyze their own courses and develop new conceptions of the relationship between undergraduate teaching and research.

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<sup>1</sup>The importance of linking teaching and research at McGill University is acknowledged in the: Principal’s Taskforce on Diversity, Excellence and Community Engagement (2011); Strategic Enrollment Management Plan (2010); McGill Strategic Academic Plan (2006); and the Principal’s Task Force on Student Life & Learning (2006). Undergraduate research also will be emphasized in McGill’s current strategic planning process, which takes form as ASAP 2012: Achieving Strategic Academic Priorities, the next white paper.

### **Conclusion 1:**

Integrating research into coursework is an effective means of communicating to students the value of attending a research-intensive university while improving student engagement and learning. Accordingly, identifying instructors who already integrate research into their teaching and sharing their examples is an important to support institutional learning.

### **Conclusion 2:**

The means by which an understanding of research can be promoted within undergraduate coursework are various and will be influenced by factors such as discipline, academic level, class size, and students' background knowledge.

### **Conclusion 3:**

Determining how to integrate research into coursework is a complex process and thus requires that instructors have the time and support necessary for designing or redesigning their courses in ways that promote meaningful student learning. This support can take many forms, but to be most effective, it must include opportunities for reflection and cross-disciplinary dialogue and be reflected in policies and practices at the departmental, Faculty, and institutional levels.

# Introduction

In 2006-07, Teaching and Learning Services (TLS) was mandated to lead a University-wide initiative to promote the links between research, teaching, and learning.<sup>2</sup> This project occurred within the context of a wider movement in higher education to improve the quality of undergraduate education at research universities, as evidenced in the influential report from the Boyer Commission (1998), which states that “research universities share a special set of characteristics and experience a range of common challenges in relation to their undergraduate students. If these challenges are not met, undergraduates can be denied the kind of education they have the right to expect at a research university, an education that, while providing the essential features of general education, also introduces them to inquiry-based learning.”

TLS thus formed the Inquiry Network, a cross-disciplinary group of faculty members led by TLS facilitators who have been meeting regularly for more than two years to explore how best to use coursework to deepen students’ understanding of research.<sup>3</sup>

The initial framework used by the group appears in Figure 1 below, where different strategies for linking research, teaching, and learning are distributed among four quadrants (adapted from Healey, 2005).

**Figure 1: The Teaching-Research Nexus: Initial framework used by the Inquiry Network**

<b>STUDENTS AS PARTICIPANTS</b>		
<b>EMPHASIS ON RESEARCH CONTENT</b>	<b>Applying research</b> <i>Students write and discuss research papers or essays.</i>	<b>Doing research</b> <i>Students undertake inquiry-based learning or low-key research.</i>
	<b>Understanding research findings</b> <i>Students listen to and/or read about research findings.</i>	<b>Understanding research methods</b> <i>Students learn about processes of knowledge construction.</i>
<b>STUDENTS AS AUDIENCE</b>		<b>EMPHASIS ON RESEARCH PROCESSES &amp; PROBLEMS</b>

<sup>2</sup> Beyond the faculty network further described in this document, this initiative includes the documentary series “Sowing the Seeds of Inquiry” ([www.mcgill.ca/tls/nexus](http://www.mcgill.ca/tls/nexus)) and the website “Teaching snapshots” ([www.mcgill.ca/teachingsnapshots](http://www.mcgill.ca/teachingsnapshots)), both of which provide examples of how instructors use coursework to increase students’ understanding of research.

<sup>3</sup> In this context, the word “scholarship” is understood to include all four elements proposed by Boyer (1990) in his book “Scholarship Reconsidered”: the scholarship of discovery (research), of integration, of application and of teaching.

Although the group quickly developed an alternative way of thinking about the links between teaching and research, this adaptation of Healey's (2005) framework provided a useful starting point: the model posits a range of possibilities for integrating research into course-based teaching and makes clear that research does not take place only in the lab or field. It also provided group members with some common language for analyzing their own teaching approaches and those of their Inquiry Network peers: this process resulted in a greater appreciation of the complexity of integrating research into coursework and a more nuanced understanding of the role played by contextual factors in determining how this can best be achieved.

As a result of the Network's conversations and analyses during the first year, the members settled on a more appropriate approach for conceptualizing the integration of research into undergraduate coursework, specifically, the articulation of relevant learning outcomes that could be tailored to individual contexts. Accordingly, over the course of the second year, the Inquiry Network developed a set of student learning outcomes that supplanted the initial framework and became the reference point for all further discussions. A more detailed description of these outcomes is provided in the next section.

## Learning Outcomes: Enhancing Students' Understanding of Research

The main categories of student learning outcomes developed by the Inquiry Network reflect the group's conception that in order for students to deepen their understanding of research in any discipline they must be guided by instructors in three main directions:

1. In terms of **knowledge**, students need to develop an awareness that knowledge is dynamic, not static.
2. In terms of **methodological skills**, students need to become familiar with the methods used to gather, organize, analyze, interpret, and evaluate data and source material.
3. In order to **develop advanced critical thinking skills**, students need to learn how to use discussion and writing not only as mechanisms for reporting on work, but as processes to help them develop and communicate their thinking.

These three goals form the basis of the Inquiry Network's framework for teaching students about research and can be addressed at increasing levels of sophistication as students progress through their undergraduate degrees. The three goals are elaborated upon in Table 1 below, where each overarching goal is followed by a list of possible interpretations. These lists are not comprehensive; they are meant to inspire others to articulate how students' understanding of research could be promoted within a particular course.

It is neither possible nor desirable for instructors to incorporate the learning outcomes from all three categories in a single course. Rather, individual instructors are encouraged to select the particular learning outcome(s) that suit course context (the discipline, academic level, class size, etc.). In a large class, for example, an instructor may use lecture time to tell the story behind a discovery and thus help students to realize that knowledge is in a constant state of flux. To assess students' achievement of this learning outcome, the instructor could invite students to ask questions during class or office hours. In a smaller, upper level class, students themselves may be engaged in conducting research; in this case, students' learning can be assessed according to the originality of their final project. Key to both—and all—course contexts is that the instructor actively guide students toward understanding how the content, methodologies, and ways of thinking they are teaching are related to research in the field.

In short, there is no single formula or approach for integrating research into coursework: determining how best to enhance students' understanding of research will require careful examination of course content, goals, and assignments as well as students' background and motivation for taking a particular course. Although such determinations can of course be made by individual instructors, the experience of the Inquiry Network has led the group to conclude that it is more productive to work with colleagues from other disciplines: cross-disciplinary discussions expose unquestioned assumptions and promote the discovery of alternative strategies.

Examples of how ten instructors in the Inquiry Network designed aspects of their undergraduate courses to support students in achieving at least one of the learning outcomes listed in Table 1 are presented in the section titled "Examples" on page 10.

Although these outcomes are designed primarily for individual instructors, apropos of Boyer (1990), they may have a greater institutional impact if they are also consulted by departments and Faculties: the

three main categories provide a framework for the design and sequencing of curricula such that students may acquire experience in all three areas by the time they complete a given program. As a final point, we emphasize that these learning outcomes are implicitly informed by the desire to uphold standards of academic integrity. In cultivating our students' ability to think and act like responsible scholars, professionals, and citizens, we must ensure that in guiding them towards these learning outcomes we also make them increasingly aware of the ethical and social responsibilities that accompany all aspects of professional and academic research.<sup>4</sup>

**Table 1: McGill Inquiry Network framework for enhancing students' understanding of research: Three categories of learning outcomes with examples**

<p><b>1. Students develop an awareness that knowledge is dynamic, not static.</b></p>
<ul style="list-style-type: none"> <li>a. Remember the facts that are part of the established consensus in a field and understand that consensus is still evolving.</li> <li>b. Identify patterns/consistencies in the knowledge base of a subject area or discipline.</li> <li>c. Make connections between concepts within a subject area or discipline.</li> <li>d. Tolerate uncertainty and accept that there is much that we don't know.</li> <li>e. Analyze purported improvements in a subject area or discipline and evaluate their worth.</li> <li>f. Be aware that there are ethical dimensions to both the production and representation of existing knowledge and the generation of new knowledge.</li> <li>g. Recognize the relationship between knowledge and cultural frameworks.</li> </ul>
<p><b>2. Students develop skills to gather, organize, analyze, interpret, and evaluate data and source material.</b></p>
<ul style="list-style-type: none"> <li>a. Become aware of the basic processes of knowledge production and the conventions that govern research in a given subject area or discipline.</li> <li>b. Pose well-formulated questions, develop viable thesis statements/hypotheses, and generate informed and well-supported arguments.</li> <li>c. Locate appropriate resources and literature relevant to the subject area or discipline.</li> <li>d. Develop observational skills.</li> <li>e. Develop psychomotor skills (e.g., operating equipment).</li> <li>f. Develop critical thinking and questioning skills.</li> <li>g. Develop teamwork skills.</li> <li>h. Perform tasks specific to the subject area or discipline.</li> <li>i. Develop skills in critical reading of scholarly and non-scholarly publications, including identifying false premises and uncovering implicit assumptions.</li> <li>j. Develop skills in ethical research practices.</li> <li>k. Replicate aspects of existing research with increasing levels of autonomy.</li> <li>l. Conduct original research.</li> </ul>
<p><b>3. Students use discussion and writing to develop and communicate their understanding of a research topic/subject area/discipline.</b></p>
<ul style="list-style-type: none"> <li>a. Use writing to explore and think about a research topic, subject area or discipline: writing to learn, not merely to record.</li> <li>b. Develop writing skills to report on research following discipline-specific conventions.</li> <li>c. Collaborate with peers, share ideas, and exchange feedback to advance understanding of the subject area.</li> <li>d. Use writing to communicate ideas about research to specialist and non-specialist audiences.</li> </ul>

<sup>4</sup> Link to website "academic rights and responsibilities:" <http://www.mcgill.ca/students/srr/academicrights/> and link to the Green Book: "Policy on the ethical conduct of research involving human subjects:" <http://www.mcgill.ca/files/secretariat/Ethical-Conduct-Research-Human-Policy.pdf>

# Recommendations

The following recommendations for the University emerge from the efforts of the Inquiry Network over the past two years. The recommendations focus on, but are not limited to, using coursework as a means of enhancing students' understanding of research. Each of the three major recommendations is supplemented by specific objectives, and would likely entail the provision of additional resources.

- 1. Provide instructors with additional support** to design aspects of their undergraduate courses to enhance students' understanding of research.
  - Build on work already completed by Teaching and Learning Services to highlight strategies currently used by McGill instructors to improve students' understanding of research within coursework. Resources include this report, video documentaries, and website profiles (all to be found at [www.mcgill.ca/nexus](http://www.mcgill.ca/nexus)).
  - Provide opportunities (such as University-wide and Faculty-specific workshops, individual consultations, faculty learning communities, summer retreats) for instructors to develop instructional and assessment strategies to enhance the development of students' understanding of research in new and existing courses.
- 2. Focus efforts at the departmental, Faculty and University levels** to promote the use of coursework to enhance students' understanding of research.
  - Design the student learning experience at the program level so that students are engaged with research with increasing levels of sophistication and autonomy throughout their degree programs. Examples cited in the Boyer Report (1998) include the inquiry-based freshman year and capstone experiences.
  - Provide recognition via both teaching awards and policies and guidelines related to merit, promotion, and tenure.
  - Provide tangible incentives for instructors who engage in the initiative; for example, course release, stipends for additional TAs or RAs, travel grants for professional development.
- 3. Develop structures** that support the integration of research into the undergraduate experience.
  - Create a university-wide Office of Undergraduate Research that creates cross-disciplinary opportunities for students to engage in the more substantive aspects of research. The Office would ensure that appropriate structures and activities are in place to support students' active engagement with research, scholarship, and inquiry-based meaningful learning.
- 4. Provide national leadership** in the integration of research into the undergraduate experience.
  - Launch the Canadian Council of Undergraduate Research, which would hold an annual conference for students from across Canada. This initiative would be supported by the long-standing American organization, the National Conference on Undergraduate Research ([www.ncur.org](http://www.ncur.org)), and have links with the newly formed British Conference on Undergraduate Research ([www.bcur.org](http://www.bcur.org)).

An important next step will be to further consult with the McGill community to determine what level of support exists for these recommendations and others that are likely to emerge. When the consultation process is complete, a final set of recommendations will be proposed to the University and an action plan will be developed.

## Examples from Inquiry Network Members

This section provides examples from ten Inquiry Network instructors who have developed an aspect of their undergraduate courses to enhance students' understanding of research in their discipline. The examples are organized according to the three major categories of learning outcomes in Table 1 on page 8 and illustrate how these outcomes have been interpreted within varying disciplinary contexts and in classes of varying academic levels and sizes.

### Category 1: Students develop an awareness that knowledge is dynamic, not static

#### David Ragsdale, Neuroscience

**Course title:** PHGY 209 Human Physiology

**Key features:** This is a large lecture course that introduces students to cell physiology. My two week long unit within the 13 week course concerns the nervous system.

**Students:** 1,100 mainly U0 and U1 students. PHGY 209 is a required course for students in Biomedical Science majors as well as Preparatory Medicine for CEGEP students (Med-P) and students in Nursing and Occupational and Physical Therapy

**Number of TAs:** 3

#### What will students learn about research or scholarship:

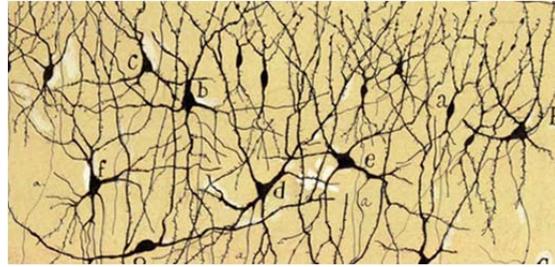
Large introductory lecture courses in science present special challenges to instructors who wish to convey to students the principles and values that guide the practice of scientific research. Students enter these courses with widely varying scientific knowledge, making it difficult to engage students with strong scientific backgrounds while ensuring that those with less knowledge of science learn the basics. Furthermore, introductory lecture courses typically require that instructors cover a certain set of well-established scientific principles and models within a limited time frame, which makes it difficult to get across the idea that science is a dynamic, ongoing process. Thus, there is strong pressure to lecture on "just the facts," with limited opportunities for student participation or class reflection on the scientific process. The two week-long unit I teach on neuroscience in Human Physiology addresses these challenges by introducing students not just to basic principles of neuroscience but also to the larger context of scientific research.

#### Detailed example:

Through a series of interactive lectures on the physiology of brain synapses, the course introduces students to four fundamental scientific values:

1. that what we "know" is not necessarily fixed, but is often the current state of an ongoing process;
2. that scientific advancement frequently depends on development of new methods and technologies;
3. that scientific breakthroughs may depend on intuition and insight as well as careful observation;
4. that scientists test hypotheses, and that scientific progress often involves clashes between competing hypotheses.

We start with one of Ramon y Cajal's famous drawings of neurons from the turn of the twentieth century. Students are asked to consider how Cajal and his contemporaries might have investigated the flow of information through the vast networks of neurons revealed by his illustrations. Specifically, we examine how individual neurons communicate with each other. We work our way through the scientific findings and insights that ultimately led twentieth-century physiologists to embrace the idea of the chemical synapse and to reject the alternative hypothesis that neurons communicate through direct electrical connections. This discussion segues into a description of the currently accepted model of the structure and function of the chemical synapse. This is not intended to be simply a history lesson; rather, students are guided through the processes by which physiologists, anatomists, and neuroscientists, over the past 100 years, progressively fleshed out the picture of the synapse that is found in modern text books.



As a coda, we discuss recent data rehabilitating the idea of electrical synapses in the nervous system. So, the picture in their text books is not the final story. It is a single snapshot of a dynamic and ongoing process.

**Assessment:** Assessment in this course is based on multiple choice midterm and final exams. Multiple choice exams are expedient for such a large class, and, despite the constraints of the format, it is possible to design questions that challenge students' understanding of scientific principles in the context of neurophysiology. Here is an example question:

*In a classic 1968 paper, Bernard Katz and Ricardo Miledi described an experiment in which they injected  $Ca^{2+}$  directly into the presynaptic terminal of the squid axon and then observed the effects on the electrical properties of the postsynaptic cell. This experiment tested which of the following hypotheses?*

- A. *Depolarization of the presynaptic terminal is required for neurotransmitter release.*
- B.  *$Ca^{2+}$  is a neurotoxin.*
- C.  *$Ca^{2+}$  activates calmodulin.*
- D. *Increased intracellular  $Ca^{2+}$  in the presynaptic terminal triggers neurotransmitter release.*
- E.  *$Ca^{2+}$  is required for synaptic plasticity.*

The correct answer is "C". These specific experiments are not discussed in class; however, the students are expected to infer the answer based on what they've learned about presynaptic terminals and about how scientists test hypotheses.

## **dik Harris, Physics**

**Course Title:** PHYS 333: Thermal and Statistical Physics

**Key Features:** A required theory course in the Physics Major program (and also in several other smaller programs, such as the Major in Atmospheric and Oceanic Sciences). All students have a common set of prerequisites. Assessment is via problem sets as homework and formal examinations.

**Students:** Enrolment 40-50, usually from the U2 year, since it has a number of Physics and Math prerequisites.

**Number of TAs:** 2-3 TAs responsible for grading problem sets and mid-term exams.

### **What will students learn about research or scholarship:**

Beyond the fundamental principles of statistical physics and thermodynamics, in this example, students learn to approach the world like physicists while being aware that there are always limitations to the insights that this approach provides.

### **Detailed example:**

The challenge of the undergraduate curriculum in physics is that much of the material is very far from the cutting edge of research. In a traditional physics program, students learn to apply theoretical models, but they are not prompted to identify the assumptions underlying these models and their consequent limitations. Because of this, undergraduate students don't usually encounter important aspects of research in physics, for example, that the understanding of real-world phenomena often—even usually—requires that assumptions be made so that simple models may be employed. In this course, the instructional strategy is therefore to present the models—in class—with recurring emphasis on their underlying assumptions, thus reinforcing that theoretical knowledge is not absolute.

The problem sets, which are graded for credit, provide practice for appropriate problem-solving approaches. However, within the sets are questions employing a variety of models to describe different real-world phenomena. Not all of these models are introduced in class, and so the students are challenged to make sense of them in their own way, identifying underlying assumptions and the consequent limitations.

The TAs are instructed to pay attention to how the students reach their solutions and to give appropriate feedback: credit is not given merely for “a correct answer.” In addition, the solutions to the problem sets are posted promptly, giving feedback to the class in addition to that provided by the TAs to individuals, and sometimes giving additional commentary.

## Isabelle Cossette, Music Research

**Course title:** Practicing and Coping Strategies for Enhanced Performance

**Key features:** Musical performance is a very complex physiological task that musicians strive to master in order to achieve musical excellence. In addition to controlling the interaction between the body and the instrument, the performer often needs to manage heightened levels of stress while performing. This course, designed for performance undergraduate students, provides musicians with theoretical knowledge of the performance process as well as practical resources and a toolbox of coping strategies that will assist them during their professional lives.

**Students:** Between 10 and 20 third-year undergraduate performance students

**Number of TAs:** 0

### **What students will learn about research or scholarship:**

As in the scientific domain, music performance requires an iterative research process: Each step of the performance involves a continuous process of discovery and adaptation. In addition to being exposed to research studies and standard knowledge in the field, students are required to use observational and assessment skills to evaluate performances and strategy practices and to develop critical thinking abilities at each step of the performance process using subjective and objective measures. Performers are at once researchers and the subject being studied. In order to become autonomous in developing their performance identity and skills, musicians need to become aware of the intrinsic parameters of the performance process and to understand how various factors influence its control.

### **Detailed example:**

Performers can be considered to be in a lab setting all the time: when they are practicing, with their teachers, and on stage. In order to develop their musical identity, they must experiment with their bodies, their instruments, and their minds and also learn different strategies, tools, and methods for improving their performance. The activities in this course are based on “real life” experiences and challenges that every professional musician must overcome in order to achieve excellence. The course is designed to offer students the opportunity to become familiar with the multiple steps involved in the performance-research process.

To trigger the inquiry process and to demystify common misconceptions, students are first asked to discuss with each other their current knowledge of performance strategies. Basic knowledge of the field is then presented to the students through lectures and readings. Recorded and mock audition performances allow students to develop observational and critical thinking skills via awareness of performance components and assessment of performances and personal strategy practices. Students also gain and provide feedback via objective and subjective assessment of the strengths and weaknesses of both their own and their peers’ performances. The feedback activity allows students to identify performance problems, for which “mechanics” are then studied based on current research. Students are explicitly told that they are engaging with professional research so that they can situate their own inquiries on performance practice in the context of the field.

Potential practicing and coping strategies for overcoming challenges are explored individually and through group activities (e.g., meditation, cognitive reframing, relaxation techniques, journal writing, exercises, imagery, and time management). In a personal journal written over a period of six weeks, students report and evaluate their coping and practicing strategies. Discussions and exercises encourage

exchanges among students and emphasize the fact that this experiential learning process is both common to all musicians and yet specific to each individual. A final paper requires students to use the main concepts and skills discussed throughout the term (i.e., Awareness, Understanding, Strategies, for Implementation, Assessment/Reassessment, Enhancement). This paper gives students the opportunity to go through the entire process of evaluating performances, setting goals, and implementing appropriate strategies to overcome debilitating performance anxiety symptoms and to situate this experience within the framework of existing theories. They are then ready to repeat the process throughout their professional lives: as their professional careers develop, they will be able to identify problems, implement solutions, and adapt their practices and performances accordingly.

## Category 2: Students develop skills to gather, organize, analyze, interpret and evaluate data and source material

### **Peter Radziszewski, Mechanical Engineering**

**Course title:** MECH 292 Conceptual Design

**Key features:** This required course is an introduction to design in mechanical engineering. Students work in teams of four to conduct research projects whose outcome is the creation of a new design.

**Students:** 60-80 students in 1<sup>st</sup> or 2<sup>nd</sup> year mechanical engineering

**Number of TAs:** 3-4

#### **What students will learn about research or scholarship:**

In this example, students learn to work in teams in a process that mimics the real-world experience of engineers working on research projects.

#### **Detailed example:**

The team project in this course mirrors the collaborative design process that engineers go through when solving problems. Students in each team are responsible for delegating and accomplishing tasks with the guidance of TAs and the instructor. Tasks include: problem formulation; idea generation; feasibility study; preliminary design; analysis, evaluation, and creation of the design.

The instructor randomly assigns students to teams of four and requires them to work together all semester. To facilitate success, each team generates a commitment statement early on in which students share their schedules, resources, and learning goals. At the end of the semester, students use the goals and criteria established for the commitment statement to evaluate each other. To build group cohesiveness, teams sit together throughout the semester while listening to in-class lectures and doing group work. Also, early on, students engage in a design competition worth 2% of the final grade; this assignment serves as an ice-breaking activity and allows students to learn to work together in a “low-stakes” environment. In general, class time is structured so that short lectures on relevant readings are followed by team meetings in which members organize out-of-class time, assign team tasks, consult with TAs, and share the results of the previous week’s design activities. When conflicts arise, students are guided through a mediation process, first by the TAs and then by the instructor if necessary. The team is graded on joint progress and final reports, presentations, and the final competition. Individual grades are given for research deliverables per activity, a design notebook, peer evaluation (team members evaluating one another using the previously established commitment statement), TA evaluation, and a final design essay or concept map of the design process.

## **Megan Fitzgibbons, McGill Library**

**Course title:** Research Tips and Tricks: A Workshop for Political Science Students in Developing Area Politics

**Key features:** This is a one-time, 1.5 hour workshop led by a subject-specialist librarian for students in an elective undergraduate course. The goals are: (1) for students to develop self-efficacy in using library resources to find and evaluate articles and books related to their chosen research paper topic, and (2) to appreciate the range of resources available to them as researchers-in-training. As such, the workshop is adaptable for many disciplinary contexts.

**Students:** The Political Science course has approximately 100 undergraduate students.

**Number of TAs:** n/a

### **What students will learn about research or scholarship:**

The underlying premise of the workshop is that in order to successfully produce a term paper and, more significantly, to participate in the research activities that characterize academia, students must understand how information is produced, organized, and retrieved.

### **Detailed example:**

An overarching learning outcome of this workshop is for students to develop the necessary skills to gather, organize, and evaluate information in the context of a specific discipline. Teaching strategies are selected that allow students to engage in scholarly information-seeking. More specifically, students will develop an understanding of the range of information resources available, how research literature is organized, and how it can be retrieved.

The formative activity involves providing students with a brief article found on a non-academic website that contains a vague mention of a “research study” on a particular topic. Students are required to track down the original study, developing an understanding of information production and dissemination, from the continuum of news reporting to academic analysis. They then learn how to “mine” bibliographies so as to identify key researchers in their field. They are asked to locate relevant authors’ publications by using search tools such as web engines and citation indexes. This process helps them to develop skills in using one relevant piece of information to find more, a strategy that expert researchers also use in navigating disciplinary literature. Instead of being given a “recipe” for finding information, they are placed in an authentic situation of using one known item to open up a larger world of scholarly literature.

Although there is no opportunity for formal evaluation in this session, informal feedback is provided throughout. For example, instead of the librarian providing a demonstration of a search in a database, students are asked to conduct a search on their own without any guidance. They then report back the number of results retrieved, and a few are asked to demonstrate their strategy to the class. Gaps in their skills are thus revealed, and suggestions for improving the effectiveness of their search strategies are offered through group discussion, guided demonstrations, and individual feedback from the librarian.

## **Terry Hebert, Pharmacology and Therapeutics**

**Course title:** PHAR 558 Research Topics in Pharmacology

**Key features:** PHAR 558 is a required course in the Pharmacology major. 5-7 professors take turns, most teaching several classes. The course coordinator determines the core set of topics and invites professors to teach in their respective areas of expertise. Each professor assesses written assignments and presentations; the coordinator marks the final papers.

**Students:** 10-30 students (upper-level undergraduates and some graduate students).

**Number of TAs:** None

### **What students will learn about research or scholarship:**

The course highlights both real-world problems in drug discovery—the discovery bottleneck—and various solutions that have been proposed as the field has evolved. It situates student learning in the context of professional research questions designed to explore how an appreciation of biology can be restored to the drug discovery process. How do we combine advances in combinatorial chemistry and the ability to screen hundreds of thousands of drug candidates but still meaningfully consider the relevant biology?

### **Detailed example:**

After a series of introductory lectures, each instructor gives a 30-minute introduction in one of his/her classes designed to provide: (1) a general overview of the topic under consideration, and (2) the necessary background for two research articles to be discussed. Individual students then present and lead the discussion of these articles. Instructors provide individual guidance to presenters as needed according to the topic for the week. During the course, each student gives two such presentations: 15% of the final grade for the first and 25% for the second. The difference in weights encourages students to adapt to the feedback received after the first presentation, especially in relation to critical thinking and analysis. Since everyone will have read the articles before class, simply repeating the content of each article has no value and will therefore not be sufficient. Instead, all presenters are required to use the content of the papers (e.g., figures, interpretations) as points of departure for more in-depth discussion. At the end of the student presentations, the instructor may provide a brief summary of the key “take home messages” for the week or assess student understanding of these in the form of a written assignment.

This exercise gives students the opportunity to develop the ability to understand, present, and discuss primary literature in the context of drug discovery. By closely reading and critiquing an article, and by leading peers in discussion, students participate in analysis of key questions in pharmacology research.

## Annie Savard, Integrated Studies in Education

**Course title:** EDEE 332 Teaching Mathematics 1

**Key features:** This course combines lectures and labs in which student teachers learn to design an effective math lesson for elementary students that includes content, processes, and concepts, use of tools (e.g., calculators), and student assessment. This is a required course that students must pass before they begin their field experience as teachers in real classrooms.

**Students:** 160 undergraduate students in the class, divided into 5 sections of approximately 30 students for labs.

**Number of TAs:** 4 TAs

### What students will learn about research or scholarship:

In this course, students learn to design, deliver, and assess effective math lessons using different approaches based on evidence from recent research. In the example below, students develop their own mathematical reasoning and learn to guide their future students to develop strategies to solve problems on their own. By engaging with current research in their field, they are given the opportunity to evaluate and contribute new approaches and apply research to practice.

### Detailed example:

Students are introduced to a new approach to problem-solving that is currently being evaluated by researchers. The goal is for them to see the value of this type of approach by experiencing it themselves in a role-play activity and then to integrate it into their own teaching. They develop their own mathematical reasoning and learn how to guide their future students toward developing problem-solving strategies. The larger goal is for them to understand the ways in which research can inform practice as they engage in professional development throughout their careers.

In their lab, students are placed in teams of four and are required to solve two mathematical word problems through discussion, debate, and role play (student/teacher). Each team chooses one member who takes the role of a learner and leaves the classroom while the three other members play the role of teachers. The “teachers” have to create a visual representation of each word problem without using words or mathematical symbols (+ ÷ × −) and without introducing numbers that don’t appear in the text of the problem. The “learner” then returns and tries to solve each problem.

A word problem	A possible visual representation
Anne helps her mother to plant tulips in front of the house. They plan to plant 48 flowers. They have already planted 27 flowers. How many flowers do they need to plant to finish the work?	

Each team reproduces their representations of their problems on the blackboard, and then the whole lab group compares the representations and additive structures of the different problems. They discuss which representations are most effective and how they can apply these with future students. They develop their understanding about different kinds of problems, the different ways to represent them, and the types of mathematical or algebraic thinking involved in solving them. Formative evaluation is provided during the discussion by the students themselves and through the participation of the instructor.

### Category 3: Students use discussion and writing to develop and communicate their understanding of a research topic/subject area/discipline

#### **Richard Chromik, Mining and Materials Engineering**

**Course title:** MIME262 Properties of Materials in Electrical Engineering

**Key features:** This course is an introductory course in materials science and engineering for (mostly) first year electrical engineering (EE) students. It is a required course that EE students take outside of their department. In order to facilitate students' appreciation of the relevance of this course to their Electrical Engineering major, a variety of lecture-based techniques have been introduced over the years, including think-pair-share, movies, and demonstrations. Students' learning is evaluated through quizzes, a mid-term, and final exams.

Students learn the basic principles of materials science and engineering and the importance of structure-property relationships for both: (1) materials selection & design in industry and (2) research and development of new materials.

**Students:** 40-60

**Number of TAs:** 2 part-time TAs (30 hours each)

**What will students learn about research or scholarship:**

By conducting an interview with a McGill Engineering professor, students discover how academics make use of the basic principles of materials science and engineering in their research.

**Detailed example:**

Instead of having students write a mid-term, the instructor created and introduced a research assignment in which students worked in groups to interview professional researchers. The project was designed to increase students' motivation for the subject by giving them an inquiry-based assignment that would help them to discover the connections between the course and their chosen discipline of electrical engineering.

The instructor identified 12 potential "target researchers"—McGill professors with a materials component to their research. Groups of three to five students were assembled based on students' interests, with both upper-level and first year students in each group. Students were required to conduct background research on the topic by reviewing the professor's recent publications. Each group, with some assistance from the TA and course instructor, formulated interview questions that ranged from their general curiosity about the research to specific questions about the professor's publications. Students were required to ask two pre-formulated questions challenging the McGill professors to explain in what ways structure-property relationships and the fundamentals of materials science are important to their research.

After conducting the interview, students formulated a group report and presentation based on (1) the interview, (2) their understanding of the chosen journal articles, and (3) connections between what they had learned from the project and the content of the course. Students were asked to write a report in a style similar to trade publications that present scientific research to a general audience (e.g., *Scientific American*). Thus, students not only undertook “research on research,” but disseminated their findings in a manner similar to that of a professional scholar in their field.

This assignment provides students with a unique learning opportunity that:

1. demonstrates that the fundamentals they learn in this first year course are used at the very highest level of research;
2. exposes them to research that they otherwise might never have known existed;
3. helps them to discover connections between engineering research and the fundamentals that they learn in the course;
4. challenges them to communicate their research findings in both written and oral form.

## Sue Laver, The McGill Writing Centre

**Course title:** CEAP 250 Research Essay and Rhetoric

**Key features:** A (mostly) elective course designed to enable students in all disciplines to become accomplished academic writers by simultaneously developing their critical reading, critical thinking, and research skills. Teaching and learning strategies include peer-editing, self-editing, multiple drafts, and recorded audio feedback from the instructor. The course is especially valuable for U0 and U1 students, many of whom have never written a research paper, in that it contributes to their understanding of the university student's most fundamental activities: researching, writing, and editing.

**Students:** CEAP 250 is open to all students in all years and programs at McGill who have native or near-to-native proficiency in written English. Although most students take CEAP 250 as an elective, the course is also a requirement for several programs at McGill and is taken by a large number of science students to satisfy requirements for admission to medical school. In light of the labour intensive nature of all writing courses, and in order to ensure that students receive as much individualized instructor feedback as possible, CEAP 250 is capped at 25.

**Number of TAs:** None

### **What will students learn about research or scholarship:**

The summative assignment in this course is the final research paper. Breaking this assignment into stages (as described below) and “forcing” students to begin the research paper long before it is due facilitates their awareness that both research and writing are process-driven practices. Students learn that professional researchers and scholars invest a great deal of time in locating, reviewing, and evaluating relevant sources and that revising, editing, and proofreading are key elements of effective written communication. The long-range goal is to motivate students to apply these practices and skills to their other courses.

### **Detailed example:**

In CEAP 250, we begin by engaging students in a discussion of what makes academic writing “academic”—in other words, what distinguishes *academic* writing from other forms or types of writing. Students are thus encouraged to make their assumptions about different genres of writing explicit and are also introduced to the key criteria that inform a meaningful identification of academic writing as a relatively distinct genre: audience, purpose, tone, and diction. In order to anchor their developing understanding of the rules and conventions of academic writing, students are redirected to these criteria as often as necessary both in classroom discussions and in the feedback provided in individual assignments.

CEAP 250 assignments are designed to enable students to become accomplished academic writers by simultaneously developing their critical reading and critical thinking skills: students are required to consider not only *what* an author is claiming or arguing but also *how* she or he expresses and organizes it. By engaging in rhetorical analysis of others' writing, both as a group and individually, students become progressively more aware of the need to formulate viable thesis statements and hypotheses, and progressively more adept at doing so; likewise, they learn the importance of providing cogent arguments supported by appropriate and adequate evidence. Peer review of key assignments, including the final research paper, provides additional opportunities for rhetorical analysis: students not only gain insight into the level of clarity and coherence of their own writing but also learn how to give constructive feedback on early drafts of others' written work.

As the final assignment for this course, the research paper provides an opportunity for students to demonstrate the progress they have made over the course of the semester in the development of their academic writing and research skills and in their ability to engage in critical thinking. Students have the option to link the research paper to another course being taken simultaneously (preferably in their major or minor program), but only if the instructor of the other course gives written permission. Otherwise, students develop a research project of their own in consultation with the CEAP 250 instructor.

The research paper assignment involves several different stages:

- a library workshop in which students learn how to search for and locate primary and secondary sources, both print and electronic;
- a class devoted to the rules and conventions—including ethical rules and conventions—that govern research writing;
- the submission of a statement of proposal, which is put through two drafts;
- the submission of a rough draft of the research paper, which is peer-edited;
- the submission of an initial “good” draft of the research paper, for which students receive recorded audio feedback from the instructor;
- the submission of a final draft.

The statement of proposal is worth 5%; the research paper is worth 25%. The first and second “good” drafts both receive a grade; the final mark for the research paper comprises the average of the two.

## George McCourt, McGill School of Environment

**Course title:** ENVR 202 The Evolving Earth

**Key features:** This interdisciplinary course is team-taught by three instructors and focuses on the history of life on the planet. The course addresses how the interplay between the key processes of geological and biological evolution has contributed to the history of the planet. All three instructors are present for each class and contribute in varying degrees. Through interactive lectures, they demonstrate how a careful analysis of the extent and nature of scientific evidence can assist in recreating the earth's history and how the interpretation of scientific evidence itself requires a critical evaluation of the limitations of the available data.

**Students:** 50 students from different Faculties (half first-year; the rest are second- and third-year)

**Number of TAs:** 1

### **What students will learn about research or scholarship:**

An important assessment component of this course (30% of the final grade) is the writing of a research paper submitted at the end of the term. Through the writing of this paper, students develop an understanding of the nature of scientific evidence and scientific inference, learn to find and to evaluate information provided by scientific evidence, and develop the analytic and synthesis skills that will allow them to meaningfully address complex environmental problems.

### **Detailed example:**

At the beginning of the term, students choose from a set of essay topics provided by the instructors that relate to the objectives of the course. Students are required to find and examine primary research literature relevant to their topic, to describe the various positions presented in the literature and to construct an argument based on the evidence to support or argue against a chosen position. To defend their position, students must analyze the extent and nature of the evidence available and critically evaluate the limitations of the available data. As a starting point for each research topic, the instructors provide two references, often reviews. The instructors also provide a handout explaining in detail their expectations for this assignment.

About six weeks into the course, students are required to submit a proposal (max. 1000 words) that provides a clear overview of the content and organization of the paper. The proposal outlines the student's ideas, specifying the logic of the arguments and the nature of the supporting evidence, which should be based on an extensive search of the scientific literature. Students must also attach a working bibliography that includes all the references investigated, even those that may not be cited in the final paper. The proposal is marked by a Teaching Assistant, who provides feedback to each student on the content and structure of the paper and on the relevance of the evidence used to support the student's arguments. Each instructor meets with the TA to discuss the grading criteria in detail. The TA sends the instructor three graded examples (from weak = C to strong = A) to ensure that the marking criteria are being applied as intended. After receiving feedback on their proposal, students are required to incorporate this feedback into a 3000-word final paper which requires students to synthesize and integrate scientific evidence that has been gathered from primary literature sources. The students are expected to evaluate and critique the scientific evidence and to use this evaluation and criticism to take a position in support of or against a given research topic outlined for their essay topic. The final paper is also marked by the TA, and the grading procedure and criteria remains the same as for the proposal. The final grade is strongly determined by the students' ability to evaluate and critique scientific evidence in a manner similar to professional researchers.

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## About the Inquiry Network

The Inquiry Network is a group of faculty members and students led by Teaching and Learning Services (TLS), who have been meeting since 2009 to explore how to best use coursework to deepen undergraduate students' understanding of research. This report is the result of more than two years of dialogue, debate and the sharing of ideas and resources. The group has exhibited extraordinary commitment to promoting undergraduate students' understanding of research within courses of all sizes, disciplines, and academic levels.

## About the Nexus Project

In 2006-07, Teaching and Learning Services was mandated to lead a university-wide initiative, "The Nexus between Teaching, Learning & Research / Scholarship Project," to promote the links between teaching, learning and research. As part of this project, TLS launched the Inquiry Network described above, and developed the following resources:

- **"Sowing the Seeds of Inquiry -- Undergraduate teaching and learning at a research university,"** a documentary series which profiles five McGill instructors who engage undergraduates with research as part of coursework. Find out more at [www.mcgill.ca/tls/nexus](http://www.mcgill.ca/tls/nexus).
- **"Teaching snapshots: Perspectives on teaching and learning at McGill,"** a website which presents written interviews with instructors on the subject of teaching and learning, and includes their answers to the question "How do you help your students understand what research and/or scholarship is in your discipline?" Find out more at [www.mcgill.ca/teachingsnapshots](http://www.mcgill.ca/teachingsnapshots).



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