Teaching Nuclear Energy:

The Challenges of Interdisciplinarity in the Classroom

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Introduction

Dr. Duane Bratt, Professor of Political Science in the Department of Policy Studies and Dr. Brett McCollum, Associate Professor of Chemistry in the Department of Chemical and Biological Sciences together teach a third year undergraduate course entitled "The Science and Politics of Nuclear Energy" at Mount Royal University (MRU) in Calgary. To the best of our knowledge this is the only course of its kind offered in Canada that combines science and politics of nuclear energy in the same course and taught by specialists in both of those areas. Dr. Bratt has been studying the politics and policy surrounding nuclear energy for over two decades. He was written two books[1] as well as numerous articles and conference papers, and presentations on the topic. Dr. McCollum has over a decade of experience working with the radioactive muon conducting research at TRIUMF, Canada's national laboratory for particle and nuclear physics. He has an active research program in chemical education. He is also an advocate for investment in STEM (Science, Technology, Engineering, and Mathematics) education research and increased public understanding of science, having contributed materials used in the MRU general education course GNED 1101: Scientific and Mathematical Literacy for the Modern World. They have also written one paper together.[2]

Panelists at the 2012 meeting of the American Association for the Advancement of Science in Vancouver, Canada argued that there is a need for increased understanding of the

[1] *Canada, The Provinces, and the Global Nuclear Revival: Advocacy Coalitions in Action* (McGill-Queen's University Press: Montreal and Kingston, forthcoming) and *The Politics of CANDU Exports* (University of Toronto Press: Toronto, 2006).

[2] Duane Bratt and Brett McCollum,"Is the International Year of Chemistry the right time for a Global Nuclear Renaissance?" *Mount Royal Centennial Reader* (June 2011). Accessed at http://centennialreader.ca/international-year-of-chemistry

science of energy resources among a greater proportion of the population, including the media.[3] We contend that an appreciation for how science impacts the politics of energy policy is equally important.

The purpose of this paper is to do a critical self-assessment of all aspects of the course and, in particular, offer insights into inter-disciplinary teaching. This paper is structured into five parts. Part one describes the methodology used for this study. Part two identifies the origins of and description of the course. Part three discusses the issue of student recruitment. Part four analyzes the multi-faceted challenges in teaching such a unique course. Part five assesses what students have learned about nuclear energy from taking the course.

Methodology

The methodology of this paper was derived from four sources. First, there were demographic statistics that were compiled from the student class list. The student class list provided overall enrolment numbers, enrolment broken down by faculty and major, and aggregate final grades. Second, there was a content analysis of course documents (outline, lab assignments, tutorials, tests, lecture notes, etc). Third, a confidential student survey was used for the 2012 class. This was done on-line using the too fast survey tool during the month of April 2012. 16 out of 29 students completed the survey, which was a 55% response rate. Fourth, there was a qualitative assessment of the course made by the instructors. This project was given ethics approval by the MRU Human Research Ethics Board (HREB).

[3] Julia Wilson, Michael Hanlon, Tracey Brown, Mark Henderson, Paddy Regan, Elizabeth Dowdeswell, Albert Yuan, Pieter Doornenbal, and Ramesh Sadhankar, "Misreporting Fukushima: A Failure of Science Journalism with Global Repercussions?" *Meeting of the American Association for the Advancement of Science* (February 2012).

Origins and Description of the Course

Last year Mount Royal celebrated its centennial as an educational institution and its third year as a university. A central principle of the degree programs offered at MRU is General Education. "A great education doesn't just make you an expert in one area - it gives you a well-rounded knowledge base in a variety of areas."[4] A typical 40-course degree at MRU includes 12 (30%) General Education courses. These options are selected by students to complement studies in their chosen fields. Thus, alongside the new discipline-specific course offerings being developed for the 4-year degree programs there was a need for courses accessible to non-majors.

In 2009 there was no course at MRU that introduced students to the concepts of radiation, nuclear science, or nuclear energy. While designing the first such course as an option for students in the BSc program, Dr. McCollum began collaborating with Dr. Bratt on a unique offering that would bridge together the typically separate yet linked fields of nuclear science and nuclear public policy. The purpose of the course was to assist students in developing their own position on nuclear energy, informed by both the science and the politics of the field.

A list of possible course topics was generated and then narrowed down to create an experience appropriate to the diverse and novice audience. We agreed that it would profit students to first provide a foundation to the necessary science and afterward explore the impact of the science on society. Whenever possible, we both attended all lectures to enrich the

[4] "The Department of General Education" *Mount Royal University* (June 2011). Accessed at http://www.mtroyal.ca/programscourses/facultiesschoolscentres/TeachingLearning/Departments/GeneralEducation/index.htm

discussion, regardless of the topic of the day, from both vantage points. No single textbook covered both sides of the course, and so we selected two relatively inexpensive texts.[5]

In the first six weeks of the course students develop a foundation in the science of radiation and nuclear energy. At the midterm examination a successful student is able to: classify radiation; balance nuclear reactions; describe basic models of nuclear structure; perform calculations related to nuclear stability, energetics, and decay kinetics; explain the design and function of a variety of detection equipment; compare and contrast the purpose and design of a nuclear reactor and a nuclear weapon. Class consists of three hours lecture per week supported by one hour of computer laboratory exercises each week. In addition to the pre- and post-laboratory assignments, students complete biweekly problem sets.

During the next six weeks the subject matter shifts to provincial, national, and international public policy on nuclear energy. Topics include: the history of nuclear energy in Canada; nuclear energy in Canada and the World; comparing nuclear reactor designs; Canadian exports; industry, government, and non-governmental organizations; security; trade; the cost of nuclear energy; and nuclear safety and nuclear disasters. For this portion of the course the weekly laboratories are used for guest lectures, debate modeling, and student debates on topics such as:

- Is there a global nuclear revival?
- Is nuclear power the solution to climate change?
- Is nuclear terrorism a significant threat?
- Is nuclear waste a significant problem?

[5] Hans Tammemagi and David Jackson, *Half-Lives: A Guide to Nuclear Technology in Canada* (Oxford, 2009) and Jeff C. Bryan, *Introduction to Nuclear Science* (CRC Press, 2009).

- Has the Fukushima Daiichi accident ended the global nuclear revival?

Students present their assigned debate position as a small group in a 15-20 minute oral presentation. They are graded on their quality of research, clarity of argument, and ability to respond to questions. These debates continue in the laboratory sessions until the end of the semester. Meanwhile, the last three weeks of the lectures are devoted to discussing other nuclear technologies and applications, such as medical isotopes.

The first offering of the course was in the Winter 2011 semester (January - April 2011). It was during this semester that the great Japanese earthquake, and subsequent tsunami and nuclear disaster at the Fukushima-Daiichi nuclear power plant occurred. Relying on the information released by organizations such as the International Atomic Energy Agency (IAEA) and the Canadian Nuclear Society (CNS) we were able to discuss the daily updates with our students. It is rare, particularly for science students, that current global events are directly applicable to their course work. Since that time the Fukushima-Daiichi disaster has been an important part of the course.

While we have our perceptions surrounding nuclear energy, the students are challenged to generate and explain their own opinions, supporting their positions with reliable fact-based evidence. Students successfully completing this course have demonstrated an ability to effectively communicate, in both written and oral formats, on topics related to the field of nuclear energy.

Recruitment of Students

The Science and Politics of Nuclear Energy is an approved Level 3 general education credit at MRU. All students must complete four courses at this level prior to graduation.

Advertisements for our course are shared with students by all chemistry faculty. However, having a CHEM designation, the course is located in a section of the course calendar not normally read by non-science students. To overcome this obstacle, advertisements are annually provided to all GNED 1101 (Scientific and Mathematical Literacy for the Modern World) and GNED 1102 (Controversies in Science) instructors as all MRU students are required to take one of these two foundational science courses. In the next year or two we should see the fruit of these efforts as more students move through their programs and begin looking for ways to fulfill their Level 3 general education requirements. As shown in Table 1, when the students were surveyed about why they took CHEM 3802 many expressed an existing interest in nuclear energy while just as many mentioned educational requirements, either to complete their chemistry minor or to fulfill the general education requirement.

Table 1
Motivators for Enrolment

Reason	Number of Comments
Interest in nuclear energy	11
Chemistry minor	7
General Education requirements	4
Broaden my knowledge	1
My girlfriend was taking it	1

As with all optional courses at a university, word-of-mouth is the most important recruitment tool. This has proven very effective among science students. Unfortunately, the number of non-science students in the course to date has not yet reached a critical mass to make word-of-mouth transmission reliable among this population. Table 2 lists the majors of students who have taken CHEM 3802. The vast majority of enrolment comes from science, with a few

students in business, psychology, and Open Studies. Although not required, all students have completed a minimum of high school mathematics and exhibit a strong personal interest in science. This results in a population that is more homogenous than intended.

Table 2
Student Profile

		2011	2012
# of Students Registered		6	31
# of Students Who Completed		5	29
BSC	**General Science**	1	12
	Health Science	0	13
	Biology	0	1
BBA	**Management**	1	1
	Marketing	1	0
BA	**Psychology**	0	2
Open Studies		2	0

While the course enrolment was full this past Winter semester we would still prefer for our students to represent a greater distribution of academic disciplines. Toward that goal, we are planning on expanding our recruitment efforts to upper-division public policy and political science courses. Using contacts in other departments we hope to further increase the diversity, including students in communications and sociology, and a greater number from business.

Another important observation from Table 2 is the dramatic increase in enrolment between 2011 and 2012. While some of this growth can be assigned to a successful first offering, a significant proportion is likely the result of increased public interest in nuclear energy following the Fukushima Daiichi nuclear disaster. In fact, in the student survey, several explicitly mentioned that the Fukushima-Daiichi nuclear accident spurred an interest in nuclear energy.

Another important factor is that 2012 was the first year that MRU graduated BSc students who had started their academic career after the introduction of the BSc program, and many of these students selected our course out of the various options to complete their general education graduation requirements. Presumably, the conditions that have made this course a success will continue for the foreseeable future. There is growing student demand to offer one section of the course in the Fall in addition to the regular Winter offering. At this time we feel it is best to maintain at a single offering per year that is fully subscribed.

Challenges

There are numerous challenges to teaching nuclear energy at Mount Royal University. The first challenge is the location of MRU in Calgary. There is currently no nuclear industry in Alberta. Bruce Power's December 2011 decision to abandon its plans to build nuclear reactors in Peace River means that it is unlikely that there will be a nuclear industry in Alberta for many years to come. The absence of the nuclear industry from the province has two major aspects. First, students are not expected to get jobs in the industry by taking courses on nuclear industry. Contrast this with geology students who expect to be employed in the oil patch immediately after graduating. Post-graduation employability can be a major driver in student recruitment.

Second, it makes it tough to attract guest speakers to class. The use of guest speakers is an important pedagogical tool because it allows students to get away from academic theory and hear directly from practitioners in the field. We were fortunate in the Winter 2012 semester when we succeeded in bringing in two guest speakers from the Canadian Nuclear Safety Commission: Jacques Lavoie (Senior General Counsel) and Jean-Claude Poirier (Site Inspector). The CNSC was coming to Calgary to deliver a CNSC 101 seminar to people using nuclear materials in the medical and pipeline industries. I was able to contact them in advance of their trip, and they

arrived a day early to speak to our students. It was a 2 hour presentation and was greatly appreciated by the students.

A second challenge is MRU itself. Currently, the university has only four majors within the BSc.[6] The campus does not have a research reactor. Laboratory space has historically been overbooked and difficult to access for non-required courses. While new construction has alleviated some of the teaching lab constraints there is still concern around safety and the necessary steps for licensing for radioactive samples. Recent research quality equipment purchases will provide students with exceptional experiences. However, the equipment acquired has primarily been for required courses in existing or planned majors, not for options such as our course. Fortunately, the enrolment in CHEM 3802 justifies future equipment purchases. Plans for new majors within the BSc may also resolve some of these challenges.

A third challenge is the design of the course in an interdisciplinary way that treats the science and the politics equally. Despite a university initiative – through the General Education requirement – to get MRU students to develop a breadth of knowledge, some students are scared about taking classes that are far away from their comfort zone. For example, science students are afraid of writing long argumentative essays. Meanwhile, arts/social science students are afraid of the periodic table and mathematical equations. These fears manifested themselves in two ways. First, there was a significant absence of non-science students taking the class. As Figure 1 showed, there were only 4 students outside of the science faculty enrolled in 2011, and 3 in 2012. Second, the student survey showed that the science students, who represented 26/29 of the students who completed the course, were deeply concerned by the politics section of the course. When asked "What was your biggest fear in taking CHEM 3802?" 12 of the 16 students

[6] Health Science, Cell and Molecular Biology, Geology, and General Science.

explicitly identified the politics portion of the course. Examples of their comments included: "the political portion of the course would be too complicated for me," "the political side of the course would be too dry for me (as a science student), "having to write a poli-sci paper was daunting." This was also reflected in the fact that 9 students wanted more emphasis on the science of nuclear energy, but no students wanted more emphasis on the politics of nuclear energy.[7]

A fourth challenge was the team-taught delivery of the course. In fact, the delivery was a modified version of sequential teaching. Dr. McCollum taught the first part of the course focusing on the science of nuclear energy, and Dr. Bratt taught the second part of the course focusing on the politics of nuclear energy. The third part, which focused on medical isotopes, saw both of them in the classroom. In addition, both professors were usually at every class and there was often input from the professor who was not leading the discussion. A common problem with team taught courses, especially those that use a sequential model, is that students see it as two different classes. This was reflected in the survey comments, when one student wrote that the course needed "more integrated classes. Instead of JUST science or JUST politics, integrate the science into the political discussion, or vice versa." Despite the challenges, the students liked the team-teaching approach as 14/16 either strongly agreed or agreed with the statement "I enjoyed having this course team taught."

What did Students Learn?

One of the fascinating questions that the survey helped to answer was about the level of student's knowledge about nuclear energy before they entered the class and after they left the class. 11/16 students believed that they did not know a lot about nuclear energy before taking the class, and only 1 student said that they did. In the qualitative comments, it was commonly

[7] 6 students thought the course was appropriately balanced.

mentioned by the students that they lacked details surrounding the cost and waste issues of nuclear energy. One student even admitted that they had never heard of Chernobyl. But after taking the class, 15/16 strongly agreed or agreed that "nuclear energy is a safe and efficient form of electricity generation."

The Fukushima-Daiichi nuclear accident was an important component of the course. There was a description of the accident and its causes, as well as discussion of its effects. As with the rest of the course, the Fukushima-Daiichi accident was analyzed from both a scientific and a political perspective. 4/16 students said the Fukushima-Daiichi accident "made me more concerned about nuclear energy," but 9 students said that it did not.

Looking Forward and Recommendations

The final grades for the course are reported in Table 3. For a 3rd year option course the grades were high (but not too high), but, more importantly, there were very few failures and withdrawals.

Table 3
Grade Breakdown

	2011	2012
A	3	5
B	1	19
C	0	5
D	1	0
F	0	0
W	1	2

As stated earlier, we aim to increase the enrolment of non-science students and active recruitment techniques will be important as we work to meet that goal. Another significant

consideration as we move forward is the perception of politics among the science students at the end of the course. Close to half of the survey respondents provided comments that can be classified as having developed an appreciation for how science can impact public policy. Others commented that the politics of nuclear energy was "extremely boring". What triggered the sense of value among a portion of the students for the political content? Can we assist more students in reaching that turning point?

For other faculty embarking on the development of an interdisciplinary course we have a number of recommendations. Begin by crafting a wish-list of topics for both disciplines and then identify any commonality. For these common topics it is important that you plan if they will be taught from only one approach or if time should be invested to teach the content from both points of view. While it will result in less content in the course, these topics can serve as strong anchors, helping students appreciate the overlap between the two fields. In fact, due to the potentially diverse audience, narrowing the content to fewer topics provides time to focus on concepts and fill in foundational gaps in either population.

Each discipline has its own culture. Are students expected to read the textbook or is it an optional resource? Are online sources considered acceptable references? Are you looking for a specific answer on an exam or asking students to construct their own thesis based on core concepts? By 3rd year, students have been trained in the norms of their discipline and may have to unlearn what is expected. Clear and regularly repeated communication of the importance you place on various learning materials is absolutely necessary, as well as guidance on how you will be evaluating their work.

Learn to play to the strengths of the different disciplines. Actively use your mathematically literate students as a resource to support the remainder of the class. Similarly,

those that are confident with essay writing can serve as first reviewers of their peers' work. Encouraging your students to work in groups and fostering learning communities among people from different discipline backgrounds can strengthen the class as a whole. In particular, we observed this when students were assigned to their debate teams. The quality of research and strength of arguments were impressive, especially considering their inexperience with the field.

Finally, we would encourage you to team-teach the course if possible. Having two experts in the room (one leading the discussion while the other provides support as required) is highly effective in our experience. Not only does it expand the range of complex issues you can address in class but it also permits you to model deep thinking as one instructor poses questions to the other.

Conclusion

The course appears to have been successful. This can be measured in three ways. First, enrolment substantially increased between Winter 2011 and Winter 2012. Second, student participation remained high throughout the semester, reflected in near perfect class attendance and in the low number of failures and withdrawals. Third, the students themselves enjoyed the course. 15/16 of surveyed students strongly agreed or agreed that they would "recommend this course to my peers." However, the instructors are committed to continuous improvement in the content and delivery of the course. One area for improvement is to find innovative strategies to attract non-science students, especially policy studies majors, to take the course.