New Orleans JAZZED about Engineering Education

Paper ID #15238

Science Fiction Literature Crossed with Nanotechnology: How Experiential Learning Enhances Engineering Education?

Dr. Anne-Marie Nickel, Milwaukee School of Engineering

Dr. Anne-Marie Nickel is a Professor of Chemistry at the Milwaukee School of Engineering (MSOE). In 2002, she earned her Ph.D. in Inorganic Chemistry from the University of Wisconsin-Madison. She earned her B.A. in Chemistry at Lawrence University in Appleton, Wisconsin in 1997. Dr. Nickel is a member of the ASEE and the American Chemical Society (ACS).

e-mail:nickel@msoe.edu

Dr. Jennifer Kelso Farrell, Milwaukee School of Engineering

Jennifer Kelso Farrell is an Associate Professor at the Milwaukee School of Engineering. She has a PhD in English Literature (Science Fiction) from Louisiana State University (2007), an MA in English from Montana State University, and a BA in Creative Writing from the University of Montana. At LSU, Jennifer was part of the Communication Across the Curriculum (CxC) and worked in the Engineering Communication Studio. Jennifer has published articles in The Leading Edge, Carbon, The Journal of Popular Culture, and Foundation.

Dr. Alicia Domack, Milwaukee School of Engineering

Impact of Experiential Learning on Mastery of Course Outcomes

Introduction

This paper describes the development and evolution of interdisciplinary, experiential-learning with carefully crafted reading assignments and an interactive activity that was used simultaneously in two different courses surrounding the same theme. The authors undertook this project because educational pedagogy suggests that experiential learning and interdisciplinary learning should results in greater student-learning.[1-4] Although the authors describe their experience with specific courses at their institution, the idea that experiential learning and creating connections between classes from different disciplines can improve learning and enhance learning experiences could be employed at other institutions. Throughout the evolution of the interdisciplinary teaching strategies, the authors gained knowledge, experience and convictions that guided future experimentation. This article aims to share these experiences and describe future plans to measure the impact on learning. A subsequent article will discuss attempts to measure changes in students' learning.

The theme of the interdisciplinary, experiential learning in the two courses is the societal impacts of new technologies. The courses are elective courses from different departments; Nanoscience and Nanotechnology, a science elective, and Science Fiction, a general studies elective, are integrated with three activities focused around this theme. In the nanotechnology course, societal impacts of nanotechnology are woven through the course. In the science fiction course multiple pieces of literature are used to explore the question, "What is the author asking about the relationship between society and technology?" The interdisciplinary learning activities designed for both courses included reading assignments, classroom content discussions, and specific integrated assignments where both classes participate simultaneously. By involving students in both classes to engage in discussions together on the topic of societal impacts of new technology, the authors expect that student learning should be enhanced. Not all institutions will have these specific courses, but some institutions may have courses with similar themes such as in engineering design or entrepreneurial courses.

The authors intended to broaden students' experiences and magnify the significance of their course to topics outside their course. By broadening their experience, the authors hoped to enhance learning outcomes. This holistic, interdisciplinary learning pedagogy is supported by the literature.

Past Approaches

This paper will briefly examine the evolution of the crossover assignments spanning the years from spring 2009 to the spring of 2015; but, the focus will be on the years 2013 to 2015. A brief timeline of the evolution is provided in Table 1. The first iteration of the two individual courses included the nanotechnology students reading a science fiction book and the science fiction students reading at least one work involving nanotechnology. When the authors learned that these courses were offered at the same time in the academic year, they were inspired to

strengthen the learning experience, by creating an interdisciplinary learning experience for students in both courses where the students interacted with one another. In the first two years of the project during years 2009 and 2010, the authors built interdisciplinary activities into each course. The assignments were asynchronous online discussions based on common short readings. Students were required to both respond to threads and create their own threads. One iteration of the assignment involved forming small discussion groups that included students from both courses. Student feedback from all iterations of the assignment suggested that the early assignments were not effective at enhancing learning. Faculty's observations concurred with students. At that early point, the authors' analysis was that the project was viewed as only a homework assignment to complete and failed to engage students.

The second iteration of the interdisciplinary assignments, during years 2011 and 2012, included projects where the students in both courses prepared to teach the public about nanotechnology. One of the courses presented to elementary school children and the other groups presented at a local museum. In one of the academic years the student groups comprised of students from both courses. Unfortunately the outreach component along with the interdisciplinary component became too logistically challenging for the authors to pursue. However, the idea of teaching one topic to the other class emerged as the important component to inspire student engagement in the assignment. Refinement and re-strategizing over the early years resulted in a model where we believe we witness authentic, interdisciplinary learning. It is in the later time frame (2013-2016) that the interdisciplinary interaction culminated with students in each course "teaching" each other the principles from their respective class.

Table 1: Evolution of Hybrid Project

Evolution of Hybrid Project	
Years	**Activity**
2009-2010	Asynchronistic on-line discussions on common reading assignments
2011-2012	Asynchronistic presentations to community organizations
2013-2016	Synchronistic presentations to other class

Current Approach

Within each course, the interdisciplinary approach included four parts: a brief introduction to the other field; science fiction reading assignments that include the theme of nanotechnology's impact on society; a project that involves synchronistic interaction of the students from each class where the students teach the other students about principles from their class and written student reflections about their experience in presenting to the other class.

Table 2. Key interdisciplinary activities included in the courses.

Key Interdisciplinary Activities		
When (Week of 10 week course)	**Activity**	**Activity Description**
Week 1-2	Brief Introduction to Other Field	• Nanotechnology professor presents nanotechnology to science fiction course students in one class period. • Science fiction professor presents science fiction to nanotechnology course students in one class period.
Week 1-6	Science Fiction Readings	• Students complete science fiction/nanotechnology readings • Nanotechnology students read *Prey* ○ Science fiction students read *The Diamond Age*
Weeks 7	Presentations	• Student groups present aspect of their course to student groups from the other course.
Weeks 8-10	Reflections	• Students write reflections on their experience presenting to the other class.

The integration of the two courses began early in the quarter with a brief introduction of science fiction to the nanotechnology course and a brief introduction of nanotechnology to the science fiction course. This provided students with a foundation on which to build their learning experience. The nanotechnology students experience an introduction to the function and role of science fiction literature in scientific and cultural discussions. Likewise, the nanotechnology professor is brought into the science fiction class to give students an overview of nanotech, its applications, and its potential.

One aspect that is often overlooked or underdeveloped in interdisciplinary courses is reading comprehension.[4] Students need to be taught to read with an open mind so that underlying assumptions and main messages can be better understood. Including instructions alongside reading material can help students become better readers. A second way to make students become better readers is through role play wherein students learn the difference between critiquing a text and understanding a text.[4] The nanotechnology students are asked to critique the presentation of nanotechnology by the author. The science fiction students analyze the ways in which science fiction texts critique and question the relationship between society and technology. By engaging in these activities, students in both courses are using their learned and practicing their reading comprehension.

Both classes are also assigned science fiction novels that focus on nanotechnology. Students are better informed to read these science fiction works in context after learning the basics of both science fiction and nanotechnology. The reading assignments overlap though the students do not read the same novel. In the science fiction course students are assigned Neal Stephenson's *The Diamond Age* and the nanotechnology students are assigned to read Michael Crichton's *Prey*. Unlike *Prey* which focuses on what possible negative outcomes could come about if nanotech were to run amok, *The Diamond Age* presents a world where nanotech is fully integrated but still asks one to consider the potential hazards of controlled nanotech. These reading assignments

allow students to explore and critique a fictional society impacted by nanotechnology. The reading assignment can be treated as a case study on the impacts of technology on society.

The interdisciplinary, experiential assignment plays three roles in the courses. The first is to solidify students' understanding of specific aspects of nanotechnology and science fiction following the idea that in order to educate others, one must first have a broad and deep understanding. Students conduct a thorough investigation of a topic in order to develop an effective strategy for teaching it. The second role is to educate non-experts. Students have potential for engaging other students because they speak to each other as peers or even role models. Lastly, the interdisciplinary approach should help demonstrate the significance of the course topic, the societal impacts of technology, because the theme is an important component to studying both science fiction and nanotechnology.

The interdisciplinary approach culminates with a synchronistic, interactive activity between both classes. In two different elective courses, students were required to select a topic within the scope of their course and teach it to the other class by developing a ten-minute presentation with images and hands-on demonstrations. On the day of the event, the student groups were paired to include one group from each class. In their pairs, they listened to the presentation from the other group and then gave their presentation to that same group. Depending on time, two or three rounds of these cycles were repeated with different pairs. In this assignment, students served as experts in order to educate the other class. The overlapping themes between the two courses were then witnessed as the students learned about concepts from the other course. The students not presenting were charged with filling out rubrics to provide feedback to their peers. This has proved highly beneficial as students often catch weaknesses that faculty might miss while grading for other metrics.

Creating the interdisciplinary, interactive activity proved to be logistically demanding. Although both electives are offered during the same academic period, they do not share class time. A separate time and location was established to allow students from both classes to be in the same place at the same time; the instructors used an hour when classes are not scheduled. Student groups of 4-6 students were selected by the instructor using students' schedules to ensure that at least one student in each group was free before the presentation to set up and one student was free afterwards to clean up. Faculty graded the presentations, displays and hands on activities during the presentations. Science fiction groups alternated with nanotechnology groups and the groups repeated their presentations to provide students the opportunity to learn about multiple principles from the other course. Repetition also provided faculty with the opportunity to evaluate the presentation using pre-established rubrics. Two progress reports were assigned prior to the presentation to ensure student groups progressed appropriately. Short reflection assignments reinforced student-learning following the presentations.

Evaluation of Current Approach

The evolution of this interdisciplinary project was driven by the authors' belief that learning could be improved through overlap based on experience and pedagogical research. The authors believe that there are some critical components to the development of a successful interdisciplinary project including synchronicity, face-to-face interaction and appropriate

significance in the course structure. Synchronicity provides true interaction. When the students from both courses were not engaged face-to-face, there wasn't true interaction and therefore little impact on learning. The assignment needed to be a large enough component that it was deemed important to students. When the students were merely completing a homework reading and discussion assignment, there was little buy-in to the importance.

Future

By using science fiction literature, critical analytical papers, and class assignments in which students from both courses work together we have designed metrics by which we can now gather empirical data to gauge whether or not our efforts have resulted in improved (i.e. more in-depth and engaging) learning.

In spring 2015 we began the process of data collection. The first thing we did was to determine that the spring 2015 classes would serve as our "controls." Given the way our institution works on the trimester system, it was virtually impossible to run two sections of our courses concurrently and without impacting our sample size. The spring 2016 courses are our experimental courses. To provide control conditions we removed the experiential learning component from our spring 2015 courses since it is what we hope to prove enhances the learning in our courses. Evaluation tools will be implemented in 2016 to measure the impact of the common student project on the course outcomes directly related to the themes of societal implications of new technologies and nanotechnology include analytical papers and exams and quizzes. Specifically in Science Fiction, the outcomes will be assessed through analytical papers. A typical analytic paper will address the following: "One of the themes that keeps replaying is that there is a divide between the pure (i.e. non-augmented) and those who embrace transhumanism including nanotechnology. Explore this divide as presented in the novels and then analyze similar arguments in the real world drawing your own conclusions about perceived threats or benefits to society." In the Nanotechnology course, exam and quiz questions will be used. Example questions will be evaluated for the Nanotechnology course such as, "Describe how nanotechnology impacts society currently and describe the potential for nanotechnology to impact society in the future," and "A size-dependent property of nanoparticles is their chemical reactivity. Explain why gold nanoparticles can act as catalysts for some reactions whereas bulk gold is inert." In addition, student-written reflection papers will provide anecdotal data from both classes. External raters have been identified for both courses to ensure rater reliability.

We decided that learning outcome surveys administered at the beginning and the end of the course would provide some quantifiable data. Students in each course were asked to complete a ratings scale survey assessing their knowledge of, and interest in, learning outcomes specific to that course. An analysis of covariance (ANCOVA) will be conducted to determine if the scores from the end of course learning outcome surveys varied between the control and experimental courses, using the scores of the beginning of course learning outcome surveys as a covariate. It is hypothesized that the students who engage in the experimental courses will have a more successful learning experience, as measured by a larger gain in the learning outcomes survey.

In order to augment this data in the science fiction course an analytical paper is assigned and the rubrics gathered and entered as data. An outside literature professor is assisting in normalizing

the data by also filling out rubrics. In the nanotechnology course, pre- and post-questions were employed to evaluate the impact of learning. These anonymous free-response questions were evaluated using pre-established rubrics by a nanotechnology expert on campus, who is not connected to the course. This project was approved by the authors' Institutional Review Board in April of 2015.

Conclusion

Although the specific details of this assignment may be challenging to duplicate at other institutions due to a variety of difference, there exist common themes in courses that engineering students study. The authors believe that creating interactions between courses with overlapping themes can enhance student learning. As we educate engineers and citizens, it is critical for our students to consider how their careers and personal lives will be impacted by new technological advances. By involving students in both classes to engage in discussions surrounding these areas of overlap, student learning should be enhanced and the significance of the topic in their lives should be magnified by the experience.

Bibliography

[1] Boyer, Ernest L. "Scholarship Reconsidered: Priorities of the Professoriate." The Carnegie Foundation for the Advancement of Teaching. 1990.

[2] Kellogg Commission on the Future of State and Land-Grant Universities "RETURNING TO OUR ROOTS: Executive Summaries of the Reports of the Kellogg Commission on the Future of State and Land-Grant Universities" 2001. http://www.aplu.org/page.aspx?pid=305

[3] Kolb, Alice Y. and David A. Kolb. "Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education." Academy of Management Learning and Education. 4:2 (2005), 193-212.

[4] Andersson, Asa and Hildur Kalman. "Reflections on Learning in Interdisciplinary Settings. International Journal of Teaching and Learning in Higher Education. 22:2 (2010), 204-208.