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ARTICLE
Using the Humanities to Teach Neuroscience to Non-majors

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We developed and offered a sequence of neuroscience courses geared toward changing the way non-science students interact with the sciences. Although we accepted students from all majors and at all class levels, our target population was first and second year students who were majoring in the fine arts or the humanities, or who had not yet declared a major. Our goal was to engage these students in science in general and neuroscience in particular by teaching science in a way that was accessible and relevant to their intellectual experiences. Our methodology was to teach scientific principles through the humanities by using course material that is at the intersection of the sciences and the humanities and by changing the classroom experience for both faculty and students. Examples of our course materials included the works of Oliver Sacks, V.S. Ramachandran, Martha Nussbaum, Virginia Woolf and Karl Popper, among others. To change the classroom experience we used a model of team-teaching, which required the simultaneous presence of two faculty members in the classroom for all classes. We changed the structure of the classroom experience from the traditional authority model to a model in which inquiry, debate, and intellectual responsibility were central. We wanted the students to have an appreciation of science not only as an endeavor guided by evidence and experimentation, but also a public discourse driven by creativity and controversy. The courses attracted a significant number of humanities and fine arts students, many of whom had already completed their basic science requirement.

Key words: team teaching, the two cultures, play, time, space, emotions, perspective, film, neurocinematics

INTRODUCTION

In 1959, the English scientist and novelist C.P Snow gave a Rede Lecture entitled the "The Two Cultures and The Scientific Revolution" in which he lamented the separation of the intellectual world of Western nations into the sciences and the literary arts. He pointed out that this separation is dangerous for the societies (Snow, 1959). Since this lecture, a number of articles have been published demonstrating the separation of the two cultures at American colleges and universities (Snow and Cohen, 1968).

Although most colleges and universities require courses in the sciences and humanities as part of their curricula, this has not succeeded in disrupting the two cultures structure. Instead, we know that non-science majors (the population that is of interest to us) usually enroll in science courses not because of their intrinsic interest, but to fulfill requirements (Smith et al., 2004). There are several possible reasons why non-science majors show little interest in taking science courses. One of these is the phenomenon of science anxiety which is well documented in the literature (Mallow, 1994; Udo et al., 2001; Desy et al., 2009; McCarthy and Widanski., 2009).

There is a strong relationship between students' attitudes towards science and their achievement in science courses (Ferreira, 2003, Osborne et al., 2003; Cook and Mulvihill, 2008). The student suffering from science anxiety develops a negative attitude towards science, which lowers their achievement in the sciences (Steiner and Sullivan, 1984). This in itself may exacerbate the student's science anxiety. A lack of self-confidence (Mallow, 1994, 2006) and a lack of the appropriate cognitive framework for acquiring and retaining new science knowledge (Anderson and Clawson, 1992) have both been proposed as factors affecting science anxiety.

A further complication in the students' choice in taking a science course is their perception of the role of the course in their future careers. Glynn et al. (2007) showed that the achievement of non-science majors in science courses was directly linked to their motivation, which was in turn influenced by their belief in the role of science in their careers. Further, Cook and Mulvihill (2008) showed that non-science students who took a science course in which the information was applicable socially and to their everyday lives, demonstrated an increased interest in science. Clearly, the role of science courses in the education of the non-science student is complicated by science anxiety, career choices, and perceived applicability to their lives.

Student perception of disciplinary knowledge is also important. Marra and Palmer (2008) showed that students understood science and humanities as operating with different notions of knowledge. Students in this study saw science knowledge as fact or "…fact with exceptions" and humanities knowledge as "…multiple opinions." This reinforces an earlier study by Serpienka (1987) that showed humanities students would not challenge mathematical claims even though those claims were controversial. These examples show that, in effect, students are treating their intellectual world as fragmented, supporting, sadly, Snow's lament of the two cultures.

Despite these challenges, the importance of giving a non-science student a scientific education, i.e., to create a scientifically literate society, remains a national imperative

(National Research Council, 1996). Some of the many good reasons given for creating a scientifically literate population include keeping the nation globally competitive, improving the standard of living, and developing a citizen population capable of participating meaningfully in the political process (Thomas and Durant, 1987; Business Roundtable, 2005; National Academies, 2007). Therefore, the need to create a scientifically literate population necessitates that college and university students, most of whom are non-science majors, receive a reasonable science education, despite the issues raised.

To achieve this goal we need to develop approaches for teaching science to non-science students that will attract and retain those students in the courses, taking into consideration the unique issues that they bring to the experience. Given that non-science students respond best to science that is grounded in their lives and careers (Glynn et al., 2007; Cook and Mulvihill, 2008), a reasonable approach is to link the science principles under discussion to the issues that are important in the fields of their choice. It is not reasonable to assume that every class could address every individual student's particular interest. However, it is reasonable to assume that students whose primary interests are in the arts and humanities are more likely to develop an interest and succeed in a science course that centered the science within the arts and humanities. Some faculty have begun to experiment with these ideas. For example, Gunther (2011) has incorporated novels into teaching a course on sensation and perception.

This approach is not entirely without precedent. Existing studies (Hoskins et al. 2007, 2011; Krontiris-Litowitz, 2013) suggest that the use of primary *scientific* literature increases science students' engagement, interest and understanding in those courses. From these data one could argue that reading primary scientific literature increases the relevance of those ideas and principles to the student who is already interested in the sciences. It is not unreasonable, therefore, to suggest that taking a similar approach with non-science students would also increase their interest in the scientific principles under discussion. However, instead of using primary *scientific* literature, one could instead use *literature* of the kind that such a student might encounter in a humanities course. The selected readings should immerse the students in scientific principles, providing them an opportunity to examine those principles and link them to the work under review. We posit that this approach should serve the purpose of expanding science education to those students while engaging them in ideas about which they already cared.

Goals

Our main goal, therefore, was to create non-majors neuroscience courses that would have broad appeal to students of the arts and humanities and those who had not yet chosen a major. We intended the courses to be an interactive way of exploring neuroscience ideas through the lens of the humanities by emphasizing writing, discussion and debate.

A second goal was to teach science in a dynamic and argumentative way; to model the evolution of arguments and lines of reason, not to simply provide a neat story with inevitable conclusions. Put another way, this goal was to model and teach critical thinking skills. We wanted to encourage students to develop the habits of analyzing arguments in light of available data, a central skill in the practice of science. Given that what passes in the wider culture for reasoned debate appears to us to be less about ideas and more about personalities, a second aspect of this goal was to model and teach civil disagreement.

A third goal was to introduce students to the excitement of neuroscience. We believe that neuroscience is uniquely positioned to engage the arts and humanities. It addresses those issues that artists, writers, poets and philosophers have wrestled with for centuries and is beginning to provide answers to some of the more vexing of these (e.g., Greene, 2003; Gray and Thompson, 2004). Therefore, it intersects perfectly with the arts and humanities and provides an excellent venue for introducing and discussing scientific principles. To be clear, the courses were not designed to make the students into neuroscientists; rather, they were designed to bring the excitement of the neurosciences to a population of students who would normally never get to the advanced courses where these kinds of conversations occur. We hoped also that the students would see the relevance of neuroscience, and by extension science, to their everyday lives and fields of study, and that this would help them grow into more scientifically literate citizens.

We identified success in this project as our ability to attract and retain significant numbers of non-science students in the courses. Specifically, we were interested in knowing whether such courses would enroll significant numbers of students who:

1. had not yet declared a major
2. had already declared a non-science major
3. had already completed their science requirement and did not need to take another science course.

COURSE DEVELOPMENT

We began course development after successfully competing for an internal grant. We also applied for a GLCA New Directions Grant, which was funded. Both grants allowed us to acquire materials, mostly books, which we read in preparation for team teaching. The grants also provided some stipend support for planning meetings in the summers. We developed a book and articles list together. Not every book we selected was for use in the courses. We read many of them together as a way of understanding each other's discipline and perspective, and to give us common frames of reference (see supplementary materials, part A for examples). The latter was particularly important for guiding classroom discussions.

In our initial planning conversations we envisioned a small seminar-style course of about fifteen students. We thought that this approach would allow us to engage the students in rigorous writing and in-class debates. But as the time came to propose the course to our respective departments, we reconsidered this approach thinking that our chances of success in offering the courses might be lowered if we proposed two faculty members teaching a class of only fifteen students. So we settled on a course of thirty students, hoping but not knowing whether we would make those numbers.

Much to our surprise, on the day of our inaugural class, we walked into the classroom expecting thirty students, but were astonished to find instead, eighty-three students, most of whom were carrying Add/Drop forms hoping to be signed into the course. Given that Kenyon College has a total student population of approximately 1550 students with an average class size of 15 students, this was in context, a rather large class. We had to decide on the spot who to let into the course.

Therefore, having made no contingency plans for what to do if eighty-three students showed up, and having no reasonable mechanism for selecting who should or should not be let in beyond our initial criteria, we set about to signing every Add form that was handed to us. We viewed this level of interest as vindication of our view that students would respond well to this kind of course and as our first measure of success. We also knew that we wanted to teach a second course and, having no assurance that our respective departments would agree a second time, thought that documenting this level of interest would help to make the argument. Of the eighty-three students who showed up on the first day, sixty-three students remained registered to the end. Some students dropped the class but, to our amazement, most of the students who stopped taking the class for credit asked our permission to *continue attending* the classes. And so, in the end, the class had regular attendance of approximately eighty-three students. So much for a class of thirty!

Team Teaching

In addition to using humanities literature to open dialogues in neuroscience, we also opted for a team teaching approach. Team teaching is a model that benefits both the faculty and the students. For the students the benefits include more interesting classes, better student-teacher relationships, higher achievement, and a wider perspective on the discipline. Teachers benefit in that they expand on their teaching methods, gain a fresh perspective, and develop a more philosophical relationship to their discipline (for review see Letterman and Dugan 2004). A joint benefit for all (teachers and students) is the sharing of “cognitive space” by a group of individuals of varying background (Flannery and Hendrick, 1999) as they work on an intellectual project.

There are several models in the literature that can be adopted for interdisciplinary team teaching, especially in cases where the faculty are from the humanities and sciences. The most basic, least interactive and possibly most common model of team teaching is one in which the instructors teach individually in separate time periods (Winn and Messenheimer-Young, 1995). However there are some other interesting models in the literature. Three examples are the “jigsaw,” the “kaleidoscope” and the “transdisciplinary” models (Rives-East and Lima, 2013). In the “jigsaw” model, the ideas to be taught are separated into distinct disciplinary pieces and “reassembled” in class (Grossman, 2001; Rives-East and Lima, 2013). In the “kaleidoscope” model the disciplines involved in the course make claims about the same ideas from different perspectives (Grossman et al., 2001; Rives-East and Lima, 2013). In the “transdisciplinary” model the disciplines are abandoned entirely in favor of building something new and distinct (Latucca, 2001) within the collaboration.

None of these accurately described our courses even though our initial planning revolved around the kaleidoscope model. In practice, we found that our courses focused on understanding neuroscientific (and by extension scientific) concepts and that the humanities served as a point of entry. We abandoned the commonly employed ways of team teaching and instead used an approach that we call *vulnerability teaching*. In this approach, both members of the team are present in the classroom for every session, taking turns lecturing and leading discussions. However, during these presentations, the non-presenting faculty member is free (and encouraged) to interrupt, disagree, argue, present alternative views, and in general advance a debate of the ideas being presented. Clearly, not every idea is debatable, but where there is ambiguity or alternative interpretations, the non-presenting professor pointed this out. Put another way, the non-presenting professor modeled skepticism for the students, and both professors modeled civil discourse and tried to actively draw the students into the discussion.

Vulnerability teaching changes the classroom in very specific ways. It alters the traditional model in which the professor present and explain the discipline to students who (generally) accept their knowledge authority. Instead, our approach disrupts this traditional model in that faculty challenge each other to defend the ideas and methodologies of their disciplines *in the presence* of the students. Further, the students are encouraged to participate in these conversations. Not only does this method risk exposing the shortcomings of the disciplines, but faculty themselves risk exposing the limits of their individual knowledge.

This approach teaches the students to critically analyze ideas even if they are believed to be long-standing truths. We believe this model upends the student-held notion that science is simply a collection of facts (Serpienka, 1987), and introduces the notion that it is a public debate based on evidence. We observed that initially, students were hesitant to join these debates, a problem we solved by randomly calling on students to offer insight or analyses. As time went on and this kind of interaction became the norm, the students became more engaged and our problem became that of containing the debate, not getting it started.

This approach evolved because we believe, as do others (e.g., Ross et al., 2013; Scott, 2014), that some of the issues identified (e.g., science anxiety) are related to the manner in which science is presented at the early stages. Non-science majors in large part take introductory courses, which are often lecture based with limited opportunity for the students to participate in meaningful discussion. While the facts are covered, this method does not present science as a living, dynamic debate of ideas that are open to revision. Rather, science is presented as a collection of facts to be memorized (Ross et al., 2013) and the students gain little understanding of the process. As Scott (2014) puts it, "…introductory courses … can actually end up being overly focused and pre-professional, the opposite of liberal." Our team teaching goal therefore, was to discuss and debate ideas, not necessarily to end each discussion with neat, encapsulated conclusions, but to teach the students how to explore the issues and to come to their own conclusions after thoroughly examining the evidence available.

Classroom

The students were assigned a broad variety of reading materials (see syllabi for the two courses in supplementary materials, parts B and C) and encouraged to engage in dialogue both with fellow students and the faculty. The faculty provided a combination of lectures and discussions and students were also required to give presentations. Vigorous discussions occurred in the classroom, which included both the faculty and students.

Online Discussions

Because of the large class sizes, online forums were used as a means of continuing conversations beyond the bounds of the classroom. The rules were fairly broad; civility was to be paramount and posts had to meaningfully drive the conversation forward. Course participation was a part of the final grade and forum posts counted as participation. Therefore, everyone posted to some discussion but no one had to post to all discussions. The faculty posted the initial question to be discussed and monitored the online discussions but did not interfere. The discussions were open ended. Active debates around the posted issue emerged, and occasionally smaller debates could be seen housed within the larger debate. New questions emerged within the discussion and these were discussed by subgroups within the overall population. Because the two courses we taught were slightly different, the specifics of each course are discussed separately below.

THE COURSES

Neuroscience 191 (NEUR191): Special Topics
The Neuroscience of Film, Space, and Play.

This was our first of two different non-majors courses. Eighty-three students attended although sixty-three were formally enrolled. It was envisioned as a one-semester course that would allow the student to fulfill half of their science requirement at Kenyon College. It was taught by two permanent faculty members, a professor of Neuroscience and Psychology and a professor of Philosophy with an ongoing affiliation with the Neuroscience Program. Students taking this course had the option of pairing it with one of two non-majors' biology courses, or with the majors introductory neuroscience course as a way of satisfying the Kenyon science requirement.

The course was divided into two major sections (see supplementary materials, part B). The first section, lasting several weeks, was aimed at providing the background necessary for meaningfully engaging the topics of film, space and play. We recognized that in order to successfully discuss the humanities and neuroscience in an interactive way, everyone in the class needed to be grounded in some of the basic ideas of each discipline.

We therefore began the course with an introduction to naturalism, neuroscience and the humanities. In this section the students were introduced to the philosophy of science. Here the major reading assignment was Karl Popper's "Conjectures and Refutations." This was followed by an introduction to the humanities *as a research program*. The major reading assignments here were Martha Nussbaum's "Introduction: Form and Content, Philosophy and Literature" and Virginia Woolf's "The New Dress."

Next, neuroscience *as a research program* was introduced. In this section, the major reading assignments were V.S. Ramachandran's *A Brief Tour of Human Consciousness* and selections from Oliver Sacks' *The Man Who Mistook His Wife for A Hat.* This section was followed by an introduction to Naturalism and Natural Selection and the major reading assignment here was Charles Darwin's "On Natural Selection." We ended this introductory half of the course with an Introduction to Ethology with Jakob von Uexküll's "A Stroll through the World of Animals and Men" as the major reading assignment.

Each professor took turns leading the discussions on these topics based on their particular strengths and expertise. For example, the philosophy professor led the discussions on the philosophy of science and guided the students through their reading and analyses of Popper's article. The neuroscience professor led the discussions of neuroscience as a research program and guided the students through their reading and analyses of the Ramachandran book and the Oliver Sacks' selections. Throughout this process, as one professor led the discussions, the other was present to challenge ideas, raise objections, agree on some points, disagree on others. This is the vulnerability aspect of our teaching method.

At the conclusion of these sections, which constituted half of the course, the specific topics of the neuroscience of Play, Film and Space was addressed. We were comfortable that having spent the previous six weeks examining the humanities and neuroscience in a critical manner, the students were now ready to tackle these specific topics in the same critical and analytical manner. First, the class read and discussed the ideas surrounding play behavior in humans and animals. The major reading assignments were the chapter on play (chapter 15) from L.E. Dugatkin's *Principles of Animal Behavior*, 2nd Edition; K.V. Thompson's "Self Assessment in Juvenile Play" from Bekoff and Byers' *Animal Play: Evolutionary, Comparative, and Ecological Perspectives*; and selections from Johan Huizinga's *Homo Ludens*. These readings were supplemented with lectures by the neuroscientist on research from his laboratory on play behavior in rats and mice. After approximately two weeks on play behavior, the topic of Space was introduced. The major reading assignments for this section were Edwin Abbott's *Flatland*; Rudolph Arnheim's chapter on "Space," from *Art and Visual Perception: A Psychology of the Creative Eye*, selections from Oliver Sacks' *The Man Who Mistook His Wife for a Hat*, and "Spatial Processing," Chapter 7 from G. Dennis Rains' *Principles of Human Neuropsychology*.

For the final topic of the course, the neuroscience of film, the major reading assignments were Joseph Anderson's *The Reality of Illusion*, and "Neurocinematics: The Neuroscience of Film" (Hasson et al., 2008).

Assessment

Assessment of student work and participation in the course was based on five items: quizzes (40%), thesis statement and paper (10 and 15%, respectively), final examination (30%) and participation/forum post (5%) (see supplementary materials, part B).

Quizzes

We recognized that if the course was to work as designed, i.e., to have vigorous debates around the ideas presented, then it was essential that the students kept up with the assigned readings and arrived in class prepared for the discussions. In order to ensure that the students did the readings in a timely manner, we instituted a series of *timed* online quizzes. These quizzes were set up using the MOODLE course management system. Briefly, quizzes on the readings and topics to be discussed during the upcoming week were posted on the prior Sunday evening. The class met on Tuesdays and Thursdays for 80 minutes, so the week's quiz remained available until one hour before the start of the class on Tuesday. Once a quiz closed it was not re-opened and once a student logged into a quiz, they were required to complete it in that session; they were not allowed to log out and return later.

Because the quiz was on material in the reading that had not yet been discussed in class, the only way for the students to do well on the quizzes was to conscientiously do the reading. For all readings, the students were provided with a study guide (see supplementary materials, part D for an example), which they were encouraged to use to guide their reading of the particular assignment. The quizzes were short, (10 to 25 Multiple Choice and/or True/False questions), and timed so that the students had enough time to complete the quiz but not so much time that they could look up all of the answers. We had no objection to the notion that a student who was knowledgeable enough to complete most of the quiz in a relatively short time might look up one or two of the answers. We saw this as a part of the learning process and a reward for having put a good faith effort into the work.

To discourage collaboration between the students, the quizzes were scrambled so that for each person, the order of the questions as well as the order of the choices within the questions was randomly generated. Therefore, it was unlikely that for any two students, question 5 would be the same (as one example). However, if by chance the question was the same, then the order of the choices for the answer was scrambled so that for one student the correct answer could be **A** but for the other it could have been **D**. One final control that we instituted to discourage collaborative work on the quizzes was to break the quizzes up into multiple pages with only five questions per page. Therefore, no two students could simply scroll through the test from top to bottom looking for questions that matched. One had to navigate the quiz on a page-by-page basis. While students could collaborate, the effort required combined with the limited time available would have made this a fruitless endeavor. We recognize that these control measures did not guarantee that students did not collaborate on the quizzes. However, based on our results, we are confident that these measures worked. Most importantly, we believe that after the first few quizzes, a quiz-taking culture had developed that for most students, made these measures unnecessary.

Thesis Statement and Paper

Each student was required to select a research or review paper from a list provided for critical reading, and to answer a short series of questions in writing. Specifically they were asked to identify the main thesis and secondary theses of the paper, to identify the evidence provided that supported these theses, to identify any counter evidence presented, to evaluate the evidence and determine whether it was convincing, to identify or generate alternative hypothesis, and to determine, based on their reading of the paper, what the next research question would be. They were then required to formulate that question into a testable hypothesis and to briefly explain how the test would be carried out. They were given strict limits on the length on their paper (see supplementary materials, part E).

Participation/Forum Posts

Students were encouraged to participate in class discussions. This included asking questions, challenging ideas presented in the reading, by the faculty, and by their colleagues. However, not everyone could or would participate in the live class conversation. Further, students occasionally wanted to continue the conversation on some topics even after the class had moved on to a new topic. Therefore, we instituted Forum Posts in MOODLE to encourage ongoing conversations outside the classroom. The forum was initiated by the faculty members who posted a question to start the discussion. Students were required to post either a) a response to the original post; b) a response to someone else's response, or c) a new question that grows organically from the ongoing discussion. While everyone was required to have at least one posting to the forum, everyone could post as many responses or questions as they liked. There was a single forum for each major topic. For example, the faculty began the forum on play behavior by posting the following questions: *Based on your knowledge of ethology, neuroscience, evolution and the arts, what do you see as the value of play to human society? Why do human beings play? How would our lives be different if play didn't exist?*

(For an example of the forum instructions, see supplementary materials, part F).

Final Examination
The Final Examination followed the format of the quizzes. The main difference was that the test was cumulative and therefore based on *all* the material covered throughout the year. The students were given more time to answer the questions on this longer examination.

Neuroscience 105 (NEUR105)
Neuroscience of Emotions, Perspective and Time.
This was our second non-majors course. Forty-three students took this course for credit. Like NEUR191, the course was structured into two sections (see syllabus in supplementary materials, part C), the first focusing on introducing the sciences and humanities as fields of study, and the second focusing on the main ideas to be discussed (emotions, perspective, and time).

The course began with an introduction to naturalism, neuroscience and the humanities and the first background reading focused on functionalism and natural selection. The required readings for this section were selections from Richard Dawkins' *The Selfish Gene*. This was followed by background reading in neuroscience and cognition which consisted of selections from Antonio Damasio's *Descartes's Error*. Next we assigned background readings in perception from Richard Gregory's *Eye and Brain*.

Following this background preparation we began to address the course topics. We began with Perspective, using as the major reading assignment Erwin Panofsky's *Perspective as Symbolic Form*. This was followed by Time. The required reading here was J.D., Palmer's *The Living Clock*; William James' "The Perception of Time," from the *Principles of Psychology*; Oliver Sacks' "Speed: Aberrations of Time and Movement" from *The New Yorker;* the selection on time from Augustine's *Confessions*; and Ivry and Spencer's (2004) article on "The Neural Representation of Time." The required reading for the emotions section of the course consisted of William James' "What is an Emotion"; selections from Antonio Damasio's *Descartes's Error;* and Chapter 9: "Emotions and Stress" from Jackson Beatty's *The Human Brain: Essentials of Behavioral Neuroscience* (see supplementary materials #3).

Assessment
Course assessment followed that which was used in NEUR191 with one significant change. We required the students in NEUR105 to develop and present their thesis statement and experimental ideas orally to the class, to stand for questions and challenges, and defend their ideas (see supplementary materials, part G). To accomplish this in a timely manner, in the last two weeks of the semester, we broke the class into two sections by randomly assigning half of the class to each professor. Each section met for those two weeks for oral presentations. Each student was required to write 10 substantive critiques of other students' presentations. These critiques were required to be approximately 1-2 pages long. Non-substantive critiques were rejected by the faculty and the student was required to write a replacement critique. All students took the same final cumulative examination.

RESULTS

A breakdown of the 106 students who took our courses for credit reveals that 30% of the students enrolled were first year students, 36% were second year students, and 34% were juniors and seniors. This means that 66% were either first or second year students. Further, of the 106 students, 13 (12%) had already declared a major in the natural sciences, 8 (8%) had declared a major in the social sciences, 37 (35%) had declared a major either in the humanities or fine arts, and 48 (45%) were undecided. This means that 88% of enrolled students in our courses were either humanities or fine arts majors, or had not yet declared a major. Clearly the courses were successful in that they attracted and retained our target population.

We also found that 43% of the students taking the courses had already completed their college mandated science requirement. For this population, the courses did not serve to fulfill a college or major requirement. In fact, that percentage undercounts the actual number because it includes the first year students who could not yet have already fulfilled their requirements because the classes were offered in the fall. However, adjusting for that we find that 64 students took one of our classes who were not in their first year and 44 of those had already completed their science requirement. This means that 69% of the students took the courses even though doing so did not satisfy a requirement.

Fate of the Undeclared Students
Of the forty-eight students who had not yet declared a major when they enrolled in our classes, eleven (23%) became science majors and thirty-four (71%) became non-science majors; one (2%) became a synoptic (self-created, interdisciplinary) major, and two (4%) withdrew from the college. Of the undeclared students who became science majors, five (10%) became neuroscience majors, five (10%) became psychology majors, and one (2%) became a Biology major.

Gender Breakdown
In NEUR191, the male to female ratio was 47% to 53%, mirroring the 47% (men) to 53% (women) in the college from 2004 to the 2013. There was a slight increase in the number of women taking the second course in the sequence (NEUR105) where the male to female ratio was 45% to 55%. However, the overall average of the two courses was 46% (men) to 54% (women), well within the range of the college population average.

DISCUSSION

We present here two courses that are examples of how to build an interdisciplinary team-taught non-major's neuroscience course. Our goal was to teach science in a way that appealed to non-science students by bridging the perceived divide between the sciences and the literary arts. We taught using books written by authors who presented neuroscience in a literary manner (e.g., V.S. Ramachandran and Antonio Damascio), which explored topics with broad appeal (e.g., play behavior and emotions). We supplemented these with chapters from traditional science texts and journal articles. Our primary goal was to attract non-science students and students who had not yet declared a major, particularly those in the first two years college. As expected, the courses attracted primarily the students in our target population.

Although we developed our courses explicitly to attract humanities, fine arts and undeclared students, we hoped that some science students would also enroll. We began this journey because we wanted to disrupt what we saw as a two-culture problem in our local environment. We did not think that significant progress could be made unless members of both cultures read, discussed and debated the same ideas together. Therefore, we were pleased to find that a small but significant number of students enrolled were indeed science majors. We viewed this as a successful outcome of our model. The overwhelming majority of the enrolled students were undeclared or non-science students, and a significant number of them took the courses out of interest and not because they were required to do so. We took this as a clear indication that there is a strong interest among these students to take science courses taught in a non-traditional way.

Although we did not systematically measure student attitudes, we noticed anecdotally that the classroom dynamic changed over the semester. Students became more willing to engage in reasoned debate and more readily interrogated ideas. We believe that this shift in attitude was real and plan to measure and report on student attitudes in the future. Because of the broad range of meanings of the term and the brief exposures of our courses, we cannot claim to have created scientifically literate students. Despite the differing definitions of the term science literacy, DeBoer (2000) suggests that this imprecision of definition may itself be an asset. That, notwithstanding a “wide range of meanings…” science literacy might be summarized under nine goals. Three of these in particular were important for our project. These were:

- Teaching and learning about science that has direct application to everyday living;
- Learning about science as a particular way of examining the natural world
- Teaching students to be informed citizens.

We believe that our courses have made some progress in achieving these goals.

Challenges and recommendations

The open enrollment method we employed demonstrated that there is a strong interest among the non-science students for interactive, humanities based, science courses. However, we believe that this kind of course should be small enough to facilitate discussion. Although our classes worked well, we are convinced that the experience for both faculty and students would have been richer had the class been the thirty students we originally expected.

Our emphasis on vigorous debate in the classroom and online meant that disagreements and controversies emerged. These must be properly handled if the course is to be successful. For students, especially the younger ones, disagreements or contradictions can be confusing and has the potential to reinforce any fears and misgivings they might already have about taking a science course.

However, in teaching this kind of course the goal is not to avoid contradictions (Winn and Messenheimer-Young, 1995), but to explore them when they emerge and to use them to teach the scientific process. There are many controversies in science; a scientifically literate population must not only understand this, they must be able to think through the controversies and understand the issues. Properly handled, these “contradictions” serve as excellent teaching moments. We do not recommend that the contradictions be “manufactured” as teaching tools; rather, we recommend that they be embraced and explored openly with the students as they emerge. This leads to a very exciting class.

We agree with Winn and Messenheimer-Young’s (1995) suggestion that to be successful the team members must have trust, respect and honesty. These are some of the values that we were attempting to model and therefore we needed to demonstrate these traits to the classroom. Further, without these, vigorous debate is impaired and the class does not achieve its goals. We recommend that in addition to selecting reading materials and agreeing on a syllabus, that some effort is spent in the planning period to develop a working friendship if it does not already exist. This is the time to have real arguments about disciplines and ideas. It allows the team members to get to know each other and to learn and trust that arguments are about ideas and not persons. It is also a time to learn each other’s boundaries in areas like humor and sarcasm. This is perhaps not necessary advice if the team is made up of old friends; however, for a team that is just getting to know each other, honesty and openness in the planning stage is essential for a successful teaching experience.

If possible, choose topics that are particularly interesting to the instructors. This will translate to passion in the classroom, which will draw the students into the conversation making the science and the course more interesting.

Summary

We set out to create neuroscience courses that would attract first and second year students, students whose primary academic interest were the humanities and fine arts, and students who had completed their science distribution requirements and would not normally take additional science courses. Judged by these standards the courses were successful. The majority of the students taking the courses were our target population. Most were in their first or second year of college and had not yet decided on a major. Of those who had already declared, most were non-science majors and many of these had already satisfied their science requirement and did not need to take our courses. These results support our premise that if we change the way we teach science, non-science students will voluntarily return to the science classroom. The enrollment pattern in our courses bears this out.

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