ARTICLE
Creating Cross-disciplinary Courses

Elaine R. Reynolds
Neuroscience Program, Lafayette College, Easton, PA 18042

Because of its focus on the biological underpinnings of action and behavior, neuroscience intersects with many fields of human endeavor. Some of these cross-disciplinary intersections have been long standing, while others, such as neurotheology or neuroeconomics, are more recently formed fields. Many undergraduate institutions have sought to include cross-disciplinary courses in their curriculum because this style of pedagogy is often seen as applicable to real world problems. However, it can be difficult for faculty with specialized training within their discipline to expand beyond their own fields to offer cross-disciplinary courses. I have been creating a series of multi- or cross- disciplinary courses and have found some strategies that have helped me successfully teach these classes. I will discuss general strategies and tools in developing these types of courses including: 1) creating mixed experience classrooms of students and contributing faculty 2) finding the right tools that will allow you to teach to a mixed population without prerequisites 3) examining the topic using multiple disciplinary perspectives 4) feeding off student experience and interest 5) assessing the impact of these courses on student outcomes and your neuroscience program. This last tool in particular is important in establishing the validity of this type of teaching for neuroscience students and the general student population.

Key words: interdisciplinary, multidisciplinary, pedagogy

The neuroscience community is a leader in the development of interdisciplinary curriculum; our research, training and teaching is by its nature, interdisciplinary. Many of us would describe ourselves as neuroscientists, geneticists, physiologists, pharmacologists, molecular cell biologists, behaviorists, and psychologists all rolled into one. We as teachers within this community have had to be open to learning new fields given the rapid pace of neuroscience as a discipline, often teaching beyond what we were "trained" to do. In addition, because neuroscience focuses on the underpinning of action and behavior, most of us are at least curious about the underlying creativity and motivation in other disciplines and sets of knowledge. In these ways, we are uniquely positioned among our colleagues to lead an interdisciplinary revolution.

I would venture to say that on most college campuses interdisciplinary course offerings have been discussed and embraced as a general part of the curriculum. Various books and institutional reports have developed definitions of interdisciplinary education, cited studies that point to the importance of these classes, and presented assessment criteria and best practices in generating interdisciplinary curriculum (Teagle Foundation White Paper, 2006; Harvard University, 2005; Lattuca, 2001; Project Kaleidoscope, 2011). I hope to re-emphasize some of these same issues, but also to provide a first person perspective on the development and teaching of these courses.

The "White Paper on Interdisciplinary Education at Liberal Arts Institutions", supported through the Teagle Foundation in 2006, defined interdisciplinary education this way:

> Interdisciplinary education is a mode of curriculum design and instruction in which individual faculty or teams identify, evaluate, and integrate information, data, techniques, tools, perspectives, concepts, and or theories from two or more disciplines or bodies of knowledge to advance students' capacity to understand issues, address problems, appraise explanations, and create new approaches and solutions that extend beyond the scope of a single discipline or area of instruction.

I have found this definition to be instructive in designing courses because it sets out specific ideas for what to do in the classroom and what the specific student outcomes should be. In general, the appeal of an interdisciplinary curriculum stems from outcomes such as the ability to integrate across fields and to apply knowledge in different contexts. Many studies show this type of thinking is important for problem solving and can be applied to real world problems. Students appear to find these types of courses interesting and because of their engagement they are more involved in their own learning. Many people think that this pedagogy also reflects the goals of a liberal arts education.

I have used cross-disciplinary in my title because I believe that while true interdisciplinarity is a goal for many of my classes, mostly they are courses that cross multiple disciplines or show problems from multiple disciplinary perspectives. Table 1 summarizes the courses I have developed and refer to here, the fields that are integrated into the courses, and the audience. I will refer to these courses in my descriptions of general strategies as examples and I provide a resource list related to these courses at the end of this article.

Strategies for Developing Cross-disciplinary Courses

One of the strategies that I have found to be very helpful in teaching these types of courses is to create mixed-experience classrooms of students and contributing faculty.

In doing this, you automatically bring people together that have different perspectives on the topic at hand. I have done this several different ways. The first obvious model for this approach is team teaching—the two experts in the room scenario. However, with this approach, students often rely too heavily on the faculty expertise rather than doing their own thinking. In addition, not every institution has the resources to team teach regularly. I have found that having experts visit the classroom to bring alternative perspectives is a much more productive use of faculty time and promotes more student engagement. In Intro to Neuroscience, faculty from neuroscience, computer science, art, philosophy and religion visit the classroom during the semester to bring their perspective and expertise to the class. Students prepare questions to ask visitors about problems we have been discussing. I also bring in expertise via YouTube. It's more engaging to have Daniel Dennett describe his philosophical perspective on the mind body problem then having me explain his ideas.

Another way to create an interdisciplinary environment is to enroll a student population with a mixed set of expertise and experience. In my ANC course, we mix upper-class science majors and art majors together to look at the intersections of art and neuroscience. Students teach each other information through small group discussion or art practice, and every question or topic in class gets an input from multiple perspectives, reinforcing the integrative learning through the students' engagement.

Sometimes it is daunting for the professor to teach and manage mixed-experience classroom that are heavily dependent on peer interaction. There is a chaotic component to peer-to-peer teaching that not everyone is willing to accept. However, I find that in-class activities that bring students together with different backgrounds, but that set boundaries for student engagement, work best. In my ANC course, students with different backgrounds form groups to work on a visual modeling project at the end of the semester. These projects integrate the ideas from both backgrounds by asking students to find visual expressions or metaphors for science-based knowledge. These collaborations create novel ideas and interpretations of the material in the course. The students have produced wired cage brains with visual representations of different forms of mental illness and huge canvases where the group has captured the rhythms of various dance forms with painted feet (Figure 1).

Teaching a mixed-experience classroom requires that the material one teaches has to be introductory to some extent because we can't assume any prior student knowledge. The second strategy in developing these courses is to find teaching tools that can be utilized without prerequisite knowledge by a general audience. In particular, tools that also assume a multidisciplinary perspective parallel to the course topic are most helpful. Ideally you would like each individual student to review prior knowledge in a new context, but to also integrate new information. Fortunately, there is a wealth of general audience books that have a multidisciplinary bend related to neuroscience. I have used general audience texts for most of these courses and I have listed some of these tools in a reference list at the end. One of the best examples from my own teaching is a text I use in my ANC course called *Understanding Comics*. This text reviews many basic ideas in cognitive science and perception in a classic comic format. The visuals get the concepts across to students from any background relatively painlessly!

Course Name	Fields Integrated	Audience
Intro to Neuroscience	neuroscience, philosophy, comp sci, cog sci, art, religion	freshman neuroscience, biology, psychology and other majors
First year seminar: Fear	biology, sociology neuroscience, film and media	first semester freshman-all majors
Art, Neuroscience & Consciousness (ANC)	art, neuroscience, cognitive science	science and art majors, usually upperclassmen
Advanced Neuroscience	neuroscience, web design, comp methods	senior neuroscience majors

Table 1. Courses developed and referred to in this article.

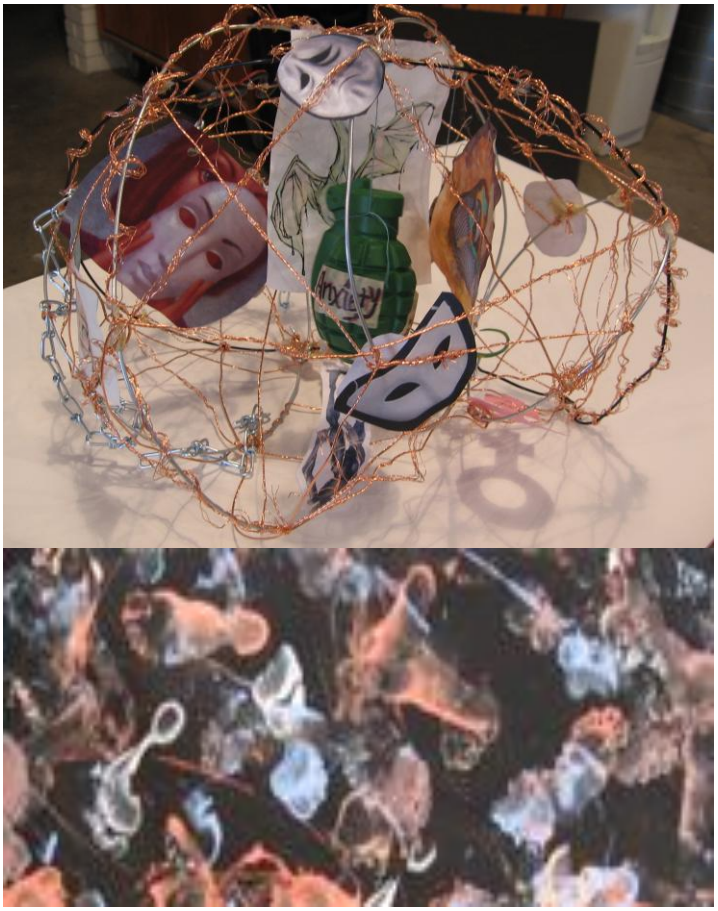

Figure 1. "Visual modeling projects from an art and neuroscience cross-disciplinary course. *A.* Visual representation of behavorial disorders. *B.* Visualization of the rhythmic patterns of movement in dance.

Another way of creating a cross-disciplinary approach in a classroom is by forcing the students to look at one topic from multiple disciplinary perspectives. This type of course is easier to develop than a truly interdisciplinary course

where there is a synthesis of the fields. I also think this approach works well in a mixed-experience class of freshman or sophomores. I utilized this approach in my first year seminar entitled *Fear*, which I developed on my own, but in consultation with other faculty members. In this course we look at fear as a physiological response, as a pathway in the brain, as a positive and negative psychological response (protective response vs. anxiety and phobia), as something that reflects the fears and values of society (we watch horror films), and as a way to manipulate people's ideas (culturally and politically). I hope that these multiple perspectives give value to the different disciplines students might study in their common course curriculum as well as teach them to think critically and from different perspectives when encountering a new topic. Again in this course, general audience texts and films provided the appropriate level of engagement in the topic and supplied necessary background material for all of us. Likewise in my Intro to Neuroscience course, we look at the topic of consciousness from neuroscience, medical, behavioral, computational, philosophical, and religious perspectives. All of these different approaches give students an integrated perspective of the topic and allows them to fit their neuroscience learning into a larger knowledge context.

A general strategy I implement in all these courses is to feed off of student interest. We are in the golden age of narcissism it would seem, and as a teacher I can use that to generate engagement in the material and also again to produce multiple perspectives in the classroom. In all of these classes students design projects related to their own interests or behavior and share their projects with the class. They write about their own fears in the FYS class and their own intuition about the mind-body problem in Intro to Neuroscience. They design visual modeling projects for ANC and their own website for Advanced Neuroscience. While the students chose their projects, they do so within strict boundaries I create for the assignments.

A lack of control over content is one commonly perceived problem in teaching these courses and with using many of these strategies presented here. A course using these strategies varies from semester to semester and the knowledge the students gain is not uniform. Allowing students to take control of a project or peer-to-peer teaching can lead to a variable quality of learning. Assessment can be difficult, especially if a major or program is focused on content as a student outcome. Programs or majors can also be hesitant to accept these courses since they are perceived to contribute only minimally to knowledge within any particular discipline. There is also some difficulty assessing the value in this type of pedagogy because the impact on students can be years in the making.

One strategy to successfully developing these courses is to provide validation in the short term by clearly defining the desired student outcomes and by creating assignments that directly measure the outcomes. For example, instead of having the outcomes focus on a particular content, the outcomes can focus on critical thinking, data acquisition or problem solving skills. Several of the resources mentioned previously have sets of learning outcomes that might be expected in multidisciplinary courses. Assignments like the project mentioned previously in the ANC course where students create a visual metaphor for an idea, measure students' ability to apply their knowledge to a problem in a different context as well as what they have learned about the visual system in perceiving and creating art. As another example, in my *Fear* class students analyze a current horror film in terms of physiological response on an individual and its reflection of our society fears. Assignment should directly measure the student outcomes that are the core strengths of this pedagogy to validate the emphasis on skills rather than in depth content.

Courses can also be assessed as larger goals within the program assessment. For example, I have an assignment in our *Advanced Neuroscience* capstone course for our majors that requires students to create their own website based on the knowledge they have accumulated over their 4 years. This course was originally team-taught and developed by a team of biology/psychology faculty to bridge those disciplines, but in recent years has extended to combine neuroscience with other disciplines as well. In my class, students collect and integrate original source material, they create text, collect or design visuals for the website, and they work individually and in teams to complete the project and present it for evaluation by their peers. Since the emphasis of web-based material is visual and integrative, I can assess the impact of the ANC course by comparing the success of students who have and have not taken the course. For example, for the class in 2011, students who took my ANC class performed better on this website assignment (92.3 vs. 89.7). This type of assessment provides a clear measure on the attainment of a particular skill set.

As teachers, we all want our students to develop critical thinking and problem solving skills. One key overall component of these strategies is to have students stand in the shoes of someone else, someone with different experience and training to gain perspective. This flexibility of mind is key to both of these skills. To assess them properly, we need to provide students with a problem to solve and then stand back and see how they do. We need to focus less on content after a student masters foundational knowledge and give them more time and space to acquire knowledge on their own, to integrate that knowledge with the foundation and to practice these important skills. Cross-disciplinary courses provide that opportunity.

RESOURCE LIST

General

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FYS:Fear

Altheide DL (2002) Creating fear: news and the construction of crisis. Piscataway, NJ: Aldine Transaction.

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Intro to Neuroscience

His Holiness The Dalai Lama (2005) The universe in a single atom: the convergence of science and spirituality. New York, NY: Morgan Road Books.

Art Neuroscience and Consciousness

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Address correspondence to: Dr. Elaine R Reynolds, Biology Department, 111 Kunkel Hall, Lafayette College, Easton, PA 18042. Email: reynolde@lafayette.edu