ARTICLE
Brain Literate: Making Neuroscience Accessible to a Wider Audience of Undergraduates

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The ability to critically evaluate neuroscientific findings is a skill that is rapidly becoming important in non-science professions. As neuroscience research is increasingly being used in law, business, education, and politics, it becomes imperative to educate future leaders in all areas of society about the brain. Undergraduate general education courses are an ideal way to expose students to issues of critical importance, but non-science students may avoid taking a neuroscience course because of the perception that neuroscience is more challenging than other science courses. A recently developed general education cluster course at UCLA aims to make neuroscience more palatable to undergraduates by pairing neuroscientific concepts with philosophy and history, and by building a learning community that supports the development of core academic skills and intellectual growth over the course of a year. This study examined the extent to which the course was successful in delivering neuroscience education to a broader undergraduate community. The results indicate that a majority of students in the course mastered the basics of the discipline regardless of their major. Furthermore, 77% of the non-life science majors (approximately two-thirds of students in the course) indicated that they would not have taken an undergraduate neuroscience course if this one was not offered. The findings also demonstrate that the course helped students develop core academic skills and improved their ability to think critically about current events in neuroscience. Faculty reported that teaching the course was highly rewarding and did not require an inordinate amount of time.

Key words: neuroscience education; learning community; general education; neuroscience anxiety; critical thinking; writing skills; research skills; team teaching; mental illness; bioethics; neuroethics; interdisciplinary

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Neuroscience can be perceived as an intimidating and difficult subject by undergraduate students. As a result, students who need to choose science courses to fulfill general education requirements may shy away from neuroscience courses. While overall student interest in neuroscience continues to expand, "neuroscience anxiety," defined as "student fear and anxiety about topics or coursework in the field of neuroscience," has been identified as a phenomenon that may contribute to the avoidance of classes related to the subject (Birkett and Shelton, 2011).

If students are avoiding neuroscience courses, this presents a problem for our society. There is a growing need for the public to become more literate about the brain. Increased funding for brain research from programs such as the U.S.'s BRAIN initiative and the European Union's Human Brain Project will likely result in many new discoveries about the human brain. It is known that neuroscience findings reported in the popular media are prone to inaccuracies and exaggeration (Illes et al., 2010), particularly when the findings challenge commonly-held beliefs about people's minds, personalities, or actions. Being able to critically evaluate neuroscientific findings is a skill that is rapidly becoming important in non-science professions such as law, business, and politics. The courtroom is a good example where neuroscientific findings can be particularly influential. If undergraduates who eventually become lawyers and judges are never exposed to neuroscience, they would have a more difficult time acquiring the tools needed to properly evaluate neuroscientific evidence, and effectively incorporate important insights from neuroscience into their field.

Scientists and educators have been charged with helping to advance public understanding of brain-related diseases, disorders, and research (The Dana Foundation, 1992; Presidential Commission for the Study of Bioethical Issues, 2013) so that our society is able to competently address controversial issues that arise from neuroscience research. In May 2014, the Presidential Commission for the Study of Bioethical Issues released the first of two reports from their investigation into the ethical implications of neuroscience research. One of the four recommendations in the report is to "integrate ethics and science through education at all levels" (Presidential Commission, 2014, 29) as part of an effort to develop sufficient fluency for discussion and collaboration across professions.

This article reports the experience and outcomes of teaching a year-long neuroscience "cluster" course, "Mind Over Matter: The History, Science, and Philosophy of the Brain," to first-year undergraduates at UCLA. The goal of the course is to provide undergraduates with a general introduction to neuroscience from an interdisciplinary perspective. We believe that framing neuroscience concepts within a larger context makes them more accessible to a general undergraduate audience and promotes the goal of delivering neuroscience education to a larger community. It is our hope that the approaches outlined in this article can be used by educators to make introductory neuroscience courses less intimidating for undergraduates so that neuroscience courses can become a larger part of the general education experience.

UCLA CLUSTER COURSES

General Education Clusters at UCLA are year-long interdisciplinary courses designed for incoming first-year students. Cluster courses aim to develop foundational academic skills, such as critical analysis, problem solving, research, writing, and communication. Students are immersed in an intensive educational experience, studying a topic of academic and social importance from the viewpoint of different disciplines (UCLA Academic Senate, 2012). Examples of UCLA clusters include: Environment and Sustainability; Interracial Dynamics in American Society and Culture; America in the Sixties: Politics, Society, and Culture; and Sex: From Biology to Gendered Society. Clusters are taught by interdisciplinary teams of distinguished faculty, teaching fellows (experienced graduate student instructors), and librarians. During fall and winter quarters, clusters are taught in a lecture and discussion format. In spring quarter, the students enroll in one of several 20-person seminars that focus on a specific topic related to the cluster.

The Cluster Program at UCLA strives to form learning communities for freshman students that facilitate interactions between students and instructors, while also fulfilling general education requirements. Learning communities are identified by the Association of American Colleges and Universities as one of nine high-impact educational practices that increase student retention and engagement (Kuh, 2008). With 29,000 undergraduates, UCLA can be a large and intimidating place for new students. Being a part of a learning community that organizes activities inside and outside of the classroom can help ease the transition from high school to college, both intellectually and socially. Students additionally benefit from taking a year-long cluster course by fulfilling four general education course credits and a writing requirement for the university. By the end of the year, cluster students are on the road towards successfully completing the university's degree requirements (UCLA Academic Senate, 2012).

CREATING A NEUROSCIENCE CLUSTER

The Dean/Vice Provost for Undergraduate Education approached Professor of Neuroscience Scott H. Chandler approximately five years ago to ask if he was interested in developing a cluster course in neuroscience. Although intrigued by the idea of bringing neuroscience education to a wider undergraduate audience, Dr. Chandler was skeptical. He thought it would be difficult to recruit faculty for the long-term commitment required for a cluster. Moreover, he thought that an interdisciplinary course in neuroscience would be challenging for many first-year general education students, especially those without a strong science background.

Nevertheless, Dr. Chandler thought about his 30-plus years of teaching neuroscience and decided to take on the challenge. After numerous conversations with various professors about course content, he crafted a proposal. To his surprise, Dr. Chandler had no problem recruiting faculty – once he described how the course would be interdisciplinary, with a philosopher, historian, cognitive psychologist, and physiologist all talking about the brain from different points of view, the faculty he approached were enthusiastic.

The Neuroscience Cluster: "History, Science, and Philosophy of the Brain," was first offered in the 2012-13 academic year. This article reports results from the second year of the Neuroscience Cluster (2013-14), for two reasons: 1) much of the data reported here were not collected during the first year; 2) a new team of teaching fellows came on board for the second year and revised the writing assignments, discussion section outline, and community activities.

The rationale for creating a neuroscience cluster is that students majoring in any discipline will benefit from taking a neuroscience-themed course. As neuroscience continues to play an increasingly important role in our society, having a basic understanding of the brain helps students become better-informed citizens. Additionally, we believe that structuring the Neuroscience Cluster to include history, philosophy, and other topics students could relate to (e.g., learning, memory, and mental illness), makes the course more palatable to first-year students who might not otherwise decide to take a neuroscience course for general education credit.

Life science majors benefit from taking the cluster, as well. They gain the experience of being in a strong introductory course focused on the intersection of neuroscience with other fields, one of the recommended "blueprints" for 21st century undergraduate neuroscience education (Wiertelak and Ramirez, 2008). In addition to basic neuroscience, cluster students learn about scientific philosophy in general. They are also exposed to the history and evolution of the field of neuroscience since its inception, an aspect that life science majors rarely receive. Laying a foundation that merges science, philosophy and history equips all undergraduate students to become effective critical thinkers across multiple disciplines.

FALL AND WINTER QUARTERS: CORE CONCEPTS OF NEUROSCIENCE

The Neuroscience Cluster employed an integrated topic structure: history and philosophy lectures were interleaved week-by-week with neuroscience lectures throughout the year. This framework lent itself naturally to an introduction for non-life science majors, as it provided illustrations of how and why neuroscience has influenced society. Presenting the neuroscientific concepts alongside their historical and philosophical importance allowed students to connect these topics to parts of their lives, including perhaps their chosen fields of study. Simultaneously, our curriculum imparted the foundational knowledge students will need to understand and appraise new neuroscientific findings as they become integrated into various disciplines in the future.

Course lectures began with the elemental basics: the history of the scientific revolution leading to the birth of neuroscience; and, in alternating lectures, basic neuroanatomy and vocabulary. Students learned about the fundamental unit of the brain, the neuron, while also learning about the painstaking observations of Camillo Golgi and Santiago Ramon y Cajal and their heated debate: where does the neuron begin and end? At each point, those early discoveries were put into their historical context so that students learned, explicitly, how knowledge of the brain trickled into society at large and changed the way people thought about and perceived the mind.

Another emphasis of the course was drawing connections between historical scientific debates and current ones. Recognizing that solutions to past quandaries took time to solve – and required a consensus of evidence – helped students place the structure of the scientific method into a larger context. This contextualization also seemed to ameliorate fears surrounding biology and chemistry content.

In discussion sections throughout the fall and winter, the teaching fellows helped students further explore topics from lecture and make the integration of different disciplines more explicit. The overall goal of pairing interdisciplinary topics was to help students practice viewing the same subject matter through different "lenses," and, in effect, become comfortable with using neuroscience as a method of evaluating everyday experiences. Topic pairings that exemplify this companion strategy include:

1. **Sensory systems and theory of mind**
   - transduction and perception from the biological and philosophical perspectives
   - historical and philosophical study of the mind
   - past and present views of subjective experience
   - mental representations
   - computational theories of the brain
2. **The culture and science of memory**
   - historical importance of memory across cultures
   - neuroscience of memory
   - strategies for optimizing memory based on current understanding
3. **Movement: neuroanatomy and historical study**
   - spinal cord and reflexes through cortical movement systems
   - volitional movement regulation and disorders of movement
   - changing public opinion with new discoveries
   - the importance of quality of life in medicine
4. **Philosophy of rationality and the history of mental illness with the neuroscience of mental illness and mood disorders**
   - challenges of the language used to describe subjective experience as it informs a "well" mind (for example, during the pharmaceutical revolution, public opinion changed as treatments changed)
   - neuroscience of mood disorders, emphasis on subjective experience of patients as it relates to specific brain systems and dysregulation of those systems

The scientific perspective allows for evidence-based discussion; philosophy provides the framework for addressing problems at a more conceptual level; the historical perspective focuses on how our understanding of the mind has changed our comprehension of feeling and being. Writing assignments in both fall and winter quarters furthered these connections (see Writing and Research Skills).

Although science courses designed to fulfill general education requirements sometimes gain a reputation for being "watered-down," this cluster steadfastly maintained a focus on thorough, in-depth presentation of neuroscientific material, elevated to the same standards expected from an introductory neuroscience course.

Regardless of their major, a majority of students appear to have mastered the core concepts of the discipline. To investigate the extent to which non-life science majors grasped the neuroscience concepts, the teaching fellows selected 22 multiple-choice exam questions that they felt best supported the five essential "Components of Basic Neuroscience Knowledge" identified by Kerchner, Hardwich, and Thornton (2012). Students were divided into two groups: non-life science majors and life science majors, based on their major at the time of fall registration. Table 1 shows the percentage of correct answers from each of the groups of students. For 11 of the 22 questions, a higher percentage of life science majors responded with the correct answer (Table 1). For 10 of the 22 questions, a higher percentage of non-life science majors responded with the correct answer. For the single remaining question, the same percentage of life science and non-life science majors answered correctly. The data suggest that all students, regardless of their major or general discipline, learned the basic neuroscience concepts that are essential to our understanding of the brain.

SPRING QUARTER: IN-DEPTH SEMINARS

Following completion of the first two quarters of the course, students were given the option to select from seven seminars (Table 2). The seminars were taught individually by the teaching fellows, one faculty member, and the librarian; topics reflected each instructor's area of expertise or interest. In contrast to the fall and winter quarters, which covered a broad range of neuroscientific material, the individual seminars allowed for a focused quarter of study in a uniquely interactive environment. An interactive environment was fostered through the use of active learning exercises such as debates and small group discussions.

Enrollment for each seminar was limited to 20 students. Seminar curriculum was centered on students reading

Neuroscience Cluster Multiple-Choice Exam Questions [Grouped According to the Components of Basic Neuroscience Knowledge (Kerchner et al., 2012)]	**% of students who answered correctly**		
	All Students	**Non-Life Science Majors***	**Life Science majors****
Fall midterm	**N=139**	**N=99**	**N=40**
Fall final	**N=136**	**N=98**	**N=38**
Winter midterm	**N=120**	**N=88**	**N=32**
Winter final	**N=119**	**N=88**	**N=32**
Understanding the cellular and molecular function of neurons, including how neurons communicate			
FALL MIDTERM Which of the following best characterizes the flow of information within a neuron? (A: Dendrite to soma to axon)	98%	99%	95%
FALL MIDTERM At the peak of the action potential, the membrane potential becomes close to the equilibrium potential for (A: Sodium)	91%	89%	98%
FALL MIDTERM The absolute refractory period refers to the brief period of time (A: After a neuron has fired an action potential during which the same neuron cannot fire another action potential)	99%	99%	100%
FALL MIDTERM ________ are the glial cells that make myelin while _______________ are responsible for providing support for neurons (A: Oligocytes, astrocyes)	80%	78%	85%
FALL MIDTERM A key causal event in the release of neurotransmitter molecules from vesicles into the synaptic cleft is the (A: Influx of calcium ions in response to the arrival of an action potential at the terminal)	94%	93%	98%
Understanding of basic neuroanatomy			
FALL MIDTERM Collectively, the caudate nucleus, the putamen, and the globus pallidus are referred to as the: (A: Basal ganglia)	84%	82%	90%
FALL MIDTERM Each cerebral hemisphere is divded into four sections, or _____________, which are separated by grooves called (A: lobes; sulci)	98%	97%	100%
FALL MIDTERM The postcentral gyrus receives ____________ information, while the precentral gyrus has ____________ function (A: Somatosensory; motor)	71%	72%	68%
WINTER FINAL Each folium of the cerebellum contains a layered cellular structure. Which of the following is not one of these layers? (A: All are layers: Purkinje cell layer, molecular layer, granule cell layer)	98%	99%	97%
Understanding of behavior and cognition, as they relate to neuroscience			
WINTER FINAL The case of Henry M., who lost his ability to form new long-term memories after having surgery for epilepsy, showed that: (A: declarative memory loss follows damage to the hippocampus)	97%	98%	97%
WINTER FINAL Which of the following is not an effect of damage the the cerebellum? (A: tremor at rest)	90%	89%	94%
WINTER FINAL Which of the following has been shown to inhibit the breakdown of the neurotransmitters involved in depression and, consequently, alleviate depression? (A: Monoamine oxidase inhibitors)	93%	93%	94%
WINTER FINAL Patients with type II schizophrenia are likely to demonstrate which of the following? (A: Enlargement of the cerebral ventricles, altered patterns of neuron orientation, a general decrease in brain size)	84%	88%	74%
Understanding of sensory and motor systems, as they relate to neuroscience			
FALL FINAL Which is true of olfactory receptors? (A: They turn over fairly frequently)	57%	57%	55%
FALL FINAL Humans have taste receptors for all of these except (A: starchy)	100%	100%	100%
FALL FINAL The medial geniculate is important for (A: hearing)	74%	74%	71%
WINTER MIDTERM Muscle spindles (A: receive input from gamma motoneurons)	76%	78%	69%
WINTER FINAL During normal muscle contraction, (A: Force is produced by increasing the discharge frequency of active agonist motoneurons)	68%	65%	77%
Understanding development and plasticity of the nervous system			
WINTER MIDTERM Which is an example of nonassociative learning? (A: sensitization of the eyeblink reflex)	68%	73%	56%
WINTER MIDTERM Which of the following is NOT TRUE of motor skill learning? (A: The ability to verbally describe the desired motor action necessary to achieve it through practice)	99%	99%	100%
WINTER MIDTERM Which is true of perceptual learning? (A: Perceptual learning occurs very gradually)	91%	90%	94%
WINTER MIDTERM Habituation of the gill withdrawal reflex involves (A: reduction of neurotransmitter release on motorneurons)	96%	98%	91%

*"**Non-Life Science Majors**" include: Afro-American Studies, Art, Astrophysics, Chemistry, English, Environmental Science, Physics, Pre-Applied Mathematics, Pre-Business Economics, Pre-Economics, Pre-Financial Actuarial Mathematics, Pre-Global Studies, Pre-Mathematics, Pre-Mathematics of Computation, Pre-Mathematics/Applied Science, Pre-Mathematics/Economics, Pre-International Development Studies, Pre-Political Science, Pre-Sociology, Undeclared-Humanities, Undeclared-Physical Science, and Undeclared-Social Science.

"Life Science Majors**" include: Biochemistry, Biology, Marine Biology, Molecular/Cell/Developmental Biology, Neuroscience, Physiological Science, Pre-Cognitive Science, Pre-Human Biology and Society, Pre-Microbiology, Immunology & Molecular Genetics, Pre-Psychobiology, Pre-Psychology, and Undeclared-Life Science.

Table 1. Students' performance on multiple-choice questions that test understanding of core concepts in neuroscience.

Seminar 1	How Psychologists Reimagined the Brain in Early 20th Century
Seminar 2	Elements of Choice: Decision Making, Free Will, and the Brain
Seminar 3	Curing Death: Sciences' Creation of Their Own Philosopher's Stone
Seminar 4	Sex, Drugs, and Rock and Roll: How Romance, Psychoactive Substances, and Music Change the Brain
Seminar 5	Neuroethics and Moral Machines
Seminar 6	Diagnosing Difference: Interdisciplinary Perspectives on Stigma, Empathy, and Disability
Seminar 7	Castles of the Mind: Exploration of Mental Illness through Art and Neuroscience

Table 2. Seminars offered in Spring 2014 by teaching fellows, the librarian, and select faculty.

primary source articles, as well as related fiction and nonfiction. Following completion of the weekly reading assignments, the intimate, interactive seminar environment then provided opportunities for students to try to articulate and discuss neuroscientific findings *in their own words*, increasing their ability to have a knowledgeable dialogue about research. Additionally, the small-group setting also provided greater opportunities to directly ask the seminar leaders to clarify confusing topics, which increased student comprehension of the course material.

The spring seminars also included extracurricular field trips to enhance engagement with relevant topics. For example, the "Neuroethics and Moral Machines" seminar featured a field trip to the USC Robotics Open House to see how engineers and neuroscientists re-create functions of the nervous system in artificial bodies and minds. Following discussions of research using fMRI, the "Elements of Choice" seminar took a field trip to the UCLA Staglin Center for Cognitive Neuroscience to see how MRI is conducted. Upon concluding a unit on music and the brain, the "Sex, Drugs, and Rock & Roll" seminar took a field trip to hear a performance by the Los Angeles Chamber Orchestra, to synthesize what they had learned about auditory processing and motor planning with a real-life example of performance. The seminars "How Psychologists Reimagined the Brain in the Early 20th Century" and "Castles of the Mind" organized a joint field trip to the grounds and the history collections of a local state psychiatric hospital. The trip was intended to give students an appreciation for psychiatric treatment in early 20th century and to compare that treatment to the current standard of care. To that end, seminars not only gave students opportunities to engage in interactive dialogue about curriculum with both instructors and classmates *within* a session, but also gave students opportunities *outside* of classroom sessions to see the relevance and importance of the topics they were discussing during a given week.

WRITING & RESEARCH SKILLS

One primary benefit of the cluster is having a full academic year to develop core writing and research skills. Course assignments progressively pushed students to improve their writing while also helping them engage with class concepts at a deeper level. In the fall quarter, students worked on basic concepts of communication and academic writing. In the winter quarter, they analyzed current ethical questions in science and furthered their general research skills. In the spring quarter, the students were encouraged to create a research project focusing on a topic of current relevance to neuroscience. This allowed students to delve into scientific literature, using empirical findings to build their understanding and opinions regarding a specific topic. We were thus able to teach students with different levels of writing experience the skills necessary to synthesize and communicate neuroscientific findings relevant to different aspects of life.

The UCLA Library provides each Cluster instructional team with its own library liaison. In the Neuroscience Cluster, the librarian is "embedded" in the course and is part of the learning community. Embedded librarians attend class lectures, lead research skills instruction sessions, and meet with students one-on-one to assist with research and writing projects. The librarian and teaching fellows defined a suite of research skills that students should acquire by the end of the year, and subsequently mapped out the timing of the delivery according to when a particular skill would be needed to complete an assignment.

The purpose of such collaborations was to accomplish three things: to develop effective research skills for complex subject matter, to establish strategies for building and organizing written work, and to nurture the students' writing styles. Some of the concepts discussed were: scholarly vs. popular sources, primary vs. secondary sources, peer review and scholarly communication. Key aspects of strong academic writing were also discussed and practiced. Building upon the basis of good academic writing allowed them to see the importance of creating a strong thesis and main points that relate back to that thesis.

Once the students understood attributes of good academic writing, we asked them to complete writing assignments on current topics in neuroscience and bioethics. As technology expands, it is imperative that students have the ability to assess the ethical debates that will arise from advancements in science and technology, without solely basing their decisions on popular sources. Although roughly two-thirds of the Neuroscience Cluster students are not planning to enter the life sciences, they have the potential to help shape both the laws and the general understanding of science as members of the general public.

During fall and winter quarters, students received hands-on training sessions at the library introducing them to online resources, and research tips relevant to their assignment. In these sessions, the students learned how to generate effective keywords, create search strategies, use PsycInfo and Google Scholar, and use controlled vocabulary terms in PubMed. One example of a topic they were assigned to investigate was consciousness, one of the most difficult and contentious concepts in neuroscience. To help them focus their research, the students were given an opinion article on eight controversial and impactful topics in neuroscience (Anil, 2012). The research skills instruction gave them the tools to assess and write a strong opinion paper on an ethical argument in the sciences. It is our hope that the development of these skills will also enable students to make informed decisions in the future about challenging issues.

By the end of the second quarter, over 80% of the students reported stronger writing, analytic, library, research and writing skills as a result of the cluster (Table 3). A greater percentage of students responded positively in the winter when compared to the fall quarter, highlighting the benefit of a year-long writing course.

"Please indicate the extent to which this cluster strengthened your skills or knowledge in the following areas"	**Percentage of students who indicated stronger or much stronger skills**	
	Fall 2013	**Winter 2014**
Writing Skills	60%	82%
Analytic Skills	73%	81%
Library Skills	75%	89%
Research Skills	80%	94%
Communication Skills	63%	69%

Table 3. Students' self-report of stronger skills in five key academic areas.

Consolidating these learned tasks from fall and winter quarters, the students were asked during spring quarter to take their research skills to the next level by completing an in-depth research assignment on a theme proposed in their respective seminars (Table 2). This gave them the freedom to first identify a research question and then frame their thesis. Oftentimes, broad-based assignments that require students to focus their own research are the most difficult for undergraduates. The spring seminar provides a rare opportunity to allow first-year students to build upon their knowledge from the prior two quarters to dig deeper into a topic that interests them.

Completing a full academic year in the Cluster provides freshmen with a suite of analytic, library, and research skills that they can use to investigate any question that may arise in their lives. In addition, they have had a significant amount of practice of communicating their discoveries and ideas in writing and dialogue. These foundational academic skills help prepare students for the tasks they will encounter in their academic career and in life.

THE LEARNING COMMUNITY

In contrast to many university courses with a large number of students enrolled, the Neuroscience Cluster set specific goals for instructors to connect with students on an intellectual and personal level, and to foster a sense of community amongst the students themselves. This emphasis on personal connections was manifested through several activities conducted outside of class. First, students were offered increased contact with faculty via campus lunches, extended office hours, and lab tours, where students could see examples of the types of research each faculty member conducted. These extracurricular sessions gave students the opportunity to discuss difficult course material, discover new research opportunities, and build rapport with their instructors. By building connections with instructors outside of the classroom, students were given an opportunity to participate in the academic community and gain a broader perspective on what it means to lead a life of intellectual inquiry.

Second, extracurricular activities related to the class, such as movie nights and game days, built on concepts introduced in lecture and provided a wider perspective on the material. For example, periodic "movie nights" featured films relevant to neuroscience, such as "The Matrix," "A Beautiful Mind," "Awakenings." The DVDs were checked out from the UCLA Instructional Media Library and shown in residence hall classrooms. In a question-and-answer session held after the film, students discussed how ideas in the movie related to actual research being conducted in fields such as psychology, neuroscience, and computer science.

Finally, immediately following weekly lectures, ten non-graded "Friday Study Questions" were posted on the course website. Students were given the assignment to meet in small study groups to discuss the questions each week. The goal of these study groups was to help students develop a deeper understanding of the material by having to explain the information to others, instead of simply memorizing details. Interestingly, while the formal requirement for the study groups ended halfway through the first quarter, many students continued to meet throughout the year, having found the groups to be an effective way to learn the material and prepare for examinations (Figure 1).

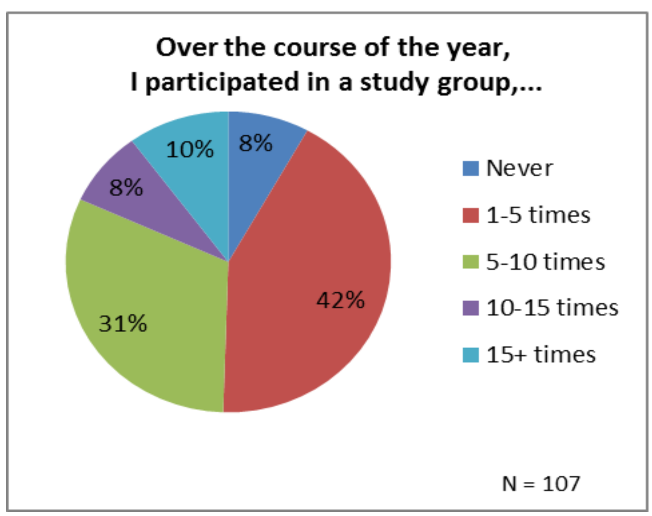

Figure 1. Frequency of study group participation during the academic year.

Data from questions asking students about the extracurricular, community-building experiences was collected from quarter-end evaluations conducted by the UCLA Office of Instructional Development (Table 4). As can be seen in the student responses, extremely high percentages of students thought the extracurricular activities were well-organized, worthwhile and increased the sense of community among people involved with the course. Additionally, the extra effort made by course instructors to make themselves available during lunches, office hours, and review sessions also increased students' level of comfort in seeking instructional assistance either inside or outside of class.

STUDENT FEEDBACK

We assessed student responses to the course using course evaluations from fall and winter quarters, as well as a questionnaire designed to measure students' opinions about different aspects of the class, administered at the end of the academic year. Students' responses on course evaluations included answers to Likert scale questions and free response questions asking students to describe which aspects of the course they enjoyed and soliciting suggestions for improving the course. In addition to examining how students felt about the content and organization of the course, we were interested in assessing what percentage of students, especially among non-life science majors, would not have otherwise been exposed to neuroscience.

During the fall quarter, course evaluations were completed by 96 out of a total of 138 students (70% response rate). In winter, 104 out of 120 students completed the evaluation (87% response rate). Evaluations asked students to rate different aspects of the course on a 4-point Likert scale, 1 being "disagree" and 4 being "agree." Positive response rates were determined by calculating the percentage of students who answered a 3 or 4 on the Likert scale. Students' ratings of whether the purpose of the cluster was clear to them were overall positive at the end of both quarters: 96% positive ratings in fall; 97% positive ratings in winter (Table 4). Students also responded positively overall to whether the major themes underlying the course were clear to them (95% positive ratings in fall; 98% positive ratings in winter). These results suggest that students were able clearly understand the goal of the course, which was to teach them major concepts of neuroscience, and that they were able to understand the interdisciplinary nature of the approach used in this course.

The students also had positive responses to items assessing organizational components of the course. To a question of how well lectures from different faculty were connected to one another, the students responded positively overall (83% positive ratings in the fall; 81% positive ratings in winter). The students also agreed that material presented in lab/discussion sections reinforced material they learned in lecture (97% positive ratings in fall; 96% positive ratings in winter). This data suggests that the faculty and teaching staff were successful in integrating a wide variety of interdisciplinary content within a single neuroscience course.

"Please indicate the extent to which you agree with each of these statements."	**Percentage of students who agreed or strongly agreed**	
	Fall 2013 N = 96	**Winter 2014 N = 104**
The purpose of this cluster course was clear to me.	96%	97%
The major themes that underlie this course were clear to me.	95%	98%
Lectures by different faculty were well-connected to each other.	83%	81%
Discussion sections/labs reinforced material presented during lectures.	97%	96%
Extracurriculuar activities (field trips, film nights, social events) were well-organized.	86%	92%
Extracurriculuar activities provided me with valuable information and experiences.	72%	74%
Instructors made students feel welcome in seeking help in or outside of class.	96%	92%
I felt a greater sense of community among the students in this course than in my other courses.	78%	84%

Table 4. Student responses to the course.

Community components of this course were evaluated by asking the students to rate how welcome they felt in seeking help from the faculty and teaching staff outside of class and whether they felt a greater sense of community in this course compared to other courses at UCLA. The students responded positively to the first question (96% positive ratings in fall; 92% positive ratings in winter), as well as the second question (78% positive ratings in fall; 83% positive ratings in winter). These responses suggest that we largely succeeded in our goal of building a community around the course, which encouraged peer-to-peer interactions and the exploration of course concepts outside of class. Student evaluations across all domains were consistent across both winter and fall quarters, suggesting that these scores accurately represent students' feelings about the course.

Student ratings were corroborated by their written comments. Indeed, some of the comments speak to the success of this course in fulfilling its mission of advancing non-science majors' understanding of the brain. One student wrote, "The class was very fascinating and almost convinced me to become a neuroscience major." Another wrote, "What I will take most from this cluster is approaching difficult subjects, such as neuroscience, with confidence that they are conquerable." Both of these quotes highlight the extent to which this class was able to bridge the divide between the sciences and the humanities.

It helped students outside of life sciences develop an understanding and a sense of mastery over complex scientific principles, while giving them an understanding of neuroscience from an interdisciplinary perspective. As one student said, having multiple perspectives on the material "gave the course a certain depth that I have not experienced in any other class."

In addition to examining information provided in quarterly evaluations, we administered a questionnaire to our students at the end of the academic year that asked them to rate how they felt about the course as a whole and to indicate whether they were a life science major or a non-life science major at UCLA. Students were asked to rate their responses on a five point Likert scale: 1 being "strongly disagree"; 3 being "neither agree nor disagree"; and 5 being "strongly agree." Our study was reviewed and approved by the Institutional Review Board (IRB) at the University of California, Los Angeles.

Out of 120 students enrolled in the class, 107 completed the questionnaire (89% response rate). Out of those, 38 indicated being a life science major (36%) and 69 indicated that they were not a life science major (64%). When responding to the first question, whether or not students would have taken a neuroscience course at UCLA if this Cluster course was not offered, 77% of non-life science majors indicated that they would not have taken a neuroscience course at UCLA, 13% neither agreed nor disagreed, and only 10% indicated that they would have still taken a neuroscience course (Table 5). For life science majors, 58% stated they would have taken a neuroscience course anyway, 13% neither agreed nor disagreed, and 29% stated they would not have taken a neuroscience course. These responses suggest that while the majority of life science majors would have likely encountered neuroscience content as part of their regular curriculum, this course was likely the only exposure to neuroscience for over three quarters of non-life science majors and one third of life science majors. This strongly suggests that the course fulfilled its mission of providing exposure to neuroscience for students who would not have otherwise taken a neuroscience course as undergraduates.

To the question of whether this class improved the student's ability to think critically about news reports related to neuroscience; 100% of the life science majors and 94% of the non-life science majors reported in the affirmative. The remaining small fraction of students did not feel strongly about this either way. These results support our assertion that the purpose of providing a strong foundation in neuroscience for undergraduate students is to ensure that they are able to understand and interpret neuroscience related content they encounter in their lives more accurately and efficiently. Given the rise in frequency with which the legality or ethics of neuroscience-related topics is debated in today's society and the likely continuation of this trend, increasing the students' understanding of neuroscience concepts serves the University's mission of preparing students for becoming informed members of a democratic society.

Due to the high degree of stigma associated with mental illness in our society (Parcesepe and Cabassa, 2013) and its high prevalence in the U.S. (Kessler et al., 2005), giving undergraduates a deeper understanding of mental illness is one especially important component of neuroscience education. To assess how well our course met this goal, we asked students whether their perspective of psychiatric disorders changed after taking the course. A large proportion of the students (90% of the non-life science majors and 87% of the life science majors) agreed, approximately 10% did not feel strongly about it either way, and only one student disagreed (approximately 1% of the total respondents). Indeed, some students commented in the written portion of the evaluation that they have become more comfortable with the topic of mental illness as a result of taking the course.

We also asked our students whether taking this class influenced their choice of major. Of the life science majors, 66% of the respondents answered in the affirmative, 5% disagreed, and 29% did not feel either way about it. For the non-life science majors, 30% of the students felt that the course influenced their choice of major, 35% said that it did not influence their choice, and 35% said that it did not influence them either way. The fact that a large proportion of individuals who identified themselves as life science majors at the end of their freshman year cited our course as having played a role in their choice of major speaks to

	Disagree	Neutral	Agree
If this course did not exist, I would not have taken a neuroscience course at UCLA.			
Non-life science major	10%	13%	77%
Life science major	58%	13%	29%
This class has improved my ability to think critically about neuroscientific issues I hear about in the news.			
Non-life science major	0%	6%	94%
Life science major	0%	0%	100%
This class changed how I view mental illness.			
Non-life science major	1%	9%	90%
Life science major	0%	13%	87%
This class has influenced my choice of major and/or minor.			
Non-life science major	35%	35%	30%
Life science major	5%	29%	66%

Table 5. Student responses to a questionnaire given at the end of the academic year, in which they were asked to identify themselves as a life sciences or non-life sciences major. A total of 107 students responded. Non-life science majors: N=69. Life science majors: N=38.

the impact that a interdisciplinary course can have on not only making students more educated members of society, but also in helping them chose a field of study.

FACULTY FEEDBACK

"My only regret is that I didn't develop and teach this course many years earlier."

- Scott H. Chandler, PhD., course director

A request for feedback about teaching the cluster was sent to all five of the faculty instructors (all of whom are currently in their third year teaching the Neuroscience Cluster). Four out of five responded. While some of the faculty noted that there was a significant time commitment to develop and teach the course during Year 1, none of the respondents stated that it was excessive. Teaching the cluster appears to be a highly rewarding and stimulating experience for the faculty, as evidenced by the following quotes:

"*Teaching the course itself is a pleasure, and is certainly more stimulating than one where I only get to listen to myself talk."*

"I was teaching topics that I was familiar with, so it took less time than when I am teaching a full comprehensive course where I have to prepare lectures on topics I am less familiar with….I definitely tried to make connections with the other lecturers, and when a student asked a question in a different prof's lecture about something I had talked about- it was a great feeling!"

"The Cluster has been a challenging course for me in that I wasn't just presenting my own knowledge, but trying to find ways to make sure the lectures I presented not only reflected good historical scholarship, but also resonated with the concepts discussed in the neuroscientific lectures. In some cases, this was not difficult – for example, lectures on mental illness; but in other cases, such as movement disorders, it was more challenging, but also very rewarding!"

"For my entire career, I've heard lectures, talks, and seminars from numerous neuroscientists, but I cannot say I've listened to any philosophers or historians discuss the topic. To say the least, it was quite a learning experience for me."

Course director Scott H. Chandler noted four factors that have been instrumental to the success of the Neuroscience Cluster:

1. **Have all faculty attend each other's lectures when possible.** This allows for a seamless transition of lecturers and topics, and stimulates faculty to bring up topics that other faculty discussed.
2. **Use active learning techniques to engage the students and enhance learning**. Over time, the students become less intimidated to speak in front of their peers.
3. **Hire seasoned Teaching Fellows who are highly motivated to enter the teaching profession**. The teaching fellows are effectively in "the trenches" with students and are responsible for all aspects of the discussion sections and writing assignments.
4. **Embed a librarian**. The librarian provides critical instruction on the use of the library, appropriate selection of databases, and guidance on how to formulate a research topic.

In summary, the faculty of the Neuroscience Cluster found that teaching a year-long interdisciplinary neuroscience course to general education students was gratifying and worthwhile.

CONCLUSION

Our paper provides a case study of how a year-long interdisciplinary course can expose students to new disciplines that are likely to make them better informed members of society. The results of our assessment, which used a questionnaire, course evaluations, and test scores, support this assertion. Test scores indicate that a majority of students in the course mastered the basics of neuroscience regardless of their major. Importantly, the majority of non- life science major cluster students said they would not have taken another neuroscience class as undergraduates had our course not been offered. Based on students' responses to the questionnaire as well as course evaluations, we can also ascertain that taking the course helped them improve their writing and reasoning skills, research and library skills, as well as communication skills. Our course also helped students gain exposure to concepts that will be highly relevant in the coming years as advances in the field of neuroscience pose new legal and ethical challenges to society at large. We believe that giving our students a broad and solid background in neuroscience, past and present, as well as general critical thinking and writing skills will help prepare them to be informed citizens and perhaps active participants in the ongoing debate over the role of neuroscience in our society.

While there may be a variety of ways to provide undergraduates with a solid foundation in neuroscience, we believe that the structure of our course helped ease some of the anxiety many non-life science majors feel when asked about taking a neuroscience course. Providing students with different perspectives on course content while maintaining the rigorous curriculum of an introductory neuroscience course helped spark their interest in the class and relate more closely to material they may have otherwise found overwhelming.

Another goal of this course was to help college freshmen transition from high school classrooms to the more rigorous requirements of a university. By teaching students a variety of general research and writing skills, we helped students become accustomed to the expectations of a rigorous academic environment. At the same time, by fostering a sense of community around the course, we attempted to smooth the transition to a large public university.

Reports from a majority of the Neuroscience Cluster faculty indicate that teaching the cluster is a uniquely rewarding experience; one that allows them to be learners as well as lecturers. None of the faculty reported that the time commitment was excessive.

Although the approach to implementing general neuroscience education outlined in this paper may not be applicable to all disciplines or institutions, it is our hope that some of the concepts presented here will be helpful for creating greater exposure to the sciences for a wide range of students. Given the need for more science education in our society, it is vitally important to ensure that students are not only exposed to a variety of subjects but that they are challenged to engage with concepts they learn in class more deeply and to think about them in new ways.

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