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ARTICLE

Drugs, the Brain, and Behavior: A Graduate Student-Run Comprehensive Course in Neuroscience

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Drugs, the Brain, and Behavior is an interdisciplinary two-semester upper level course at Georgetown University designed to expose undergraduate and graduate students to broad areas of the neurosciences, to promote the development of scientific literacy in these students, and to provide pedagogical experience for Ph.D. students in the Interdisciplinary Program in Neuroscience (IPN) at all stages of training.

Drugs, the Brain, and Behavior fulfills these goals through a unique model of student-teaching. This lecture-based, team-taught course is completely run and taught by Ph.D. students in the IPN. It is designed to gradually increase the teaching duties of new instructors, providing a structured setting for them to develop their pedagogical skills.

We encourage scientific literacy in our students through the incorporation of primary literature and experimental results throughout the course. The strategies we have employed have increased student confidence on a variety of measures of scientific literacy.

While running a team-taught course, we have also developed several strategies for coordinating team-taught courses within semesters and across years, which could easily be adapted to other courses.

Key words: interdisciplinary learning, team-teaching, graduate teaching, pedagogy, scientific literacy, continuity

Early and engaging neuroscience education is critical in recruiting and retaining undergraduate students to our field. While some of these students will pursue graduate education (e.g., M.S., Ph.D., medical school), their first exposure to neuroscience will occur in the undergraduate classroom.

To engage these students, we have developed a course at Georgetown University titled Drugs, the Brain, and Behavior (DBB). This course provides undergraduate and graduate students with a well-rounded education in basic neuroscience, a clear perspective on how neuroscience research is conducted, and detailed knowledge of neurological and neuropsychiatric illness. Because we recognize that teaching ability does not diffuse from mentor to graduate student through osmosis, we have built this course as a centerpiece of graduate training in neuroscience education. Our goal is to shape the education of both undergraduate students and graduate students, who will ultimately be the next generation of college-level neuroscience educators.

Patrick Forcelli and Lauren Ullrich directed the course from Fall 2008 to Spring 2011, and Anthony Krafnick and Sonya Dumanis currently direct the course, having joined in Fall 2010 and Spring 2011, respectively. We are current or former graduate students in the Interdisciplinary Program in Neuroscience at Georgetown University. Our interests span cellular and molecular to behavioral and cognitive neuroscience. This has allowed us to create syllabi that cover a range of neuroscience topics in depth. As directors, we recruit fellow Ph.D. students to teach on topics within their expertise to ensure the quality of the lecture material covered.

Aims

DBB was founded with three principle aims: 1) to provide a comprehensive course in neuroscience to undergraduate and graduate students, 2) to promote the development of scientific literacy in undergraduate and graduate students, and 3) to create an environment that fosters pedagogical awareness in Ph.D. students early in their teaching careers. As a consequence of the difficulties inherent to team teaching, a fourth aim naturally developed over the course of our tenure as directors of DBB, namely, to develop strategies for coordinating team-taught courses within semesters and across years.

Course Description

DBB began as a one-semester upper-level course for undergraduate students that was launched in 2000 by Ph.D. students in the Interdisciplinary Program in Neuroscience at Georgetown University. Over the last 11 years, the course has changed names, increased from one semester to two semesters, and expanded focus to include enrollment of master's and first year Ph.D. students. Importantly, it has come to place special emphasis on pedagogical training for Ph.D. students lecturing in the course.

The course employs an interdisciplinary approach to normal and altered nervous system function. The fall semester focuses on psychiatric disorders, while the spring semester focuses on neurological disorders (see syllabus, Supplemental Document 1). Course emphases include: functions of neural circuits, bridging basic neural mechanisms and higher brain processes, use and validity of animal models of behavior, and drugs as experimental tools and clinical therapies. The course consists of team-taught lectures, student presentations and class discussions focused on primary literature, and a term paper (only required of the graduate students). All of these components require that students learn to read and interpret primary literature.

The course is cross-listed with the Interdisciplinary Program in Cognitive Science and the Department of Pharmacology & Physiology. Typical enrollment ranges from four to twelve students; from semester to semester the course varies from predominantly undergraduate to predominantly graduate enrollment.

Students in the following programs have taken the course for credit: Biology (B.S.), Cognitive Science minor, Neurobiology (B.S.), Psychology (B.A.), Biochemistry (M.S.), Complementary and Alternative Medicine (M.S.), Physiology (M.S.), and Pharmacology (M.S., Ph.D.). The course has typically attracted students from a wide variety of majors and minors with a range of scientific knowledge. The prerequisites are Introductory Biology, a neuroscience course, or permission of the course directors, but students with no scientific background have been very successful in the course.

This course is unique at Georgetown University for several reasons. It bridges: 1) multiple disciplines (psychology, biology, cognitive science, etc.), 2) levels of study (Bachelor's, Master's, and Ph.D. students), and 3) the medical center and main campus. In addition, it is the only course completely run and taught by biomedical graduate students. The course offers many opportunities for graduate student engagement, from the level of course director to teaching a single lecture. Faculty give input in the form of a steering committee that meets one to two times a year.

Developing Scientific Literacy

The ability to critically evaluate and effectively present primary literature is a necessary skill for developing scientists. This applies not only to analysis of others' work, but also to the organization and presentation of one's own research. Implicit in development of this skill is an understanding of the scientific method and the nature of science, what we term "scientific literacy". Acquisition of scientific literacy has been shown to improve student performance in science classes and enhance their understanding of scientific content (Herman, 1999; Dirks and Cunningham, 2006; Coil et al., 2010). For the past several decades, national standards for science education have moved away from the traditional instructional approach, and emphasized a focus on the nature of science and scientific thinking (National Research Council, 1996, 1997; Siebert and McIntosh, 2001).

To develop these skills, in DBB, students are exposed to current research through discussion of primary literature. Undergraduate engagement with primary literature has been associated with improved critical thinking and increased application to medical and graduate school (Kozeracki et al., 2006). Perhaps most importantly, exposure to primary literature increases students' self-assessment of their communication skills and understanding of science (Mulnix, 2003).

Assignments

In this course, primary literature is employed in three ways: inclusion of experiments and data in all lectures, individual paper presentations, and group discussions of recent primary literature. These activities reinforce concepts from class and focus students on discussing real data and experimental design. They also expose students to current research and teach them the importance of staying abreast of new developments in our rapidly changing field.

All lectures are required to include discussion of experiments and data. Lecturers are instructed not to simply list the "facts" as we now know them, but to encourage engagement with the scientific process, including the historical context (stressing that science is not always a linear march towards the right answer), design, results, and interpretation of a given experiment. Incorporating these themes into the lectures primes the students for engagement with primary literature.

Further student engagement comes in the form of paper presentations and group discussions. These activities share two essential goals: to help students understand and communicate the content of a paper, and, in doing so, increase their scientific literacy.

For the presentations, students sign up to present a recent paper related to the topic being discussed in lecture. There is a presentation approximately every other week. The course directors choose papers with an emphasis on clarity of writing, incorporation of a variety of methods and approaches, telling a "complete story" (preferably with a model included), and relevance to the lecture topics.

Paper presentations are limited to 30 minutes. By forcing the students to be concise, this time limit requires that only the most important parts of the paper are presented. To effectively present the key components of the paper, our students must have a deep understanding of the material.

At least a week prior to presenting, students are required to meet with the course directors. During this meeting, the presentations are assessed and feedback is given regarding areas for improvement. This also provides the course directors with an opportunity to assess student fluency in the material to be presented.

Many students reported that this was the first, or one of only a few, presentations required by their classes. Thus, development of oral communication skills is a key service that is not provided elsewhere in the curriculum.

To assist in their endeavor, students follow a detailed rubric, which helps them understand and communicate the overarching narrative of the paper (Supplemental Table 1). The rubric emphasizes two things: effective communication of the technical aspects of the paper (design, methods, and results/figures), and an understanding of the scientific "big picture" (background, aims, hypotheses, discussion, potential future experiments, and strengths and weaknesses of the paper). At the beginning of the semester, one of the course directors gives an example presentation, highlighting key aspects of the rubric. This gives students a feel for what their presentation should look like and starts the process of critically examining primary literature right away.

The rubric also makes explicit several aspects of science that are often left implicit in traditional science classes. For example, students must explicitly state the aim of each experiment they present, as well as a directional hypothesis about the predicted results, with justification for that hypothesis. These are not always explicitly stated in the paper, which tend to focus on the outcomes instead of the predictions, and thus the students must infer what the predictions would have been, based on the background information presented in the paper. Students thus “put themselves in the author’s shoes”, engaging in logical thinking about the data they are presenting.

An additional focus is placed on telling a logical “story” emphasizing the flow and progression from one experiment to the next. This helps students build an understanding of overall experimental design and improves the presentation quality by forcing the presenter to walk their audience through the experiments step by step.

Critical evaluation of the paper is also required, as students must identify strengths and weaknesses and present three experiments that would logically follow from the results of the paper or would fill in gaps in the paper. Students must engage in scientific thinking to critique what they have presented, and understand what questions have been left unanswered, or what new questions have emerged from the results, exactly as working scientists do.

This also teaches students about “scientific certainty”—students are encouraged to discuss what leads them to have confidence (or not) in the results of a paper, including the use of appropriate controls, replicability, reliability, and variety of methods, etc. The course directors are careful to stress that a “perfect” experiment is often impossible in reality, and encourage students to consider the totality of the evidence presented. A common question asked by students in the course is some variation of, “Why didn’t the reviewers of the paper ask the author(s) to do more experiments?”. By emphasizing the progressive nature of science, and the importance of evaluating the degree to which the papers’ claims *require* additional experiments, our students begin to appreciate how converging evidence from multiple sources builds scientific certainty.

The rubric has been very successful in communicating expectations and teaching students about the nature of science, but it has utility beyond the classroom: former students have reported that they have used the rubric when presenting their own data to their departments. This suggests that the rubric is not an ersatz tool (McClymer and Knoles, 1992), but one with genuine application for developing scientific thinking. In terms of educating the next generation of scientists, this is more important than course success alone.

In class discussions, all students are responsible for being able to explain every figure in the paper. The group goes through the paper figure-by-figure, loosely following the rubric for the individual student presentations. Students are randomly called on to lead discussion about the figure or answer questions, which promotes thinking on one’s feet and allows the instructors to gauge students’ knowledge of the paper and their ability incorporate material learned in lectures. The informality of the group discussion tends to encourage students to ask more questions than do the presentations, but does not usually lead to the same level of engagement with the paper that the presenting student is required to develop. Thus, we have incorporated both formats into the class.

One concern we had with opening enrollment to graduate students was that they might dominate in discussions with undergraduates. However, we have not found this to be the case. In fact, the caliber of undergraduates enrolled in our course consistently meets or exceeds that of our master’s students. In addition, the format of the paper discussions (calling on students) ensures that everyone gets a chance to demonstrate their understanding of the paper. In class discussions, we encourage the participation of taciturn students (who are not necessarily the undergraduates) by using a classroom response system (iClickers®) for anonymous polling, encouraging students to write down the answers to questions before answering, and cold-calling on students. The small class size probably also helps students feel more comfortable speaking up.

In both individual and group paper discussions, all students submit two questions about the paper ahead of class which helps the directors gauge students’ knowledge and more effectively direct class discussions.

Graduate students have an additional assignment that requires the synthesis of multiple primary literature sources. They are required to complete a term paper expanding on a disease or disorder discussed during the semester. They must include at least seven primary literature sources not discussed in class.

This assignment requires them to do research outside of class and integrate knowledge gained in class with the present state of research in a field. Our students have performed exceptionally well on this assignment. In Fall 2010, the average grade on the paper was 89%. This assignment is the only difference in grading between the undergraduate and graduate courses; however, undergraduate students have the option to replace their midterm, final exam, or paper presentation grade with the term paper. This option is provided for students who demonstrate their knowledge better in offline situations.

Examinations

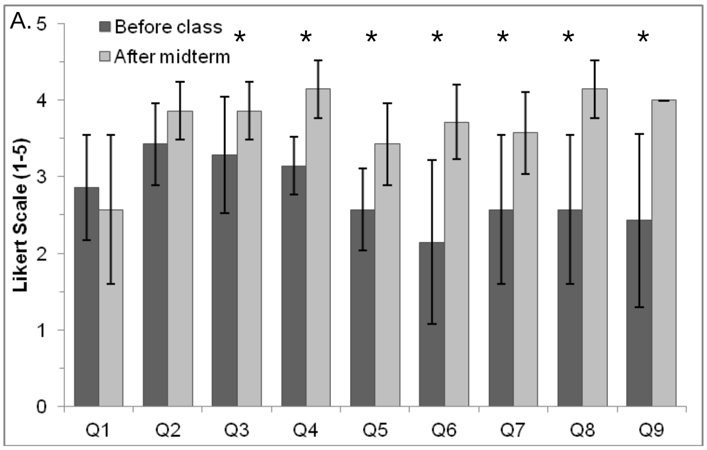
In keeping with our goals of increasing student literacy, the midterm and final examinations are designed to test student knowledge of scientific principles and require critical thinking, rather than rote memorization of facts. The exams consist of six to ten short answer or essay questions, of which the students have to answer some percentage (e.g., answer six out of nine questions). Example questions are provided in Table 1.

Results

To determine if our course goals were being met, we required students enrolled during the Fall 2010 semester to fill out a questionnaire after the midterm. We asked students to report their agreement with nine statements of proficiency in topics ranging from neuroscience methods to communication skills (Figure 1B). Responses were made using a five-point rating scale, with a score of five indicating strong agreement. We asked that students

You have found an alien life form, and would like to investigate whether it has circadian rhythms. Design an experiment to test what area(s) of the nervous system serves as the pacemaker of its circadian system. Make sure to include experimental and control groups, methodology, and discussion of possible results.
While working in Dr. Horrible's Lab of Evil Neuropharmacology, you are assigned an exciting new project: find a way to increase obesity using a gene therapy approach. Using your knowledge of brain circuitry, describe two potential targets (receptors, transmitters, etc.) that, if disrupted, would result in obesity, and why.
John Locke proposed that each human is born a tabula rasa, or "blank slate." Support or refute this claim from a neuroscience perspective, citing principles of development and experimental evidence for your claims.

Table 1. Example exam questions.



B.	
Q1	I am intimidated by research language and terminology.
Q2	I feel that I can identify the problem statements in a journal article and understand the purpose of the paper.
Q3	I feel that I can read a journal article and understand the basic methods.
Q4	I am able to describe the concepts being studied in a journal article and their relationship to each other.
Q5	I feel comfortable presenting a journal article to my peers.
Q6	I feel comfortable weighing the value and validity of different animal models.
Q7	I feel comfortable weighing the pros and cons of competing theories.
Q8	I am familiar with a variety of methods used in neuroscience research, and the specific questions they are applied to.
Q9	I have an understanding of pharmacology as both a tool to explore and a therapy to treat brain dysfunction.

Figure 1. Student's self-reported agreement with 9 statements ranging from neuroscience methods to communication skills (1*B*). Quantification is shown in 1*A*. Error bars show 1 standard deviation. * = $p<0.05$.

estimate their agreement prior to the start of the course, as well as their agreement at the time of the midterm. The results are shown in Figure 1.

These data show student improvement in various skills, including critical evaluation of primary literature, basic neuroscience methods, and clinical applications of research. Paired t-tests indicated that the students reported significant gains in statements three through nine ($p < 0.05$).

Students displayed concomitant improvement in their exam scores over the course of the semester. In the Fall 2010 semester, students demonstrated a significant improvement (21%) in raw scores (prior to curving) between the midterm and final examinations ($p < 0.05$, paired t-test).

This improvement may reflect increased comfort with designing experiments and interpreting scientific data. It may also demonstrate increased familiarity with the types of questions asked on exams in this class, or a combination of these factors.

Discussion

Using these strategies, we have shown that with a relatively small time investment, one can both encourage the development of a vital skill and enhance didactic content.

In its present form, this class would be difficult to implement with an enrollment greater than 15-20 students, but might be adapted to a larger class. The main limiting factor is the time needed for presentations. A typical semester can only accommodate around twelve weekly presentations, letting 24 students present only if they worked in pairs. One option for larger classes is to offer a smaller required recitation or discussion section as a complement to lecture, and conduct paper presentations and discussions during that time.

Encouraging Pedagogical Awareness

In addition to developing oral and written communication skills, teaching experience has been shown to improve research skills in both self-report (French and Russell, 2002; Trautmann and Krasny, 2006) and in direct measure of research skills (Feldon et al., 2011). In order to effectively teach their students to become scientifically literate, instructors must hone their own skills in research and inquiry (Feldon et al., 2011). Thus, graduate student participation in teaching should be valued for its influence on many varied aspects of scientific professional development.

Although teaching is a part of many graduate programs, teaching opportunities in many programs are not structured to explicitly prepare students for teaching and engage them in pedagogical thinking (Austin, 2002). Instead, teaching assistants typically fill in wherever the department needs help (Austin, 2002), and often they are not given adequate training to complete their duties (Luft et al., 2004). Any training provided typically focuses on ensuring the quality of the undergraduates' experience in class over developing pedagogical skills (Golde and Dore, 2001).

DBB is designed to gradually increase the teaching duties of new student teachers, while allowing students to select their own level of engagement in the course. Teaching is not required in the biomedical graduate programs at Georgetown, thus only highly motivated graduate students participate in lecturing for DBB. Opportunities are created for increasing pedagogical awareness through discussions with other instructors, a teaching practicum, and feedback from students and the course directors about the effectiveness of the lecture.

Lecturers

Most lectures in the course are given by IPN students in their second, third, or fourth years of graduate training. Approximately 20 students participate in team teaching across the two-semester sequence each year, with over 80 IPN students lecturing in the course since its inception in 2000. Lecturers teach between 45 minutes to several hours over the course of the semester, and teaching responsibilities are generally increased as the student gains experience.

Lecturers are required to provide three to five "learning objectives" for each lecture, and to submit their lectures to the course directors for feedback before they teach. The course directors act as mentors to the lecturers, providing guidance on pedagogical strategies for selecting readings, appropriately tailoring the learning objectives, encouraging student participation and active learning, using classroom technology, and balancing breadth and depth in the coverage of the subject matter. Lecturers are encouraged to ask the students "thought questions" at the end of their lectures. These questions are discussed for 5 minutes at the beginning of the next class and require about 15 minutes of student engagement with the material outside of class.

Student teachers receive regular feedback from the students taking the class and from course directors who attend all lectures. They are expected to incorporate the feedback into their next lecture, which they eagerly do. As course directors, it has been particularly rewarding to see the impact of this feedback on the rapid development of student teachers over the course of several lectures.

Teaching Practicum

Pre-thesis Ph.D. students who are interested in teaching in the course and/or eventually acting as a course director can enroll in a teaching practicum for elective credit. The practicum acts as a formal introduction to pedagogical thinking and familiarizes the students with the course material. Students are required to attend half of the classes, provide written critiques of the lectures they attended, and produce a proposal for and teach one to two lectures that include objectives, an outline, slides, readings, and exam questions. In addition, they write two in-depth reflections on a pedagogical topic of their choosing. This "course within a course" design is unique at Georgetown University.

The course directors work with the practicum student at all stages of teaching development, providing technical, affective, and reflective support (Swafford, 1998). In helping the practicum students (and, to a lesser extent, the lecturers) develop their lectures, the course directors act more like "coaches" or mentors than traditional teachers.

While teaching workshops are available through Georgetown's Center for New Designs in Learning and Scholarship, there is evidence that coaching is more effective than workshopping at getting instructors to adopt new, more effective practices. For example, when teachers were given a description of the new skill, 10% used the skill in their classroom. Workshops with modeling, practice, and feedback increased this rate to 19% implementation. When peer coaching was added, 95% of teachers implemented the new skill (Bush, 1984). Coaching teachers on new techniques has also been found to significantly contribute to an increase in student achievement scores (Showers, 1984).

Practicum students engage in written critique of the lectures they attend. Although there is a practical benefit to allowing future course directors to familiarize themselves with the course prior to directing, the tutorial is designed to encourage students to observe lectures with a focus not on didactic content, but on pedagogical strategies employed. By focusing on the degree to which undergraduates in the course are engaged by the various instructional methods, practicum students can incorporate effective strategies into their lectures from the very beginning of their careers. The team-taught aspect of the course exposes practicum students to lecturers with a variety of different teaching styles and experience.

In their written critiques, practicum students are encouraged to focus on multiple aspects of pedagogy, from general teaching style to specific teaching strategies employed. One particular emphasis is the use of technology for effective instruction. Multiple projection screens, a SmartBoard®, classroom response systems, and video recordings of lectures have enhanced the classroom experience, and provide a range of instructional formats from digital "chalk talks" to dynamic PowerPoint® presentations. The additional focus on technology in the classroom ensures that the next generation of faculty members will be well-versed in classroom technology as early adopters rather than requiring later retraining.

The practicum students reported that many aspects of the class were helpful in their development as instructors. When asked the most important thing they learned, one cited "discussing the merits and drawbacks of different [teaching] strategies" and "learning which strategies were effective through observation". Another practicum student cited the importance of setting aside time during the lecture to ask questions that require synthesis and manipulation of the material to make sure students understood the key concepts. A third student felt that the practicum highlighted "the importance of having a much deeper understanding of your topic than you may be prepared to teach". All found the course effective in achieving its goals.

Three students have completed the practicum in the three semesters it has been offered, and a fourth student is enrolled for the Spring 2012 semester. To evaluate improved pedagogical skills in the practicum students, we rely on ratings from students on clarity of learning objectives and material presented, as well as qualitative feedback on the most and least effective components of the lecture from both students and course directors. Because of the small sample size, we are only able to report a qualitative improvement in all three practicum students from their first lecture in DBB to their second.

As we continue to gather more data, we intend to refine and augment the feedback provided to practicum students to better assess the efficacy of the practicum experience. Next semester we plan to implement a more sophisticated rubric for evaluation of practicum student performance by the course directors. This will allow for better-defined markers of within-subject progress to be evaluated across semesters.

The teaching practicum component of DBB is not only beneficial for the students taking the practicum, but also for the course directors. It ensures that the course does not become stagnant by the continued infusion of fresh ideas and perspectives from the teaching practicum students. Several changes have been made in response to practicum student input, such as the removal of a required textbook, which was not as helpful a resource as we had hoped.

Setting aside protected time to focus on pedagogy creates consciousness of aspects of teaching that otherwise may be stumbled upon through trial and error, increasing both the speed at which the instructor becomes competent as a teacher, and the quality of instruction provided to Georgetown undergraduate and graduate students.

Course Directors

The most engaged participants are the course directors, who typically are responsible for the course for two to three years. Along with teaching in the course, they design the syllabi, select readings and lecturers, and prepare and grade student assessments. Course directors also function as peer mentors, training and coaching student lecturers in the course, providing oral and written critiques, and suggestions for improvement of both style and content. There are two to four course directors, so that course directorship can be staggered, always pairing a new co-director with an experienced co-director.

Over their tenure, course directors develop skills that will benefit future teaching experiences. By constructing and designing a full course syllabus, directors learn how to organize key concepts such that students are best able to digest the information they are expected to learn. Furthermore, directors must select the primary literature papers and guide lecturers through choosing readings, finding a balance between challenging the students and overwhelming them. These experiences give them valuable skills in aspects of course development that are not often available to the typical graduate teaching assistant in science.

In addition to experience in course development and leadership, directors develop proficiency in peer evaluation. Course directors guide the practicum students in the development of their lecture and provide detailed feedback to the guest lecturers on the structure and content of each lecture. This assessment includes not only what could have been improved but also what techniques and information worked well. This process provides the course director with an opportunity to reflect on successful strategies for future incorporation into their own teaching, and as suggestions for other lecturers in the course.

Directors also oversee the primary literature presentations and group discussions. Course directors are frequently evaluating whether the student accurately summarized the aim or correctly interpreted the result of the experiment presented. This formal emphasis on the scientific method means that course directors must sharpen their own skills in this area if they want to be of guidance to their students. In addition, directors become familiar with mentoring in the classroom context from having one-on-one contact with the students being taught.

Faculty Steering Committee

Course directors have faculty advisors from the IPN (Supplemental Table 2). These faculty members form the "Steering Committee" and serve several essential functions for the success of the course and growth of student teachers. The Steering Committee is consulted on changes to the course syllabus and is involved in overall evaluation of course goals and class assessment. They also provide feedback on lecture structure and teaching technique via assessment of recorded lectures.

In addition to the structured advising that occurs biannually, faculty members are available for advice on unanticipated situations. In one case, a student had plagiarized a short essay turned in for credit. A faculty member was able to guide the course directors to the appropriate resources and advise on how to approach the situation in the future. Faculty members are also available for less structured conversations about pedagogical theory (e.g. assessment strategies, offering different grading options so students can work to their strengths, etc.).

Coordinating Team-Taught Courses

One of the challenges we have worked to overcome in this course is coordinating material across lecturers to maintain continuity throughout the semester and across the years. With 20 course directors and over 80 lecturers participating since the course's inception, consistency is a top priority. We have developed and employed several strategies to meet this goal.

The first strategy is the use of structural course elements specifically designed to facilitate team teaching. Both semesters are broken into five modules, each with a designated theme (e.g., homeostasis, development), and each module is overseen by one course director who serves as the point person for the lecturers and students during that time. Each lecture is assigned one or two "key concepts in neuroscience" (e.g. lifecycle of a neurotransmitter) and each module is assigned several "key techniques in neuroscience", which are expected to be covered in detail (Table 2; Supplemental document 1). A third element is the use of standardized grading rubrics. These serve a four-fold purpose: 1) to convey to students what they are expected to know, 2) to communicate to guest instructors what should be covered, 3) to let instructors later in the semester know what has already been covered, and 4) to promote consistency across years.

To ensure the quality of guest instruction, lecturers are invited to repeat their lectures from previous years whenever possible. This gives the opportunity for the lecturer to incorporate the feedback from previous years and use it to refine their lecture. In the 2010-2011 school year, the majority of classroom hours (69%) were taught by students with two or more semesters of previous experience teaching in the course.

A. Neural Injury & Recovery
Key Techniques: transplants (stem cells), validity of animal models, electrophysiology

Topic	Key Concepts
CNS Injury	Differences between central and peripheral nervous system
Spinal Injury	Functional anatomy of the spinal cord
Recovery of Function (CNS)	Principles of recovery (differences from development)
Recovery of Function (PNS)	Principles of recovery (differences from central nervous system)
Phantom Limb Syndrome	Balance of inhibition and excitation in the brain
Multiple Sclerosis	Immune system; role of myelin and glia; action potential transmission

B. Mood Regulation
Key Techniques: receptor binding assays, BrdU and immunohistochemistry, fMRI, deep brain stimulation, TMS

Topic	Key Concepts
Neural Circuits of Mood Regulation	Neurotransmitter lifecycle, placebos
Major Depressive Disorder	Transporters, autoreceptors, desensitization
Major Depressive Disorder (con't)	Brain imaging, methods for manipulating human brain (DBS, TMS)
Anxiety Disorders	Receptor subtypes, receptor subunits, drug specificity
Bipolar Disorder	Validity of animal models
OCD	Psychosurgery, psychotherapy

Table 2. An example of two modules in DBB. Spring semester (*A*) and Fall semester (*B*). Each module includes 'Key Techniques' to ensure students are taught research tools in neuroscience and each class includes 'Key Concepts' which focus on broad neuroscience principles.

The course directors review and edit all slides and learning objectives prior to the lecture. In the case that a new instructor must be found for a lecture, effective teaching materials are maintained in a repository on Blackboard® (including videos of past lectures, PowerPoint® slides, exam questions, and readings), which lecturers have access to when developing their own lecture. Guest lecturers are also encouraged to sit in on other classes within their module to aid in tailoring their lecture.

However, probably the greatest factor in ensuring consistency is the course directors. They are present for every class, where they actively participate by asking questions of both the lecturer and the students. This allows the course directors to bridge the key concepts and themes across classes. Another strategy employed for this purpose is "thought questions" posed at the end of each class, which are answered at the beginning of the next class. Course directors are also responsible for student evaluations (e.g., grading presentations, exams), ensuring appropriate assessment of student learning.

Course directors typically dedicate around eight to twelve hours a week to the course during a module they are directing, and around half that otherwise (including time spent in class). Although this requires a greater time commitment from the directors than a typical team-taught class, we believe that students benefit immensely from the increased consistency provided by the course directors' greater oversight of the class.

A unique challenge in this course is that as course directors advance in their doctoral training, they must eventually pass on course leadership to less senior students. To maintain continuity across years, we have instituted several policies. First, course directorship is staggered, so that leadership is not replaced all at once. Second, the faculty steering committee is available to provide guidance. Third, participation in the teaching practicum is a requirement for future course directors to familiarize themselves with the structure of the class and develop their teaching skills.

Summary

Over several years of directing the course, we have developed DBB into a two-semester curriculum which introduces neuroscience concepts and promotes the development of scientific literacy in our students. This is achieved through a unique course design that fosters pedagogical awareness in Ph.D. students early in their teaching careers.

The strategies we have developed to coordinate team-taught courses are easily adaptable to other classes with a modest time commitment. Developing pedagogical skills in graduate students is more time intensive, but the benefits in both the laboratory and classroom more than justify the time burden.

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