Curriculum development and technology incorporation in teaching neuroscience to graduate students in a medical school environment

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Brann, Darrell W., and Shawnee Sloop. Curriculum development and technology incorporation in teaching neuroscience to graduate students in a medical school environment. Adv Physiol Educ 30: 38–45, 2006; doi:10.1152/advan.00068.2005.—Today’s neuroscience faculty member wears multiple hats and requires diverse skills to succeed in the competitive environment in which they find themselves. A common refrain from graduates is that there is a need for better training in the diverse, multiple skills that they will need to succeed in obtaining a faculty position and excelling in that position once it is obtained. Our university recently developed a new neuroscience graduate program that allowed us to create a curriculum and core courses de novo and that could be tailored to provide training in diverse skills used by everyday neuroscience faculty members. The current article details our rationale, design, and implementation of this new curriculum and its two major core courses. The genesis of the new curriculum also provided an opportune time to introduce and test new teaching technology in the two neuroscience core courses. The technology incorporated included on-line WebCT course sites, computer performance system, and the Tegrity system. Herein, we elaborate on our experiences with the use of this technology in the small class graduate course setting and provide insight on student feedback on the perceived effectiveness of the technology. The mechanisms and considerations that are needed for incorporation of such technology are also discussed. While no single curriculum or technology incorporation scheme will be applicable to all programs, it is hoped that our experiences in curriculum design and technology incorporation will be beneficial to other universities as they consider refining existing programs or beginning new ones.

EDUCATION; NEUROBIOLOGY; WEBCT; TEGRITY; COURSE DESIGN

ONE OF THE MAJOR CHALLENGES in graduate education in the biomedical sciences is to provide an educational environment that prepares young people to assume the multiple roles of an academic faculty member. The average biomedical academic faculty member wears multiple hats (e.g., researcher, educator, manager, communicator, writer, reviewer, and committee member) (3). Fulfilling these different vocational tasks can require overlapping but sometimes differing skill groups. The education of biomedical science graduate students thus requires a curriculum that facilitates development of a variety of skills, such as conceptualization and creative thinking, knowledge and information collection, analysis and interpretation skills, writing skills, and verbal communication skills, which collectively equip the trainee with the skill repertoire necessary for diverse multitask performance that personifies the everyday life of an academic scientist.

Recently, our university initiated a new PhD program in neuroscience, which allowed us to tailor our curriculum, particularly two new core neuroscience courses that we created and that I (D. W. Brann) direct (e.g., Neuroscience I and Neuroscience II), so that training could be given in a number of skills that an everyday neuroscientist utilizes. The curriculum revision and new course creation also provided an idea opportunity to incorporate cutting-edge technology into the graduate curriculum, a process aided by the expertise of my coauthor and WebCT administrator (S. Sloop). This article thus focuses on our experiences and student perceptions and feedback on the success of our neuroscience curriculum changes and the incorporation of technology in the graduate curriculum and courses in a medical school environment.

NEUROSCIENCE CURRICULUM DEVELOPMENT

The curriculum for the new neuroscience PhD program at our university was designed by an executive committee composed of a number of neuroscientists on campus, including several departmental chairs, program directors, and administrators. Because of the complexity of the brain, an interdisciplinary approach to unlocking its secrets has been advocated (11, 12). Accordingly, the new graduate neuroscience program was designed to be interdisciplinary in nature, involving participation by multiple faculty members in various basic and clinical science departments, centers, and institutes on campus.

The educational core of the new program centered around the development of two new graduate neuroscience “core courses,” called Neuroscience I and Neuroscience II, which constitute required courses for students in the neuroscience graduate program. The two courses are “companion” courses offered in the spring and fall and are worth four and six credit hours each, respectively. Neuroscience I covers cell and molecular neuroscience, nervous system development, and sensory systems. Neuroscience II covers motor systems, regulatory systems, behavior and cognitive neuroscience, neural diseases, and emerging models and techniques in neuroscience research. The two courses have a required textbook, Fundamental Neuroscience (13), and the lectures follow the organization of the book chapters presented in the book. The lectures are supplemented from a variety of other sources, such as other textbooks, original articles, review articles, and videos.

GOALS OF THE NEUROSCIENCE CORE COURSES AND MECHANISMS FOR THEIR ACHIEVEMENT

In devising the two new neuroscience core courses, there were several goals that we wished to achieve, which are listed and described below.
Two overarching goals of the neuroscience core courses are to provide our graduate students with a solid foundation in neuroscience, covering anatomic, cellular, molecular, and systems neuroscience, and to enhance skill groups utilized every day by academic neuroscience faculty members. It should be noted that the same skills and knowledge acquired in the core courses would still serve well those who choose a different career path, such as in biotechnology, pharmaceutical companies, or government laboratory, although admittedly such individuals may well employ a different array of skills on a daily basis compared with an academic biomedical faculty member. Skill groups targeted for enhancement included analysis and interpretation; organization and review of relevant literature; oral communication and presentation of ideas, hypotheses, and data; writing skills; critique skills; collaboration and teamwork skills; teaching skills; and question generation/discussion skills. A previous study (1) has demonstrated these skill groups to be important for success of academic science faculty, and our collective experience as neuroscience faculty members confirmed the importance of these skill groups. Below, we discuss the remaining goals of the courses and the mechanisms for accomplishing them as well as the mechanisms for enhancement of the skill groups listed above.

**Goal II: to Emphasize the Importance of Translational Neuroscience Research**

Advances in biological and physical sciences is accelerating at an amazing pace, but the significant problem of translating laboratory bench discoveries to bedside treatments or cures remains as daunting as ever. Several recent articles (7, 9) have pointed out the need for enhancement of translational research in all disciplines. The traditional physician/scientist MD/PhD training program continues to serve as the primary mechanism for advancing translational research. Nevertheless, Gray and Bonventure (7) have advocated “closing the gap from the other side,” e.g., providing in-depth or targeted exposure of PhD students to clinical training, lectures, and case studies. The design of our curriculum and core courses demonstrate our agreement and support of this advocacy, because a major stated goal of our core courses and curriculum is to emphasize the importance of translational neuroscience research and to enhance PhD student awareness, knowledge, experience, and training in clinical neuroscience. Our program uses the targeted exposure approach described by Gray and Bonventure (7), in which clinical case presentations by clinical faculty are intermingled with basic neuroscience lectures, so as to provide a “translational” (laboratory bench to bedside) emphasis and learning experience to the students. This “targeted” clinical exposure in the neuroscience core curriculum occurs primarily in the Neuroscience II core course. For instance, case studies are presented by clinical faculty on multiple motor system disorders (Parkinson’s disease, Huntington’s disease, and Tourette’s syndrome), regulatory system disorders (bipolar disorder, eating disorders, alcohol addiction, immune neuropathies, and demyelinating disorders), and behavior and cognitive disorders (stroke, schizophrenia, prion diseases, epilepsy, Alzheimer’s disease, and autism).

Lectures are also presented by clinical faculty on methods, practices, and considerations in human cognitive testing, utilization, relevance, and extrapolation of preclinical animal models of neurological disease and the use and importance of brain imaging techniques (PET, SPECT, and MRI) in clinical and basic science settings. The “targeted” clinical exposure approach ensures “big picture” relevance and helps illustrate how basic neuroscience discoveries and research directions can be targeted to or applicable to understanding and treating neurodegenerative/neural disorders. Additionally, the neuroscience graduate program curriculum at our university offers a clinical neuroscience course, which is an additional required course for our neuroscience PhD students. This course has the PhD student “shadow” the neuroscience clinician in the hospital and clinics similar to the medical students, thereby providing an intense exposure to neuroscience disorders from a clinical perspective. Collectively, these educational experiences are hoped to provide an enhanced appreciation and understanding of the needs in clinical medicine so that future PhD neuroscientists can, in effect, help close the gap from the “other side” in making the leap from laboratory bench discovery to bedside therapy. The effectiveness of these types of initiatives is admittedly difficult to quantitate. However, PhD graduates given “in-depth” or “targeted” exposure to clinical medicine have been reported to equal or exceed traditional MD/PhD physician scientists in achieving positions at academic medical centers and obtaining National Institutes of Health grants (7). Nevertheless, the true test will be whether increased translational efficacy of moving laboratory bench discoveries to bedside therapies is indeed observed as new generations of “translational”-trained physician scientists and PhD scientists move into the arena of biomedical research.

**Goal III: to Provide Faculty Laboratory Presentations That Complement and Enhance Lecture Material**

A third goal of the neuroscience core courses is to illustrate the use of key neuroscience techniques and models by having laboratory presentations built into the course at relevant points. This “applied learning” approach is designed to strengthen the learning experience of the student and provide examples of how such techniques and research models are used to answer critical research questions in the faculty’s laboratories that are extremely relevant to the topics being covered in the lecture material. This brings the techniques/models “to life,” making their description less abstract and more relevant and demonstrates application to real-life questions in neuroscience. For instance, in Neuroscience I, laboratory presentations are presented on whole cell patch clamping, the three-dimensional structure of synapses, axon guidance, stroke, and neurogenesis, in which the students visit the faculty member’s laboratory for a presentation and demonstration of the technique/model and its application in the faculty member’s research. Additionally, Neuroscience II has lectures/demonstrations on brain imaging techniques, neurogenomics, cognitive/behavior testing in research animals, human cognitive testing, and animal models of psychiatric disorders. The advantages and limitations of the various techniques/models are discussed as are their application in addressing key clinical and basic science questions. The lectures/presentations are generally held in the faculty member’s laboratory and thus are less formal and encouraging of
questions and discussion by the students. Quizzes are also utilized on the WebCT course site to test key concepts presented in the laboratory presentations, which promotes attention in the presentations and reinforced learning as well as providing feedback to the student (and faculty) on student comprehension and understanding of the material.

Goal IV: to Provide a Learning/Mentorship Environment for Student Enhancement of Literature Assimilation and Interpretation Skills, Manuscript Writing Skills, and Presentation Skills

As mentioned previously, in addition to creating a solid knowledge base in neuroscience, a second overarching goal of the neuroscience core courses is to provide a mechanism for enhancement/teaching of various skills that are important to a successful career as a neuroscientist. Along these lines, an important aspect of a neuroscientist’s career is assimilation of complex research literature with the purpose of identifying key unanswered questions in the field, which can then be targeted for research by the faculty member. The neuroscience core courses provide training/preparation for the critical skills of literature assimilation, organization, and condensation as well as the key skills of critical thinking and development of significant hypotheses by requiring the students to review papers in a journal club discussion format in the course and by having two students partner to write a minireview of an assigned relevant topic in neuroscience under the mentorship of a faculty member. Neuroscience program students also attend seminars in the neuroscience seminar series, where seminars are delivered by leading neuroscientists in the country. Students also have specialized journal clubs (e.g., the synapse journal club, stroke journal club, etc.) where they can present papers and enhance their skills in hypothesis and data presentation, interpretation, critique, and analysis.

In the core courses, the minireview writing assignment has proved to be quite beneficial to students. The minireview topic is from one of the three areas/sections covered in Neuroscience I, and the lists of topics are suggested by the faculty members that teach in the course and who themselves are expert in the particular topic they are suggesting. The students select a partner or are assigned a partner to work with on a minireview. This promotes teamwork and collaboration skills. The students rank three topics in the order of preference (one from each section in the course), and the course director makes the final assignment of the review topic so that each section of the course has representation by minireviews. Some examples of minireview topics used in Neuroscience I include 1) translational regulation during synaptic plasticity, 2) fluorescent protein-based tools to study the physiology of living neurons, 3) mechanisms of taste transduction, 4) the role of the immune system in neural degeneration, 5) neurotrophic factors and synapse elimination, 6) alterations of tactile perception in the blind, and 7) parallel processing streams through the lateral geniculate nucleus. Once assigned a minireview topic, the students prepare a outline that they discuss with the faculty mentor, who offers advice on the steps one uses in literature assimilation, organization, and condensation as well as the essentials of good writing. It is emphasized that the faculty mentor is a “guide” or “enabler;” the student is the “doer.” For this exercise to be successful, it is important that the students have a clear idea as to what is expected of them and how grading will be performed. Therefore, the course director places detailed instructions on the course information area of WebCT that explains what components should be included in the review, the grading matrix that will be used, and who the graders will be (the course director, associate course director, and faculty mentor).

The minireview exercise enhances in a “mentored environment” such skills as literature review and assimilation, identification of key questions, analyses and interpretation, critical thinking on future directions and technical developments that are needed to move the field forward, writing skills, and organizational skills. It teaches the importance of teamwork and distribution of work. To enhance other skills such as the presentation/defense of data/concepts/hypotheses, the students are required to present the minireview to the class in a 15-min presentation using a PowerPoint presentation. Some students supplemented their presentations with a video, and all were encouraged to use summary diagrams illustrating key points, pathways, and/or concepts. In presenting the minireview, the students were expected to provide a concise summary of the state of the field, list the key critical questions/areas that form the frontiers of this field (in their opinion), provide suggestions on types of experiments that need to be done, and be prepared to defend any position they take. They are also asked to discuss the suitability of current technology, its limitations, and where innovations are needed. The students were instructed that they are, in effect, “educating” the rest of the class. Thus, the students assume a “teacher” role in the course. In performing all of these tasks, the student is, in effect, emulating the role(s) that s/he will assume as a future neuroscientist faculty member. The student presentations are graded by the course director and faculty mentors who attend the minireview presentations. The criteria for grading are clearly outlined to the student in the course information section on WebCT. It should be mentioned that by having the student select from topics from the different sections in Neuroscience I, a mechanism is created for reinforcement of content in these different major sections of the course. The exercise also enhances self-learning by having the students delve into the subject in a more detailed manner and enhances global learning by having the students convey their findings to the other students in the class through their class presentation of the minireviews. Student feedback on the minireview exercise was very positive, as reflected in the student responses on this issue in the course evaluations (Table 1).

Goal V: to Provide an “Engaged” Learning Environment and Enhance Student Skills in Question Drafting and Asking

Active participation enhances learning. To facilitate an “engaged” learning experience, students in Neuroscience I are required to submit two questions to the course director by noon before the next day’s class. The submitted questions are to come from the reading assignments that students are expected to complete before the lecture. The submitted questions are forwarded to the faculty lecturer, who chooses the best questions for inclusion/answering in the lecture. Thus, the talks are peppered with lecturer comments such as “several students asked about this from the reading assignment…” or “an interesting question submitted by one of you was…” Thus, the
parallel goals of the submitted questions are to help insure completion of the reading assignments, allow students to give feedback on unclear points in the reading assignments, and encourage students to think critically about what they are reading. The students are also required to ask questions and participate in discussions in class. The expectations on class participation and how they can be met are clearly outlined in the course information section on WebCT. The effectiveness of the required question submission to the learning process can be difficult to gauge. As shown in Table 1, the students clearly were less positive about the benefit to the learning experience of this class requirement. On the other hand, the quality of student questions and their level of classroom participation in discussion has been noticeably improved in Neuroscience II after the required question submission experience in Neuroscience I. It is possible that an assignment can be unpopular, as reflected in the course evaluations, yet beneficial. On the other hand, the effectiveness of the question submission exercise in insuring completion of the reading assignments in Neuroscience I seems debatable, because the student evaluation questions on student “preparation for class” and “completion of all reading assignments” presented in Table 2 clearly show lower scores compared with other indexes/evaluations, reflecting a potential acknowledgement that not all reading assignments were completed. Thus, the question submission exercise proved to be an unpopular requirement, which may not guarantee completion of all reading assignments but may sharpen the question development skill of the student and enhance critical thinking. It should be mentioned that we have tested the use of certain technology as an additional mechanism to enhance class participation, e.g., the Classroom Performance System (CPS). Its use and perceived effectiveness will be discussed in the next section on technology use in the course and classroom.

In 1998, the Medical College of Georgia first instituted WebCT as a mechanism for electronic on-line course hosting and administration. Since this early inception, its popularity has grown, and over 511 WebCT courses are now available from different schools at the university. We are currently using WebCT Campus Edition version 4.1. WebCT has been especially popular in large class settings and distance learning initiatives, particularly in such schools as the School of Allied Health and School of Nursing. The use of WebCT in small class biomedical graduate school core courses had (until our neuroscience courses) been untested. The incorporation of WebCT in the Neuroscience I and II core courses thus represented a test of its usefulness/effectiveness in enhancing the learning environment in a small graduate class setting. Recent studies (2, 4, 5, 10) have provided evidence that incorporation of technology into college courses generally leads to enhanced student learning. Furthermore, use of an on-line course has been previously described to be beneficial in a large class size undergraduate neuroscience course setting (8). Our use of WebCT in the small class graduate neuroscience course setting yielded similar perceived enhancement of the students’ learning experience (see Table 1). Specific advantages and limitations encountered in the use of WebCT in our neuroscience graduate courses are described in detail below. A guided tour of the Neuroscience I WebCT course site using Tegrity recording can be viewed here (http://tegrity2.mcg.edu/tegrity/general/Neuroscience%20I/20WebCT%20Course%20Site%20Guided%20Tour_090905125218/class/default.htm) (viewing requirements: Internet Explorer browser, latest Windows Media Player, and latest version of Sun Java Runtime Environment, and popup blocker must allow Tegrity to launch links).

WebCT as an organizational tool and learning tool. The use of WebCT allows for the creation of a central site where all course materials can be maintained and assessed by the students. The following items are maintained on our Neuroscience I WebCT course site: syllabus, course information, all handouts, reading assignments, lecture objectives, assigned papers from the literature, quizzes, exams, grades, course evaluation forms, digital audio recordings of each lecture, PowerPoint slides for every lecture, motivational quotes, and links to other

Table 1. Neuroscience I course evaluations questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The course was well organized to help students learn.</td>
<td>1.57 ± 0.85</td>
</tr>
<tr>
<td>WebCT was a valuable asset to the learning experience.</td>
<td>1.57 ± 1.09</td>
</tr>
<tr>
<td>Course requirements, goals, and objectives were posted to WebCT and were clear and easy to understand.</td>
<td>1.29 ± 0.47</td>
</tr>
<tr>
<td>The inclusion of laboratory presentations was beneficial to the learning experience.</td>
<td>2.14 ± 0.77</td>
</tr>
<tr>
<td>The submission of questions and their use in class was beneficial to the learning experience.</td>
<td>3.14 ± 0.95</td>
</tr>
<tr>
<td>Having a textbook is a good idea and beneficial to the learning experience.</td>
<td>2.00 ± 1.24</td>
</tr>
<tr>
<td>The audio file recordings placed on WebCT were beneficial to the learning experience.</td>
<td>2.00 ± 0.96</td>
</tr>
<tr>
<td>The exams properly reflected key concepts as presented in the lecture by the instructors.</td>
<td>2.36 ± 0.93</td>
</tr>
<tr>
<td>The providing of sample/practice exam questions was a good idea and beneficial to the learning experience.</td>
<td>1.93 ± 0.73</td>
</tr>
<tr>
<td>The exams were sufficiently rigorous to challenge me intellectually.</td>
<td>1.64 ± 0.50</td>
</tr>
<tr>
<td>The assignment to write a minireview was informative and educational and enhanced the learning experience.</td>
<td>1.71 ± 0.83</td>
</tr>
<tr>
<td>Overall, I would rate the value of what I learned as very high.</td>
<td>1.43 ± 0.51</td>
</tr>
</tbody>
</table>

Values are means ± SD; n = 14 students. The numerical scoring was as follows: 1, strongly agree; 2, agree; 3, undecided; 4, disagree; and 5, strongly disagree.

Table 2. Student self-evaluation questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I was self-motivated to learn the material.</td>
<td>1.29 ± 0.47</td>
</tr>
<tr>
<td>I was well prepared for each class.</td>
<td>2.43 ± 0.94</td>
</tr>
<tr>
<td>I completed all reading assignments (both textbook and assigned papers).</td>
<td>3.29 ± 1.07</td>
</tr>
<tr>
<td>I completed all quizzes.</td>
<td>1.29 ± 0.83</td>
</tr>
<tr>
<td>I asked the course director for help and guidance when I needed it.</td>
<td>1.50 ± 0.65</td>
</tr>
<tr>
<td>I invested enough time and energy to meet/exceed course requirements.</td>
<td>1.64 ± 0.50</td>
</tr>
<tr>
<td>I participated actively and contributed thoughtfully.</td>
<td>1.93 ± 0.73</td>
</tr>
<tr>
<td>Overall, I gave my best possible effort to learning in the course.</td>
<td>1.50 ± 0.52</td>
</tr>
</tbody>
</table>

Values are means ± SD; n = 14 students. Numerical scoring was as follows: 1, strongly agree; 2, agree; 3, undecided; 4, disagree; and 5, strongly disagree.
important neuroscience and education websites. The WebCT course site also has discussion board capability, which we did not use much because the small class size was conducive for “in class” discussions. Neuroscience II has the exact same format as Neuroscience I, but instead of digital audio recordings, we moved to the use of the Tegrity system of video/audio recording of each lecture, as will be discussed in detail in a subsequent section. The WebCT course sites are password protected so that only registered students and teaching faculty members have access to the course. The WebCT course sites proved to be a highly efficient and effective mechanism for providing organization and structure to the course, and they greatly facilitated and streamlined dissemination of course materials to the students. By providing all resources in a central location and in an organized easy-to-navigate fashion, the WebCT on-line course facilitates the student’s learning experience by diminishing time spent searching for resources.

The setting up of the WebCT course sites was a large undertaking because the courses were brand new and all items had to be created de novo, formatted, and uploaded to WebCT. To make this transition as easy on the faculty as possible, they were asked to provide Word documents to the course director, who converted the documents to PDF format and uploaded them to the WebCT course sites. It should be mentioned that the faculty members were granted “teacher assistant” (TA) access, which allowed them access and gave them the ability to grade but did not allow them the ability to change the course site (“designer access”). Designer access was reserved for the course director (and WebCT administrator). This is recommended because someone needs to be responsible for all course site design and changes, and it is easier if such capability for modifications is restricted to one person, in our case, the course director. It is recommended that secretarial help be assigned to the course director to assist in formatting and uploading documents because this can be a significant job and time demand on a busy faculty member. An important feature of WebCT is that it allows student tracking so that the course director can see which pages the students visit and how many times. This allows the course director to see whether the student is utilizing the resources of WebCT. Our students were very active in using the all the resources of WebCT. We should mention that the use of WebCT in the courses was extremely well received by the students and viewed as beneficial to their learning experience (see Table 1). In fact, this experiment with WebCT incorporation worked so well that the graduate school has mandated WebCT use in all its biomedical science PhD core courses.

WebCT as a testing tool and motivational tool. In addition to its organizational and information dissemination benefits, the WebCT course sites allowed us to administer weekly quizzes and all exams electronically on WebCT. A number of studies have shown that on-line quizzes are beneficial to the learning experience (5, 6, 14). WebCT allowed us to give “date-sensitive” quizzes, e.g., quizzes became available on WebCT immediately after the lecture and typically closed 1 wk later. The limited time window for taking the quiz was instituted as a mechanism for reinforced learning to motivate the students to review/study their lecture notes in a timely manner throughout the course and not just before a major exam. The quizzes also served as a feedback mechanism to indicate to the student and teacher/course director the degree to which the student had mastered the material.

The quiz question format ranged from multiple-choice questions, true/false questions, “fill in the blank” questions, matching questions (using anatomic pictures or diagrams), and short answer questions (generally 1- to 5-sentence answers required). The student could take the quiz only once. WebCT automatically graded some forms of questions such as multiple-choice and true/false questions. The remaining questions were either graded on-line on WebCT by the faculty member or a hard copy of the quiz was hand graded by the faculty member. The hand-graded option was used because some faculty members were not experienced with WebCT and did not have time to learn its use. In that case, the course director uploaded the hand-graded scores and comments to WebCT for the faculty. The goal of the course director was to make the use of WebCT as easy as possible for the faculty, many who are heavily burdened in research or clinical/administrative services and have not learned to use WebCT. It is expected that as they become familiar with the WebCT, they will transition to use WebCT on-line grading because it is much easier than hand grading and eliminates the need for another party to upload the scores and comments from hand-graded quizzes or exams. The Division of Visual and Instructional Design on campus offers introductory courses in WebCT use for the faculty, which the faculty are encouraged to enroll in to enhance their proficiency with the use of WebCT.

It should be mentioned that all exams were also administered on WebCT in an electronic classroom. All exams utilized an essay question format, with six to eight essay questions per exam. Secure browser technology was used to administer the exam on WebCT, which prevents the student from accessing the Internet or other programs and from using the printer and screen capture functions. Once completed, the exams were automatically e-mailed to the course director, who forwarded them to the faculty for grading. Both on-line WebCT and hand grading was used, depending on the preference of the individual faculty member. The use of WebCT for the exams eliminated the problem of undecipherable handwriting that can occur in written exams. One limitation of the WebCT for exam administration is the lack of a drawing tool for students, which was circumvented by having the students place drawings (flow diagrams, etc.) on sheets of paper, which were submitted as a supplement to the electronic exam answers.

In analyzing the quiz and exam performance in Neuroscience I, it was noted that the highest scores were achieved on the quizzes compared with the exams. Additionally, there was a strong correlation to performance on the quizzes and performance on the exams, e.g., those who performed well on quizzes performed well on exams, and vice versa. Some students failed to complete all the quizzes, which collectively represented 10% of the total course grade. These students generally did more poorly in the course. There were 28 quizzes in the Neuroscience I course. The decision to make the quizzes worth 10% of the grade was based simply on goals of the quizzes (a motivational tool to review the lecture notes and as a gauge for testing understanding of material). It was expected that because the quizzes were take-home/open-book on-line quizzes, that scores would be high, which generally held true. The quizzes were, in effect, reinforced learning tools, and as such were not meant to be the heaviest weighted component of
course grading. This was reserved for the exams. Student feedback indicated that the on-line quizzes did enhance the learning experience and were a good motivational tool to stay “caught up” in the course.

We also utilized a second motivational tool in the course: the use of motivational quotes on pages throughout the WebCT courses. Table 3 illustrates some of the motivation quotes used in the courses. As seen in Table 3, the quotes cover a range of subjects, including education, learning, science, research, discipline, and discovery, to name just a few. The goal of the motivational quotes, in addition to motivation, was to keep the students thinking about the “big picture,” e.g. what they are trying to achieve via their education. It also served the dual function of making the students think, especially about what factors/habits/traits lead to success in life and in science. They challenged the students to excel, and they provided examples of those who did excel in life and science, with glimpses of the traits/factors/habits that they considered important for their success.

**Classroom Performance System**

We also tested a new technology in Neuroscience I called CPS. CPS is designed to 1) increase student participation in the class, 2) provide a mechanism for feedback on lecture effectiveness, and 3) serve as a mechanism for reinforced learning. CPS hardware requirements are simple: a personal computer (PC) or Macintosh computer, a projector, and the receiver and remote control transmitters. CPS involves distributing the infrared remote controls to the students, which allows the students to enter responses (typically A–E button choices) to questions asked by the instructor. The remotes can be used anonymously (the way we used them in the class) or they can be tracked and actually used for grading of the quiz questions. Typically, the questions are inserted at certain points as slides in the PowerPoint presentation, although the question can be spoken verbally as well. The computer has a receiver attached to it, which wirelessly receives the students’ responses/answer selections for the question. The questions can be multiple choice or true/false in format, and generally a 20- to 30-s period is allowed for students to answer via imputing/pressing the letter on the controls that corresponds to the correct answer. Once the time window for answering ends, the responses are automatically tabulated by the CPS and a graph is displayed on the screen showing the student distribution of the answers for the question. The teacher can then indicate the correct answer. In using CPS, we found that it had the advantage of making the class more fun and interactive. It also provided immediate feedback to the student and faculty lecturer as to the level of understanding of the material that the student has achieved. In addition to testing for comprehension/understanding of lecture concepts, CPS could also be used as a “pretest” at the beginning of the lecture to test the knowledge level of the students before a lecture is presented or it could also test understanding of concepts presented in the reading assignments. We found CPS to be a useful adjunct assessment tool in the small class graduate classroom; however, it may be even more useful in large class settings, such as that observed at the undergraduate level, where it is difficult or impossible to achieve total class participation.

**Tegrity**

A common and frustrating problem faced by virtually every student is the inability to take complete notes without falling behind in the note taking. This problem leads to incomplete note taking, often with thoughts being lost or segments being difficult to interpret and follow when the student revisits the notes later for studying. In an attempt to circumvent this problem, the course director digitally recorded audio for the lectures in Neuroscience I using a hand-held digital audio recorder and placed a link on WebCT for student access and playback of the audio recordings. Table 1 shows that the students felt the digital audio recording availability was beneficial to their learning. Although apparently better than just notes alone, the problem with this method of supplementation of the notes is that there is no “real-time” link or association of the audio to the visual cues used in the class, such as the lecturer himself and the PowerPoint slides presented and discussed by the lecturer. To overcome this limitation, we moved to incorporate Tegrity into the Neuroscience II course, which followed the Neuroscience I course in the fall.

Tegrity is a new technology allowing video/audio recording of the lecturer and synchronization with PowerPoint slides. It’s features/capabilities are listed in Figure 1, as is a screen capture of a viewing of a Tegrity recording on the PC. As shown in Figure 1, Tegrity records the lecturer and the pointer or digital pen; has whiteboard capability; has annotation capability, which allows writing directly on the PowerPoint slide via use of a TabletPC and associated digital pen; has a document camera for capture of graphs, figures, or text from documents; and has screen capture ability to capture use of other programs, including the Internet. We use a simple Webcam with a built-in microphone to video/audio record using the Tegrity system. The Tegrity recording can be paused at any time, and, once the lecture is ended, the Tegrity recording can be uploaded immediately to the Tegrity server or can be set to upload automatically at a later time. After uploading the Tegrity recording, the course director pastes the Web link for the recording in a PDF document that is uploaded to the WebCT course site for student access to the recording, which streams from the Tegrity server.
When the student clicks on the link, the Tegrity viewing panel opens in Windows Media Player, and the student selects his/her connection speed (dial up or broadband). A computer screen shot of a Tegrity recording viewing on a PC is shown in Figure 1.

One important feature in the Tegrity is the index feature, which allows the student to see all the slides in the recording and go directly to a specific point in the recording. This allows the student to go right to the point where his/her notes are unclear and where clarification is needed. The annotation ability provided by the use of a TabletPC has proven popular with the faculty as they can now write directly on their PowerPoint slides using a digital pen, where the pen color and line width can be selected. The ability to write on the slides allows the instructor a mechanism for emphasizing and/or elaborating on key points in the slides/lecture. The whiteboard feature allows the instructor to get a blank screen/slide in PowerPoint that the instructor can use to write upon with the digital pen just like using a chalkboard. The tool palette has an eraser for erasing the annotations as well, with the option of single item erasure or all item erasure. The tool palette also has straight line, circle, and rectangle drawing capability, which can be useful in drawing diagrams. When the student views the Tegrity recording, there are other buttons/controls available in addition to the index button. These include a search button, play/pause button, help button, and audio volume control button. There is also a print button, which allows the student to print the slides in the presentation. There are four requirements for viewing Tegrity at our university:

1. the student must use Internet Explorer as the browser,
2. the student must have the latest Windows Media Player,
3. the student must have a compatible version of Java,
4. popup blocker software on the computer must allow Tegrity to launch links. We should

Table 4. Student comments on the use of Tegrity in the Neuroscience II course

“I think this is the coolest learning tool I have seen, it allows the student to completely go back through the lecture to catch things they missed. I think it will be a great asset to my learning experience and am thankful you put this together for the students to use.”

“I really appreciate the Course Director’s efforts. I feel that Tegrity is a good technology and is really helping me to go back to the lectures whenever I want to. It is really helpful to me and I am thankful to the Course Director for incorporating it into the course.”

“The incorporation of Tegrity into the course is really great! I cannot believe that we can see the PowerPoint presentation live along with the video lecture. The index feature is really useful for us to zone in on a particular portion of the lecture that we did not understand.”

“I must say the Tegrity has been an extremely useful tool. The index is great because I remembered where in the lecture I wanted to go to, and the index allowed me to do that in no time. I no longer had to “search” for it. The best part is being able to see the slide and pointer during the lectures. Again, I would definitely agree that Tegrity will be beneficial in my learning experience for the course. I’ve noticed that going back and listening/watching the lectures allows me to fill in the gaps that I missed in class, and it is a great study tool.”

Table 5. Peer review comments

“The 2-course curriculum is a model for any graduate program. The presentation is clean, neatly organized, easily followed and profession-based. Moreover the design should provide easy editing and updating of course materials and should be easily adaptable for use by another graduate program in another field.”

“An outstanding job, of course design, of use of innovation, and of presentation in the manuscript. Technology is now much more than a sexy tool; the course offers benefits for current students that we did not have. The quality of learning, and professional development, should be superior because of what the authors use. This is the appropriate way to adopt technology.”

Written comments by Dr. Charles Eldridge, Department of Physiology and Pharmacology, Bowman Gray School of Medicine, Wake Forest University, based on viewing the Neuroscience I and II WebCT course sites, Tegrity presentations, and course materials.
mention that Tegrity also has a “student notes” feature, which our university also has a license to use. The “notes” feature is a feature in which the student uses a special digital pen with a notebook or a tablet PC for taking digital notes in class where the Tegrity system is being used. Once class is over, the digital notes are synchronized with the Tegrity lecture recording, and the student can click on any place in their notes and it will take them to the exact place in the Tegrity recorded lecture where the note was recorded. We have not as yet utilized this feature of Tegrity but plan to do so in the future as this will make search and navigation of Tegrity more efficient by using the student’s own notes.

Table 4 provides student comments on the use of Tegrity in the Neuroscience II course. Clearly, the students feel that Tegrity is an outstanding learning tool that will enhance their learning of the course material. The index feature is very popular as it allows the student to go to a specific point in the lecture. The students still take notes in class, but, as their comments reflect, they are able to use Tegrity to catch the things they missed. Thus, the students are more relaxed in class and appear to concentrate more on the lecturer and what the lecturer is saying—because now they have the luxury of doing that, knowing that Tegrity is a “safety net” for whatever they may miss in their notes. In addition to filling in the gaps, Tegrity allows clarification and reiteration of key points through student reviewing of the lectures. Because the neuroscience courses are new courses, we have no benchmarks that we can compare them with. Therefore, we can not quantify learning outcomes before and after Tegrity incorporation. Nevertheless, the student feedback clearly indicates that they feel this is a valuable technology, whose incorporation enhances their learning experience. On the basis of this feedback, we plan to incorporate Tegrity into the Neuroscience I course as well.

Conclusions

It is becoming increasingly recognized and advocated that the education of PhD scientists needs to be “reenvisioned” so that they are better equipped and more proficient in diverse skill groups that will be needed and expected once they enter the faculty ranks (1, 7, 9). This article reviewed curriculum development in a graduate neuroscience program, which was designed to enhance attainment of a knowledge base and diverse skills that an everyday neuroscience faculty member typically uses. Because this is a new program, it may be some time before the success of the new curriculum can be fully assessed. Nevertheless, it is a beneficial and important endeavor to discuss mechanisms and approaches that are being employed at different universities to meet the challenge of training tomorrow’s academic scientists. This article also provides insights on the use of new technology in a graduate neuroscience small class environment. Each technology has certain advantages, and the respective employment of each depends on what the instructor wishes to achieve. In particular, the use of WebCT on-line courses and the Tegrity system was viewed by the students as extremely beneficial to their learning experience. CPS was also viewed positively, but it may be more suitable and have greater advantage in a large class setting, where total class participation can be difficult to achieve. The incorporation of new technology into the curriculum can be an effort- and time-intensive exercise for the faculty, and particularly for the course director, who initiates, leads, and troubleshoots its incorporation. Nevertheless, these new tools in the educational arsenal provide resources and opportunities to the students for enhancing their learning experience and thus are worth faculty members and the course director exploring and potentially incorporating the tools into their courses. While we utilized these innovations in a graduate neuroscience curriculum, they could be applicable/adjustable to other scientific disciplines in graduate education. This point is reaffirmed by the comments provided by an external peer reviewer who is a physiologist at a medical school but sees how such technology and curriculum design could have application in fields other than just neuroscience (Table 5). In conclusion, it is hoped that our experiences in curriculum design and technology incorporation in a graduate neuroscience program in a medical school environment will be beneficial to other programs/universities as they consider revising existing programs or creating new ones.

REFERENCES