Report of the UW-Madison Botany/Zoology 151/152 Review Committee

December 30, 2005

Prepared and submitted on behalf of the Committee
by
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Overview

Botany/Zoology 151/152 plays a critical role in the biology curriculum, with enrollment having increased five-fold in 10 years. In order to maintain course quality, the organizational structure of Botany/Zoology 151/152 needs to be streamlined and clarified to serve the increasing numbers of students pursuing an undergraduate major in the biological sciences; to give faculty and staff greater freedom to experiment with different teaching approaches; and to use limited resources more efficiently. While we believe the course sequence is run as well as any other major biology introductory courses at peer research universities, virtually ever group we met with reported that the course simply cannot continue to function as it currently is – it is bursting at the seams and nearly at the breaking point.

For example, the two faculty course chairs are burdened with tremendous workload without compensation; the Teaching Assistants (TAs) are grossly overworked (their numbers would need to be increased by more than 50% to reduce workloads to levels set by State contract); there are shortages of money for supplies and inadequate facilities for preparation, laboratory and TA office space; there is great confusion as to who is responsible for acquiring resources for the course and making enrollment decisions; there are multiple lines of reporting for the course coordinators; and the addition of a new fifth section of the course during the 2005-06 academic year required recruitment of an additional six faculty, two of whom will teach during the spring semester were yet to be identified at the time of this review.

These issues stem from the tremendous growth in undergraduate majors in the biological sciences. The course structure was designed for 200 students 15-20 years ago and it is now trying to accommodate 1,100 students. This accommodation was done simply by replicating the old structure into multiple sections. In some ways, the strengths of the course 15-20 years ago are now its weaknesses. Currently more than 63 faculty, teaching assistants and course coordinators are involved in running the course. Each section requires three research faculty members to teach each semester, and there are redundancies and overlapping workloads for the TAs and course coordinators. The diffuse administrative structure was compounded by the establishment of the Institute for Cross-college Biology Education that provides partial support to and administrative oversight of the course. The current course structure is not conducive to innovation and experimentation. After meeting with all the groups, we conclude there are simply too many cooks in the kitchen with diffuse lines of responsibility/authority and no master chef with overall responsibility and authority for the course. That situation has to change.

An assumption that drives the course structure and decisions is that research faculty teaching within their specialization best serves the needs of introductory level biology students. The committee saw no direct and supportable learner outcome assessments for that argument. Instead, the relatively light involvement of faculty in the lecture part of the course, and their

sometimes heavy reliance on course coordinators, gives faculty less ownership in the course. Furthermore, attempts to coordinate material among the multiple sections of the course inhibit creativity and innovation by faculty, and the multiple changes in teaching and exam style that accompany a course taught by three different faculty members makes it difficult for the students to adapt. If the condition of teaching within a specialty is removed, there is no shortage of faculty capable of teaching the biological content relevant to the course, conveying the excitement and principles of practicing biology, and relating the contributions that they or their colleagues bring to a topic.

The Committee believes the course would benefit from articulating a set of clear and specific learner goals and outcomes for the students: The question should be what do students need to learn in a beginning biology course sequence. These goals should drive and coordinate the learning activities in all aspects of the course, be assessed formally, and be communicated to faculty teaching upper level courses that build on the fundamental knowledge gained in Botany/Zoology 151/152. We agree with the Self Study that individual choice for faculty should be valued and preserved, and think that shared learner goals facilitate creativity by providing common ground for faculty to compare teaching approaches and examples.

The main format used in the course is lecturing (with supporting discussion sections and laboratories), which is not necessarily the most effective way for students to learn. While many faculty we talked to stated they were engaged in active learning, most feedback from faculty and administrators, students, course coordinators and TAs did not bear this out. Lectures accommodate some questions and answers, but we did not see evidence of the rigorous use of active learning techniques. While we do not feel that advocating specific teaching techniques is within the purview of this Committee, we do feel that faculty and staff in Botany/Zoology 151/152 must justify whatever teaching techniques they adopt with rigorous assessments. There needs to be an understanding of the difference between teaching and student-based active learning, and encouragement to shift to active learning (see Appendix 3 for a critique of the Self Study from the active learning point of view). It is clear that faculty need to be encouraged to experiment with new formats and classroom activities.

In terms of assessment, there is an almost complete disconnect between the way in which the faculty instructors of 151/152 approach teaching versus research. Teaching, as evidenced by the evaluations contained in the course Self Study, has been assessed with methods that are essentially subjective (student and faculty satisfaction surveys) or constrained to a single format (multiple choice exams) and are lacking in controls. Without a scholarly and comprehensive assessment of the outcomes of real student learning, we do not believe that course changes would be meaningful for the undergraduate biology students.

Recommendations

1. Changes should be made to the administrative structure of Botany/Zoology 151/152 in light of the continued and growing student demand;
2. The 151/152 faculty should produce a document stating clear and specific learning goals for both the content and process of the Botany/Zoology 151/152 curriculum. Faculty and staff in 151/152 should then conduct experimental course sections and

scholarly assessments of learner outcomes to see if they are meeting their learning goals. This recommendation takes advantage of the current modular structure of the course into sections, with one or more sections serving as controls and the remaining section(s) using an alternative teaching/learning format. This, however, would require greater independence among sections to allow faculty and staff creativity. ICBE has the expertise to facilitate these course experiments and assessments, and could play an instrumental role in stimulating effective approaches to teaching. Based on the results of the assessments, and if warranted, the course should be redesigned around learner outcomes (first design the course goals, then pedagogical and organizational structure follow learner needs and outcomes);

3. Administration of the course should remain within Zoology and Botany for the short-term, with wholesale migration of the course to ICBE considered in two to three years; and
4. Resources should reinforce learner needs, rather than course structure, although there is a critical need for more laboratory preparation space.

In the short term, we believe these recommendations will allow the course to function at its current level, or even grow, without adding new staff. In fact, the recommendations (see below) would reduce the overall number of faculty involved in course delivery from the present 30 faculty to between 16 and 20 (depending on the number of sections), and will allow the current number of course coordinators and TAs to do an adequate job of instruction by reducing redundancy and repetition of tasks (currently the TAs are grossly overworked). The proposed course restructuring will also reduce the need for more fiscal resources for laboratory preparations and activities, and we hope they will greatly reduce course oversight confusion.

In addition to the internal organizational issues, the course has experienced organizational issues at the University-wide level with the formation of ICBE. As ICBE has taken partial fiscal and organizational control of the course, lines of responsibility have been blurred and complicated as specific functions (such as recruiting faculty instructors and maintaining the student waitlist) have been transferred piecemeal to ICBE. We feel that it is unwise to simultaneously re-organize Botany/Zoology 151/152 internally and externally. Therefore, the current fiscal and administrative oversight should be retained by Zoology, with Botany serving as traditional partner, for at least two to three years. After this time, and possibly in conjunction with the five-year review of ICBE, wholesale (rather than piecemeal) transfer of Botany/Zoology 151/152 to ICBE should be considered. A strong participation of ICBE in the learning experiments and assessments in the course over the next two to three years will test the waters for a potential transfer of the course to ICBE. The majority of stakeholders we spoke with thought the administrative home for Botany/Zoology 151/152 ultimately should be ICBE, and the committee thinks that housing the course in ICBE will help build respect and leadership for ICBE as a major innovator for cross-college biology education on campus.

Recommendation Details

Recommendation 1

Changes should be made to the administrative structure of Botany/Zoology 151/152 in light of the continued and growing student demand

- Recruit a faculty course Director to be responsible for decisions for all aspects of the course. The Director should be elected for a two-year term by the current faculty and course coordinators teaching in Botany/Zoology 151/152, with coordinators having full voting rights as faculty. An appropriate model for the Director is the Director of Biocore; if the Director is recruited from the College of Letters & Sciences, he/she would receive one month summer salary, whereas if the Director is recruited from the College of Agriculture and Life Sciences, the Medical School, or another administrative unit with 12 month salaries, they could receive a 10% appointment through ICBE or the equivalent support to their home department for their teaching role. The Director should be responsible for the operation and staffing of lectures and laboratories/discussions, assign/monitor TA responsibilities, and assign responsibilities and co-supervise the course coordinators (in conjunction with the appropriate staff supervisor in Zoology). The course Director needs to be effective at leading, motivating and supervising. This would not only simplify organizational structure and chain of command, but also allow for course experimentation. The Director will need to work closely with the Director of ICBE for staffing the lecture component of the course, because ICBE currently controls funds to promote staffing.
- Encourage Botany and Zoology to continue to contribute at least 1/3rd of the course faculty.
- Separate the lecture schedule from the laboratories/discussions, making it clear to students that the course has two separate components that complement rather than duplicate each other. This necessitates coordinating activities (but not content) between all three components of the course to identify key concepts related to the learning goals, and may involve incorporating materials and learning formats now covered in the discussions (e.g., active learning) into the lectures. Currently, students want the discussions and laboratories to cover the same materials that were presented in lectures. This unfortunately places constraints on both lecture and discussion/laboratory components of the course, inhibiting innovation and learning.
- Reduce the frequency of discussions and laboratories and use the former to reinforce the latter, rather than repeat material from the lecture. For Botany/Zoology 151/152 the labs and discussions would meet on alternate weeks. The discussions could be used to help students prepare for the lab, so that laboratory time is used most effectively, and/or to discuss results/problems from the previous week's laboratory activities. Students expressed the sentiment that the weakest part of the current course is the laboratory experience.
- Redesign the laboratory experiments. Some of the goals of the current laboratory modules are not practical when dealing with large numbers of undergraduates who do not have previous laboratory experience. For example, it may be more practical to have a greater focus on the development of technical skills. The learning goals and

methods of assessment for these types of modules would be straightforward. An added advantage would be the advance preparation of students by endowing them with practical skills that would be of use in the mentored research part of the course.

- Decrease the number of faculty instructors per section to two each semester from the current three, which would require that individual faculty cover more material.
- Increase the lecture section size to 250 rather than 200 to meet short-term demand, if needed.
- Make the CommB designation for 152 optional, with those choosing a mentored research and independent research paper placed in separate sections. Many of the current students already have met, or plan to meet the CommB requirement with another course. Therefore, having CommB required unnecessarily increases the TA workload and may actually discourage students from taking the course.
- Remove course coordinator redundancy by assigning specialized roles rather than overlapping ones. We recognize that the specific tasks and balancing work loads among coordinators will need refinement, but suggest that the coordinators be assigned as follows:
    - One coordinator for the lecture sections and help with exams;
    - One coordinator for 151 laboratories and TA preparations;
    - One coordinator for 152 laboratories and TA preparations;
    - One coordinator for Independent Research component for 152, including CommB and TA preparations; and
    - One administrative coordinator to keep records, maintain/enhance course resource base (including T4 tutorials), develop additional resources, complete scheduling, provide exam logistics and grading, submit final grades, etc.
- Change the current reporting structure so that the coordinators report to the course Director and academic staff supervisor in Zoology, thus eliminating the need for a "lead coordinator" that the four other coordinators report to.
- Restructure and reduce TA workloads to improve efficiency and eliminate redundancies. With separation of lectures from discussions/laboratory sections, TAs would be encouraged but not required to attend the lectures, discussions, and laboratories as separate tasks. Combining discussions with the laboratories would further reduce workloads. It will still be necessary to assign one TA to each of the lecture sections, although responsibilities for these TAs will be restricted to the lecture components of the course (meeting with students, grading, optional discussions, etc., under the direction of the lecture faculty). Currently each TA spends on average 25.9 hours per week – 16.75 hours scheduled time and nine hours unscheduled time. Current TA workloads interfere with and compromise the student learning experience for the 151/152 students.
- To retain the aspect of the course that puts specialized research faculty in front of undergraduate beginning course sequences, the course could incorporate a series of specialized guest lectures with the specialized research faculty presenting the same lecture to all 151/152 sections. This possibility should be evaluated experimentally in conjunction with other possible teaching experiments.

Recommendation 2

The 151/152 faculty should produce a document stating clear and specific learning goals for both the content and process of the Botany/Zoology 151/152 curriculum. Faculty and staff in 151/152 should then conduct experimental course sections and scholarly assessments of learner outcomes to see if they are meeting their learning goals. This recommendation takes advantage of the current modular structure of the course into sections, with one or more sections serving as controls and the remaining section(s) using an alternative teaching/learning format. This would require greater independence among sections to allow faculty and staff creativity. ICBE has the expertise to facilitate these course experiments and assessments, and could play an instrumental role in stimulating effective approaches to teaching. Based on the results of the assessments, and if warranted, the course should be redesigned around learner outcomes (first design the course goals, then pedagogical and organizational structure follow learner needs and outcomes)

- Botany/Zoology 151/152 goals/learner outcomes have to be set by the faculty who participate in the course. The course faculty already have regular meetings and have discussed these in an informal way, but the goals/outcomes should be committed to paper and shared and referenced. After the goals/outcomes are articulated, ICBE should take the campus lead in promoting scholarly research assessments to determine the best way to restructure the course. The assessment should be on what students really learn a few months after the course, rather than satisfaction surveys and how well they did after cramming for exams. To do this adequately, ICBE should provide opportunity and resources, and facilitate the 151/152 Director and faculty as they:
    - Define 151/152 course goals; and
    - Conduct objective assessments to determine whether the course is meeting those goals.
- After obtaining the above assessment information, faculty and staff should experiment with different pedagogical structures for achieving course goals by dedicating each section to a particular format (straight lecture, active learning, problem-based learning, etc.) for one semester. The active learning approach will require that students keep up; minimize lectures; and use frequent quizzes as learning aids. This approach will provide faculty a timely means of assessing student comprehension.
- If the active learning sections show improved student learning, ICBE should conduct campus workshops on active learning in biological and science instruction.

Recommendation 3

Administration of the course should remain within Zoology and Botany for the short-term, with wholesale migration of the course to ICBE considered in two to three years

- The overall course administration and infrastructure should continue to reside in the Department of Zoology, with Botany playing its traditional supporting role, at least for the short term until the internal restructuring has time to settle and a thorough

scholarly assessment of the course is conducted. The course needs to be in the administrative unit that will best provide infrastructure to support the course Director and course coordinators, and hire and assign course coordinators and TAs. The current infrastructure works for the most part, and both Departments have long-term commitments to the course and personnel management. However, most of the stakeholders we interviewed thought that ICBE would be a natural home for the course once the role of ICBE in campus-wide undergraduate education had solidified. The 5-year review of ICBE would be a natural time to consider the wholesale migration of Botany/Zoology 151/152 to ICBE.

- ICBE should remain a course champion and facilitator as well as function as an umbrella for biology education across campus, partnering with this and other courses.
- ICBE should help the course Director recruit faculty outside Zoology and Biology as it has the budget to do so.
- ICBE should advocate for additional resources for the course and work to fund the assessment and experimentation sections.
- ICBE should continue its valuable cross-college role in advising undergraduate biology education students.

Recommendation 4

Resources should reinforce learner needs, rather than course structure, although there is a critical need for more laboratory preparation space

- Previous reports have called for more resources in terms of money, space and TAs to support the course. However, the Committee does not recommend infusion of any major new resources into the course until, and if, learning outcome assessments mandate restructuring from the student learner point of view. At that point, the data will dictate the best way to design, fund and teach the course. In short, resources should follow course objectives. However, there are some major resource issues that need to be addressed as soon as possible. These are:
    - There is an immediate need for more preparation space for the laboratory sections. A larger or multiple room(s) should be allocated for this purpose.
    - For the nine TAs who currently share minimal office space in Noland Hall, give them the current lab prep room for an additional office.
    - It is imperative that TA hours be reduced from the current load. Even with the restructuring of the course that we propose, this might require additional TA positions.
    - ICBE should work to increase the budget to supplement laboratory experiments and activities.

Appendix 1
UW-Madison Botany/Zoology 151/152 Review Materials

- Relevant section of the Hearn Committee Report
- Roberts Committee Report
- Sussman Committee Report
- Biocore Review
- 151/152 Self-Study
- 151/152 Fall 2005 lecture sample DVD – Edgar Spalding and Grace Boekhoff-Falk
- 151 Sample Exams

Appendix 2
UW-Madison Botany/Zoology 151/152 Review Committee Meeting Schedule
Friday, November 18, 2005

Note: The committee had a pre-review meeting and conference call with Tom Sharkey from 9-10:30 a.m., Wednesday, November 9 to discuss the committee charge.

7:30-8:30 a.m.	Committee breakfast at Best Western
8:45 - 9:30	Course Co-chairs: Monica Turner (Zoology Dept)/Edgar Spalding (Botany Dept) Note: AM Reviews to be held in 163 Noland Hall
9:30 - 10:30	TAs: Catherine Bonin, Sara Christopherson, Alice Ecker, Emily Greb, Kirsten Kapp, Timothy Kuhman, Erin LaFaive, Kerry Martin, Dean Nardelli, Martin Simard, Courtney Skalitzky, Jeremiah Yahn, Sheila Yokers
10:30 - 11:15	Head Course Coordinator: Jean Heitz. Also Facilities Tour
11:15 - 11:45	Botany Department Chair: Donna Fernandez Zoology Department Chair: Karen Steudel
12 - 12:45 p.m.	Lunch with Biocore Administration: Janet Batzli, Carol Borcherding, Jeff Hardin, Michelle Harris Note: PM Review to be held in Room 110, 445 Henry Mall
12:45 - 1:25	Associate Dean, CALS: Richard Barrows Associate Dean, L&S: Herbert Wang
1:25 - 1:45	Break
1:45 - 2:15	Zoology Instructional Program Manager: Sharon Kahn
2:15 - 3:15	Course Faculty: David Baum, Seth Blair, Robert Bohanan,Grace Boekhoff-Falk, Janet Branchaw, Miles Epstein, Donna Fernandez, Steve Gammie, Linda Graham, Yevgenya Grinblat, Bob Jeanne, Rick Vierstra, Doug Rouse
3:15 - 3:45	Other Course Coordinators: Cindee Giffen, Brian Manske, Brian Parks, Carlos Peralta, Rebecca Seabul
3:45 - 4:15	151 /152 Students: Michael Ahn, Oladeji Amoo, Leann Barden, Lisa Christianson, Adam Clements, Lindsay Davis, Michelle Fischer, Leah Gillett, Megan Gussick, April Hartwig, Mitchell Hayes, Brendan Hodis, Jennifer Lachowiec, Anne Lovell, Molly Lowndes, Joe Maki, Tom Mand, Dan Matson, Erika Mikulec, Yia Moua, Derek Powell, Margaret Rosen, Katelin Shields, David Tillman, Matt Traas, Nate Truckenbrod, Sarah Vande Zande, Tyler Wittkopp
4:15 - 4:30	Break
4:30 - 5:30	Edgar Spalding and Monica Turner

6:00 - 10:00 p.m. Committee meets to discuss report outline. Best Western Board Room.

Appendix 3: Comments on Self Study

Every course should be designed with three elements in mind:

1) Learning outcomes/goals.
2) Activities designed to meet those goals
3) Assessment of the effectiveness of the activities in meeting the goals.

Accordingly, this appendix is divided into three sections that address each of these elements.

Items referred to by page are from the "Self-study, 2004-05 Academic Year" submitted on August 1, 2005.

I. Learning outcomes/goals

A. General goals

1. On page 3, the stated course goals indicate that, "Introductory Biology 151-152 will provide students with a solid foundation in the fundamental concepts and knowledge base of modern biology and help students develop the skills that are integral to the process of science." These are certainly good goals, but it is difficult to assess whether goals of this nature have been achieved. This type of statement needs to be followed by more specific, tangible goals that can be associated with specific activities and assessments. For example, the instructors may decide that every student who has taken 151-152 should understand the difference between transcription and translation. It is easy to imagine class activities that would be designed to address this goal, and methods of assessment. Furthermore, the assessment could extend beyond this course in the form of a longitudinal study if the goals are very well defined. Goals such as "develop the skills that are integral to the process of science" are very difficult to assess.

2. On page 3, the stated course goals include, "…prepare students for their upper-level courses." First, do the upper division courses rely on, or follow through with, information covered in 151-152? That is, are 151-152 doing a sufficient job of covering the material that upper level courses do not have to repeat this information, but rather can build on it? Second, has there been any objective assessment as to how well these goals are being met (see comments about assessment in section III). Third, the design of an introductory course to prepare students for upper level courses is a fundamentally backward way of thinking. The introductory course should not be retro-designed to meet the needs of some other course. The introductory course is the first one in the biology curriculum and it should be designed independently of other courses. The introductory course should cover the topics deemed appropriate, at the depth deemed appropriate. Only after this course is designed can any other courses be considered, and the latter should build on the introductory course.

3. The issue of upper division preparation comes up again on page 29. When evaluating 151-152, the upper division instructors had a common theme in suggesting, "…more

math, quantification and analysis should be taught in introductory biology courses." This issue is brought up again on page 31, "What courses students take after 151-152 should be one of the factors in the decision about which topics to emphasize." It is not necessarily a question of how the introductory course fails to prepare students for later courses, but rather a failure of these later courses to adequately integrate with the material covered in the introductory course. Looked at another way, the introductory course may feed into several upper division courses. Hence, it would be essentially impossible to meet the demands of each of these courses. That is, there may be a need to cover more genetics to better prepare the students for upper division genetics. On the other hand, there may be a need to cover more biochemistry to better prepare the students for upper division biochemistry, and so on. But it is not possible for introductory biology to meet the full demands of a range of upper division courses. The introductory course comes first and for this reason it is a mistake to look back from upper division courses and attempt to modify it. Instead, the upper division courses need to be redesigned to fit with the reality of the introductory course. Obviously the introductory course can be modified; however, the best approach would be to decide objectively what should be covered in the introductory course, essentially independent of existing upper division courses. The decision as to what to include in the introductory course can be based on "planned" upper division courses and can incorporate input from the appropriate upper division instructors, but the introductory course should not be designed around, or overly constrained by, other courses if the sole reason for the design is that these other courses exist. The problem is that most courses in existing curricula were designed many years ago and may themselves be in need of significant revision. Once the introductory course is designed, the next course in the curricular sequence can be designed, or redesigned, and it should be based on what is covered in the introductory course, not vice versa.

Page 33 continues along these lines. "The conclusion is that two semesters are just about right. Extending the course to three semesters or two years would cut significantly into the number of upper level courses that the students can subsequently take." It may be that two semesters are the right length, but not for the reason indicated. The introductory course should be designed along sound pedagogical lines. It should take as long as needed to meet the agreed upon learning goals. The time that is left can then be used to take other courses that follow from, and depend upon, the introductory course. A perceived need to take a certain number of upper level courses should not drive the design of the introductory course. If the introductory course is good, and not just one more requirement, it may eliminate the need for some of the upper level courses.

4. On page 7, under "Course Goals and Objectives" is the statement, "Scientific understanding builds on historical knowledge, which includes both factual information and the process by which those facts were discovered." This may be an innocuous statement, but what is meant by, "the process by which those facts were discovered"? Does this mean the inclusion of historical information in the introductory course? For example, is a lecture on the Meselsohn-Stahl experiment the way to convey "the process by which those facts were discovered?" The Meselsohn-Stahl experiment was elegant. Unfortunately, having students learn it as one more set of facts probably does little with regard to their understanding of how scientists think. The scientific method cannot be "taught" in this manner, but rather has to be learned.

5. On page 8, and in the accompanying syllabi, there is a brief indication of the range of topics covered in these courses. The wide range is perhaps one of the reasons for the perceived need to have experts teach this material (see section II below). One concern is that there is too much material being covered. That is, there seems to be an overemphasis on breadth, and inadequate consideration of depth. In fact, the documents discuss the need to cover all topics including those that the students might not be exposed to elsewhere. The issue of breadth versus depth is of course a common one; however, if breadth has won out here, does this fit with the learning goals and is there any assessment to justify it? It may be more important to focus on fewer topics and ensure that the students truly learn that material, even if it means a lack of exposure to other topics. There are always more topics being added to biology as we expand our knowledge, so it will be impossible to keep up if the goal is to cover "everything." Finally, there is little value in having students learn vast amounts of information if they do not learn how to apply information in solving unknown problems.

   This issue comes up again on page 31 where the choice has been made, "The course favors comprehensiveness, although time constraints prevent it from being complete—for example, behavior and development are not adequately covered." Of course it is impossible to cover everything, and that is why it is a mistake to choose comprehensiveness—a single course can never hope to cover everything and there is no need to. That is, at this time we already know too much biology (and more knowledge is being gained everyday) to cover it comprehensively in the introductory course. Accordingly, it would be better to show students how to continue to learn after they have left the course, rather than trying to expose them to as much knowledge as possible.

   On page 32 is the interesting statement "There is often a discussion about the relative merits of teaching "concepts" versus "facts". In biology this is a hollow issue." What is the reasoning behind this statement? Most introductory courses seem to focus on facts, as though the particulars were of great importance. In reality, we do not want a group of students whose heads are filled only with facts. There is little value in memorizing the solutions to problems that have already been solved. Instead, we want to educate students in such a way that they are prepared to solve unanswered problems after they leave the university. To do this requires coverage of concepts in depth, not memorization of a breadth of facts.

   Once again on page 33 is the issue of faculty expertise. In this case, the point is made that a non-expert would, "…probably have not kept up with recent developments in the field…" Conversely, it may be worth considering whether or not the people designing this course have kept up with the pedagogical literature. Are the students learning the material? Is it critical in introductory biology that students be taught the latest results coming out of research labs? Why do undergraduates in introductory biology need to know "recent developments" when they often leave introductory courses without a clear understanding of the fundamentals? Finally, most people do not like to learn information just for the sake of it; they want the information when they need it. How much effort is going into demonstrating to the students the relevance and value of the information being covered?

   The concerns being raised are not just theoretical. To quote from a former 151-152 student who responded to the evaluation committee: "…the professors seemed not to

care about the students. They sped through PowerPoint lectures creating an atmosphere that discouraged asking questions during lecture. The professors never asked the students or used any measures to be sure that the class understood the material."

II. Activities designed to meet learning outcomes/goals

A. Format

6. On page 8, it is stated, "Lectures are typically oral presentations…" On page 31 is the subheading, "Lectures: should they be replaced? No!" This is followed by, "A good lecture organized into a story line that makes sense and is true, is an indispensable teaching tool." Certainly lectures can have some value, but not as described or implied by this statement. In 2005, the NAS/HHMI Summer Institute on Undergraduate Education that was held at UW-Madison was focused on active learning strategies. Some important conclusions that could be drawn from the Summer Institute or from the pedagogical literature would suggest that lecturing/note taking is a form of passive learning and is not the most effective way for students to learn.

   From watching sample videos of 151-152 it seems that many of the problems inherent in the lecture format are present in these courses (which is true of most lecture courses). For example, there is primarily a one-way flow of information from the instructor to the students. This approach does not fit with constructivist theory or with "Principles for Good Practice in Undergraduate Education." There was very little interaction with the students and essentially no student-student interaction, even though the latter is one of the best ways for students to learn.

   Page 32 continues with the statement, "The most important thing a teacher can do is to convey enthusiasm and a passion for the topic." First, who decided this is the "most important thing"? Second, passion may be one of the most important things that an instructor can bring to a classroom; however, it is not necessary to lecture to demonstrate passion and an interest in the subject.

   On page 35 is the statement "The lecture exam format has evolved over the years to the point where it is probably an immutable fixture of the course." Unfortunately, the lecture format may be one of the fundamental problems with the course. If the instructors are truly interested in developing a worthwhile course they need to be open to alternative formats. For example, the theory of constructivism suggests that learning requires constructing new knowledge by building on, or reshaping, prior knowledge. Everyone brings prior knowledge to the classroom, and learning occurs when this prior knowledge conflicts with new knowledge during discussion. If prior knowledge and misconceptions are not considered, effective learning will not take place.

7. Page 18 refers to sample PowerPoint lectures. Do many faculty members use PowerPoint for their lecture presentations? If so, is there any assessment that verifies the value of this approach, or more importantly, verifies that it is not a terrible way to teach? Again, the pedagogical literature contains many examples of problems inherent in the use of PowerPoint. The *Practicing Biology Workbook* is brought up on page 18. Do people use this workbook when they teach?

Based on the videos, there is concern that the use of PowerPoint is problematic. An instructor was observed putting up a PowerPoint slide, writing on an overhead transparency and talking all at the same time. The students likely find it difficult to know where to focus, and impossible to think while attempting to write down all three forms of information. Also, it is very difficult for the students to reproduce in their notes images from PowerPoint slides.

B. Staffing

8. On page 4, there is a brief discussion of course format alternatives. A big point is made here, and again on page 26, of the fact that the courses are taught by "experts" in the corresponding disciplines. For example, "One strong conclusion is that professors teaching material close to their area of expertise is a strength of 151-152." Is it really important that experts be teaching at the introductory level? It may be much more important that the courses be taught by people who are "expert" in, or at least familiar with, current thinking in pedagogy. How do people learn in general? What is the best way not to teach, but to help students learn? One potential problem with experts is that they are too familiar with the material, and do not understand why those outside of the field have difficulty comprehending the information being covered. Another potential problem is the desire to share too much knowledge, rather than an amount that is appropriate for the target audience.

   Again, to quote from a former 151-152: "They also lectured at a level far beyond our understanding, as if they had no idea how to relate to the understanding level of most of the students…we (the students) were told that we should be appreciative that these professors were giving their time to teach us…It was clearly evident that these professors were very intelligent and successful researchers; however, it also became clear to me that just because someone is a world-renowned researcher they are not necessarily an effective teacher."

9. On page 8, it is indicated that the course is team taught by three faculty members. The documents make a point about the problem of finding sufficient faculty members to staff the course; however, there was not much consideration of the value, or lack thereof, to the students of changing instructors twice during the course. This issue comes up again on page 32. The discussion of this topic is focused almost entirely on the administrative or faculty members' point of view; there should be greater consideration of the pedagogical implications.

   From a student: "There was a monumental difference in the facilitation of learning between professors and their teaching styles."

10. On page 11, the point is made that the Botany and Zoology departments alone cannot meet the demand for faculty lecturers. To evaluate this contention it is necessary to have more information on the teaching loads of the faculty members. The faculty members participating in this course are only teaching 15 class hours. In itself, that is not a high teaching load.

C. Discussion sections and laboratory

11. On page 9, the discussion sections are mentioned. For example, "…discussion exercises are often designed to facilitate integration of concepts…" Are there any evaluations (objective) that demonstrate the value of the discussion sections? One problem is that the value of the discussion section is highly dependent on the quality of the TA, and this is extremely variable. In addition, on this page it is suggested, "Discussions also provide students with regular feedback on their progress…" Good practice in undergraduate education requires frequent feedback, much more than can be provided in a discussion section that meets once per week.

    On page 38, alternatives are discussed including the possibility of case studies and optional discussions. Interestingly, the concluding question is, "Do we even need discussion then?" That is a good question. What is the value of the discussion sections? The value of the discussion sections may be dramatically reduced if the students are practicing active learning in the classroom. In that case, there may be little need for lecture review in the discussion sections. Why exactly do the students need lecture review? Is the material that difficult, or rather is the problem that the students are not forced to keep up or study, and as a result the lectures do not make sense? Reviewing the lectures in discussion section will not solve this problem.

12. Page 9 is the first place where the independent mentored research in brought up. This is the most outstanding part of 151-152 (technically in 152). On page 28 it is noted that 152 not only puts more students into research labs, but also increases the likelihood of them continuing with research. However, there is concern about potential discrepancies between the ideals of the mentored research and the realities. The students who undertake mentored research are expected to carry out an independent project and then write a report. It is not realistic to expect a student with no prior research experience outside of the laboratory component of a course, who devotes six to ten hours per week to the mentored research, to be able to carry out this type of work in one semester. Much of the burden of critiquing the reports falls on the graduate students who directly supervise the undergraduates. It might be possible to get greater faculty participation, and to make this a more meaningful experience, if the goals were modified to focus on learning a technique (e.g., western blot, PCR, cloning, immunoprecipitation, etc.) and understanding how it fits into the experimental goals of the laboratory rather than supposedly carrying out an independent project.

13. On page 26, the point is also made about the unique feature of providing a research experience in the curriculum. The mentored lab experience is an exceptional feature of 151-152; however, if this opportunity is available, should the labs in 151-152 focus on practical issues to better prepare the students for the mentored research? If the mentored research is working as it should, that is where the students are truly learning the scientific method, how to ask questions, design experiments, interpret results, etc. Perhaps the course labs should show students how to use a Pipetman, how to do serial dilutions and measure cell cultures with a spectrophotometer, etc. There could also be discussions of the purpose of controls and how to do them, and possibly other topics such as forming a testable hypothesis.

14. On page 4, the issue of laboratory prep space in broached. A question that is not addressed in the documentation is whether the laboratory is worthwhile, at least in its present form. The laboratory is very expensive, and if it is not meeting its learning goals, it should be modified or eliminated, not expanded. How well does the laboratory work when it is trying to serve approximately 800 students a term? Does every student in 151-152 need to take this lab? Based on page 28 and from reading the student comments, the laboratory is not popular. It would seem a waste of resources to be running a lab if it is going to be viewed in this way, and if it is not meeting its stated goals. The students should want to take the laboratory because it is worthwhile.

15. On page 21, under "Facility and Instructional Resources" is the point, "…lab and discussion space are the primary limiting factors on student enrollment…" One approach is to increase both; however, the question must be asked as to whether these are worthwhile (at least in their current form) prior to simply expanding them. If this has not been assessed, there is no justification for spending more money to expand them. The comparison with Biocore makes it clear that more funds are being spent per capita on the students in that program; however, this may make sense. Resources are limiting and it may not make sense to spend them on students who do not want the lab or on a lab that is not meeting its learning goals. Without assessment of these points, the comparison chart between Biocore and 151-152 is essentially meaningless. Neither program deserves continued funding without verifying its success. Per capita is not a sufficient rationale to justify greater funding; only success in meeting learning goals can be a justification.

    Along these same lines, page 23 notes a problem with office space for TAs. One solution is to find more space; however, another solution is to reduce the need for TAs by using active learning in the classroom.

III. Assessment

A. General issues

16. Page 19 talks about course assessment and evaluation. The primary method of "assessment and evaluation" used in 151-152 is student evaluations. Such evaluations are obviously inadequate. Student evaluations are totally subjective; what is needed are objective measures of success in meeting the learning goals. On page 40 are two telling statements: "Students are not necessarily educated consumers" and that for them to provide meaningful evaluations "…requires a certain degree of maturity and reflection." In general, students do not have the maturity or experience to evaluate the course. In addition, they cannot fully appreciate the value of the course, or lack thereof, until they have taken upper division courses or otherwise been in situations where they need to rely on the information conveyed in the introductory course. Finally, there should be peer (faculty) evaluation in addition to objective assessment.

17. Grade distribution is also brought up on page 19. The reason for discussing this was not clear. That is, what is the conclusion from the grade distribution that is reported? The topic of grading does bring up important issues: How is grading done, on a curve or on

an absolute scale? What is the goal in terms of course grades? The report presents averages, so is there a desired average? The goal should be 100% "A" grades. That is difficult to achieve, but ideally all students would have learned the material well enough to get an "A" grade. This means that it is not appropriate to use a curved grading system.

18. On page 27 the report states, "The charge of our subgroup was to determine how well we are preparing students to take upper level courses. We realized that there would be two useful approaches…The first approach was to ask students who are taking upper level courses how well they feel 151-152 prepared them." To ask students how they "feel" the courses have prepared them is completely inadequate as a means of evaluating the 151-152 courses. There is nothing wrong with gaining a sense of how the course is perceived by the students, but this cannot substitute for an objective evaluation. Similarly, on page 29 there is an attempt to explain the low scores given for the lab component of 151-152 that includes the statement, "…the perception of decreased lab preparation for upper level courses." Relying on "student perception" is not adequate in terms of assessing the value of the lab courses.

    The second approach at assessment was no better than obtaining student evaluations as this "…was to ask instructors of upper level courses about strengths and deficiencies that they regularly observe in their students." First, this is not objective. Second, the report points out that there is no way to even differentiate among students who have taken 151-152 or other courses on this or other campuses! What is the value of obtaining this information if it has no way of even answering the question being asked? That type of information can be less than worthless, as it can be misleading. Furthermore, from page 29, the instructors, "…rated student preparation between a B and F grade." This suggests a need to be thinking about issues other than the need for prep space and more office space—something needs to be done to improve these courses.

19. On page 34 it is revealed that, "The primary assessment tool in the lecture portion of the course is the use of three 90-minute examinations." In addition, these exams are machine graded. The people who support this mechanism of assessment are not following good practices. These exams are summative with essentially a sole purpose of assigning a grade. It is better to have exams that are also formative, and are part of the learning experience. How long does it take to grade and return the 90-minute exams? Usually courses have moved on to an entirely different topic by the time these large exams are returned. In the meantime, the instructor has continued to lecture without knowing whether or not the students have mastered the previous information. Similarly, the students have not received any feedback that would indicate whether their preparation and understanding of the material has been adequate. Finally, these types of large, infrequent exams encourage cramming, not active learning.

    Studies on learning and memory show that material is retained better when there are frequent exams. Interestingly, students do not perform better on exams by simply rereading the notes or text repeatedly. Instead, they perform better if they read the material and are then tested on it, followed by a subsequent reading, which allows them to focus on material that they did not know. That is, frequent exams (possibly in the form of routine quizzes) are more effective at promoting learning than a small number of large tests.

The paragraph on "Issues" raises many valid concerns about the current method of examination. For example, the inability to develop higher order thinking by relying on multiple choice questions, the focus on "will this be on the exam" by the students, and the problem with cramming. Unfortunately, the proposed solution is to offer a comprehensive final exam. These are fundamental problems that will not be addressed by instituting a comprehensive final exam. Rather, there needs to be a radical change in the course design. The students will not learn the material if they do not keep up and study on a routine basis. It is likely that the instructors are fully aware that the students come to class unprepared. It is largely a waste of time to lecture to students who have not taken the time to read the assigned material. It is also impossible to build on previous material because the students have not yet learned that material. The students must be forced to keep up by engaging them in active learning.

One reason for using Scantron exams is, "With class sizes of 200-300 students, essay exams are not a viable alternative…" They may become a viable alternative if TAs are freed up from discussion sections that are not worthwhile, and instead are used to grade exams.

From a former student: "…when the exam results showed that most of the students were far from understanding the material…neither professor addressed this as a problem or made any effort to remedy it…I feel that there are many intelligent, successful researchers here that need vast instruction on how to effectively teach, especially to a large lecture. Interaction with students during lecture, I feel, is imperative for the learning of the students and for keeping the teacher conscious of the progress or lack of progress of the students in learning the material…I feel that multiple-choice tests are not an accurate test of students' understanding of subject matter…make the exams a mix of testing methods (i.e., a mix of multiple-choice, true/false, short answer, etc.) to allow for the exams to hit on the learning styles of all students rather than the few that learn best through memorizing, which is essentially what multiple-choice ends up solely testing."

Conclusions

The way in which 151-152 are currently run is not substantially different from the way introductory biology courses are run on most.

1. **Learning outcomes/goals**

   There appears to be a lack of understanding as to what constitutes a reasonable goal. This is probably because the goals were not developed in conjunction with activities and assessment. In addition, there needs to be an understanding of the difference between teaching and learning.
2. **Activities**

   The main format used in these courses is lecturing, which is not considered to be an effective way for students to learn. There needs to be a shift to active learning.
3. **Assessment**

   It is probably in this section where there is the most complete disconnect between the way in which the instructors of 151-152 approach teaching versus research. The former has

been evaluated with methods that are essentially subjective and are totally lacking in controls.

Recommendations

1. Decide on course goals.
2. Conduct objective assessments to determine whether the course is meeting those goals.
3. After obtaining the above assessment information, institute an alternative approach. We recommend an active learning approach that requires the students to keep up, that minimizes lectures, and that uses frequent quizzes as a learning aid and also provides a means of assessing student comprehension in a timely manner. This may initially be done on a small scale and then expanded if the results indicate that this approach is better.
4. Repeat the assessment to determine whether the revised course is doing a better job of meeting the learning goals.

Additional changes may be warranted depending on the outcomes from objective assessment including elimination of the labs, or revision of the labs to better prepare students for mentored research. In addition, elimination of discussion sections that repeat/review material covered in the lecture may allow the TAs to be utilized for more worthwhile efforts.