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In 2000 the Department of Biology at Centenary College of Louisiana abandoned the teaching of Biology 101 and 102 (*Principles of Biology I and II*) in a traditional lecture-laboratory format and created two new courses, Biology 101 (*Principles and Methods of Biology*) and Biology 202 (*Structure and Function of Organisms*) taught in studio format. The studio-format model integrates lecture and laboratory material into a seamless classroom experience in which students have an opportunity to learn using multiple modalities.

We chose to convert our introductory classes to this format for three major reasons:

- Dissatisfaction among students with the traditional format demonstrated by complaints on teaching evaluation forms and loss of students to other introductory science classes
- Disparity in college preparedness among students which led to diverse attitudes and abilities among students in the course
- Desire of the biology faculty to raise the science competency of both science and non-science students to an approximately equal level.

Our goals for the courses were to:

- Teach biology as a process
- Use hypothesis-driven, guided-inquiry laboratory exercises
- Incorporate technology into the learning experience
- Generate a high level of competence and interest among all students in the course.

Course Design

- Two weekly sessions of 2 hours and 45 minutes (330 minutes / week)
- Each section of the course is limited to 24 students
- The course is open to all students, regardless of year in school or major
- Classrooms are designed to accommodate both lecture and group laboratory work (Fig. 1 and 2)
- Ten-point short-answer quizzes are given at the beginning of every period (except on test days)
- Students take five examinations plus a comprehensive final exam (combination of objective material, short essays, and practical material)
- Groups of four students design and complete independent research projects that is presented orally to the class at the end of the semester
- Topics covered in *Principles and Methods of Biology* were deliberately narrowed to include “universal phenomena”; i.e. phenomena that occur in most, if not all, prokaryotic and eukaryotic organisms (Table 1)



Figure 1. Design of studio-format classrooms. Six tables face a whiteboard and projection screen.



Figure 2. The semi-oval table design is conducive to collaborative group laboratory work.

Table 1. Topics covered in Biology 101, Principles and Methods of Biology. Topics are listed in the order in which they are presented in the course.

Topic	Number of class periods
Life, scientific method, organic molecules	4
Cell membranes, movement of molecules	2
Cellular respiration	1.5
Photosynthesis	1.5
DNA replication, protein synthesis	3
Cell division	1
Molecular techniques, biotechnology	1
Inheritance	3
Population genetics	1
Evolution	2
Biodiversity	6
Ecology	2

Results

When first developing this course, we hoped to 1) lower the high drop rate that was inherent in the course and 2) replace time spent lecturing with additional time for students to engage in hands-on, minds-on activities. During the first year that the course was taught in studio format, a senior biology major attended every class and recorded the amount of time spent in different activities (Table 2). We also recorded the number of students dropping the course for academic reasons and compared the data to previous years when the course was taught in the traditional lecture-laboratory format (Fig. 3). When drop rates from the years 1996-1999 (traditional lecture and laboratory) are compared to drop rates from seven years of studio-format teaching, there is a significant decrease in rates after the advent of studio-format instruction (ANOVA; $F_5 = 11.13$; $p = 0.009$) (Fig. 3).

Lecture	31.0%
Laboratory activities	43.4%
Other (Q & A, testing, breaks)	25.6%

Table 2. Percent time spent in different activities in a studio-format course meeting continually for 165 minutes.

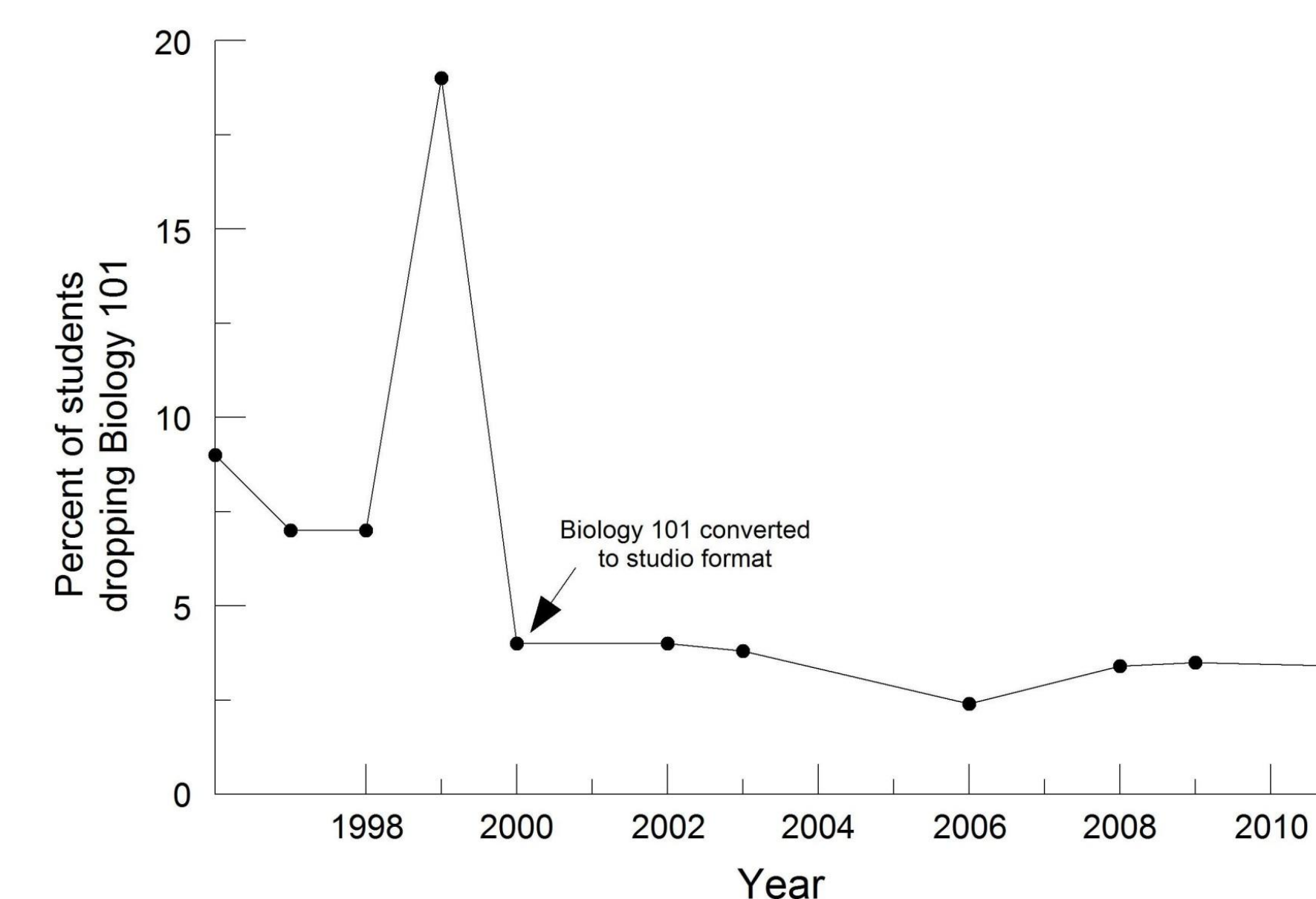


Figure 3. Percent of students dropping Biology 101 when it was taught as a lecture-laboratory course (prior to 2000) compared to percent dropping after conversion to studio format (after 2000). Data for some years are missing.

Student Satisfaction Survey

We initiated a student satisfaction survey in 2002, two years after Biology 101 was converted to studio format. No data on student performance and/or satisfaction had been maintained by the department prior to 2002, so we are unable to compare the data to satisfaction with a traditional lecture-laboratory course. As the studio-format course evolved (e.g. changing textbooks, not using a textbook, adding a student-response system), some of the questions on the survey changed. Therefore, we are reporting on a core of six questions asked of the students each time the survey was distributed (2002, 2003, and every other year since 2003) (Fig. 4). The survey was distributed at approximately mid-semester and linked with a quiz so that we received 100% return rate on the survey. Data were then collated, and averages and standard deviations for each of the questions were calculated. Students generally indicated high satisfaction with course content and structure regardless of year. There were no significant differences in satisfaction score among years or among characteristics (Fig. 4). The scores ranged from a high of 3.8 (out of a possible 4) in 2005 for Integration of Lecture Material with Laboratory Exercises to a low of 3.12 in 2002 for Lecture Content. Overall the scores were lowest in 2002, the third year of teaching the course in studio-format style, but they have remained consistently high for the past decade.

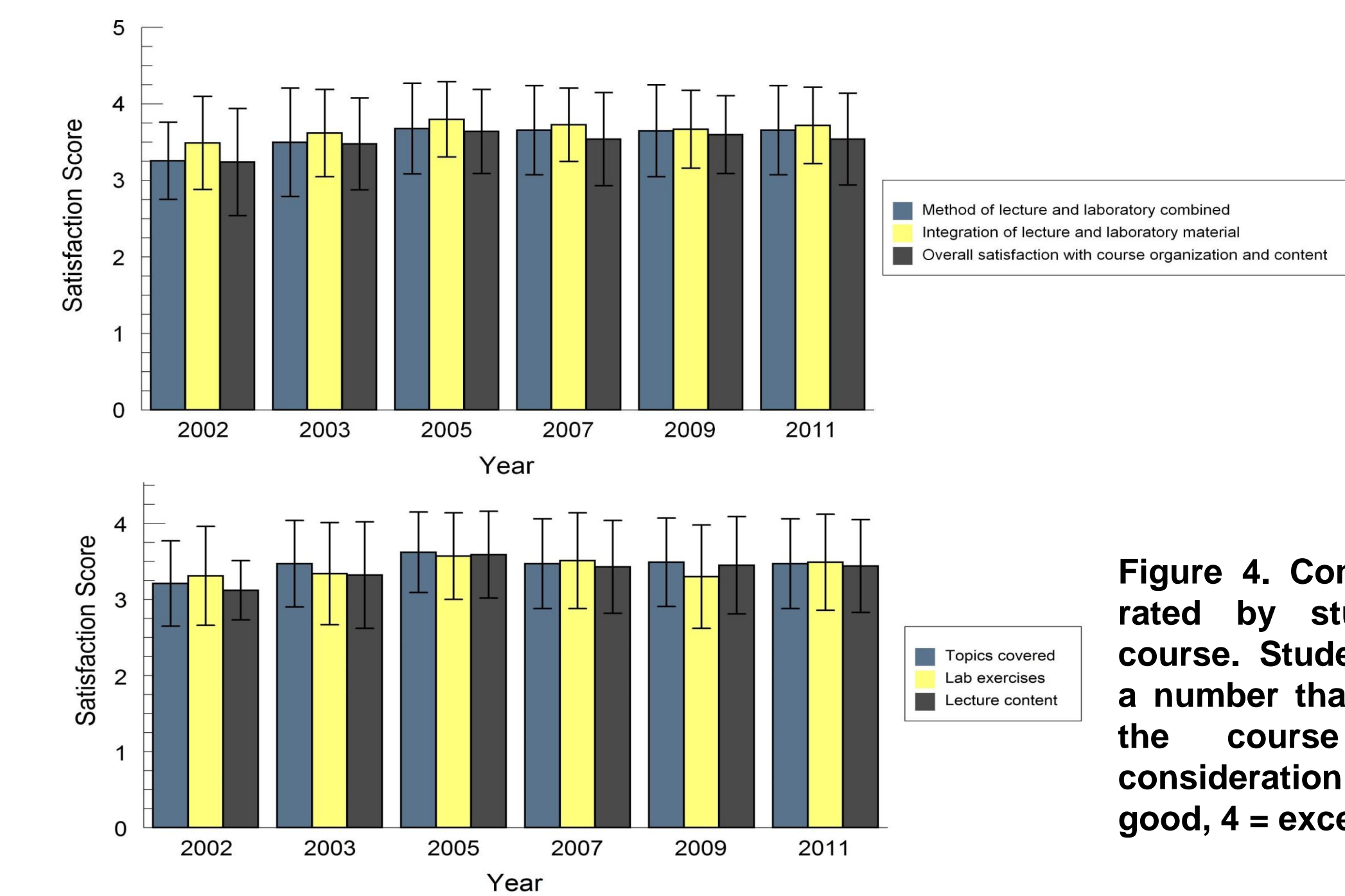


Figure 4. Components of Biology 101 rated by students enrolled in the course. Students were asked to choose a number that best fit their opinion of the course characteristic under consideration (1 = poor, 2 = fair, 3 = good, 4 = excellent).

Discussion

Centenary College requires all students to take a science course with a laboratory component as part of the core curriculum. Biology 101 has the highest enrollment of all the introductory science courses. Usually the six sections of the course offered every fall fill by the end of registration. We believe that one reason the course is so popular is due to its studio format design. The results of the student satisfaction survey indicate that students view their experience in the course in a positive light, and, anecdotally, student comments support the quantitative data (Table 3).

Table 3. Student comments about Biology 101. Students were given space on the satisfaction survey to add comments if they wished. Comments were taken from different years (2002, 2003, 2005, 2009, 2011).

“I like the fact that the lecture is combined with lab because I am able to learn visually and hands-on at the same time.”
 “I’m not really good at biology but this class style has helped me pay attention.”
 “I am very satisfied with this class and feel as though I am learning more in this class than in other classes with labs.”
 “I liked having a lab to support the material as we go over it. This works really well.”
 “I liked the integrated lab and lecture. It helped to be taught something and immediately be able to apply it.”
 “I love the way this class is taught. It’s all inclusive which makes it easier to follow, instead of two separate classes.”

Although the studio format may be an instructional method attractive to students, its effectiveness in improving biological literacy and critical thinking has not been fully demonstrated. For example, performance of students completing a larger (80 students/section) studio format class at Kansas State University did not differ significantly from students in traditional lecture-laboratory sections of the same course (Montelone *et al.*, 2008). To test critical thinking skills of students in the Centenary Biology 101 course, we began administering the Experimental Design Ability Test (EDAT) three years ago (Sirum and Humburg, 2011). On the first day of class students are given a prompt about designing an experiment and allowed 15 minutes to write a response. Students are then given a similar post-test on the last day of class, and the two responses are scored on a 10 point scale (see Sirum and Humburg, 2011 for additional details). Our results indicate that completion of Biology 101 significantly increases student performance on the EDAT by an average of 0.68 2.17 points (Students t-test; $p < 0.0001$). Additionally, when sections of the course are grouped based on pre-test scores, students in sections demonstrating a weaker initial performance (defined here by an EDAT score of < 2) increased their post-test score by an average of 1.91 1.76 points. This is a significantly larger increase than that observed in the stronger sections (0.44 2.17; $p < 0.00001$). Given that one of our objectives was to raise the performance of both science and non-science students to approximately equal levels, these data suggest that we are accomplishing this while making the course palatable to a wide variety of students.

LITERATURE CITED

- Montelone, B.A., D.A. Rintoul and L.G. Williams. 2008. Assessment of the effectiveness of the studio format in introductory undergraduate biology. *CBE—Life Sciences Education* 7: 234-242.
- Sirum, K. and J. Humburg. 2011. The Experimental Design Ability Test (EDAT). *Bioscience: Journal of College Biology Teaching* 37(1), 8-16.