Learning Analytics: Insights into Introductory Biology

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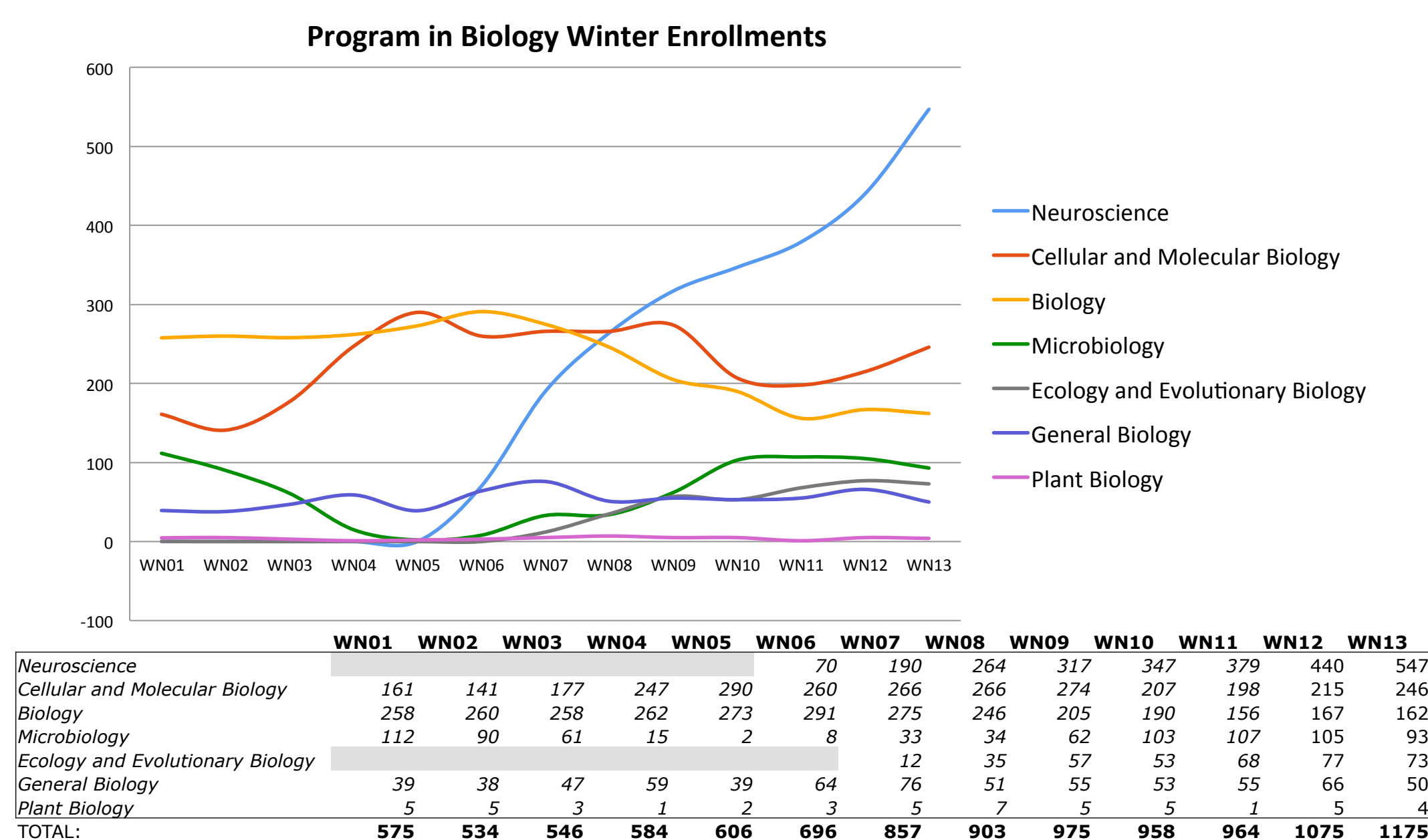
Data from the Program in Biology

Figure 1. The Program in Biology manages six majors and three minors, and works closely with the Undergraduate Program in Neuroscience.

Historical Enrollments in Large Biology Classes

Figure 2. Enrollments in large biology classes during the winter terms are shown. This may not accurately reflect annual enrollments in the intro biology courses. The CHEM 130 prereq. for BIO 162/172 may delay enrollment by a term for many students. The dotted lines are included to show continuity in courses during transitions in 2007-2009.

Range of Grades in Large Enrollment Courses in LSA

Figure 3. Distribution of grades in large enrollment LSA courses compared to student standing determined by cumulative GPA. Data are from the University of Michigan, 1996-2012. These courses were selected for study by the 2013 Learning Analytics Fellows Program. It would be useful to have this data for CHEM 125, to compare with BIO 173, and also for BIO 305, to compare with MCDB 310 and EEB 390.

Course Descriptions for Introductory Biology Classes

Figure 4. There are currently four introductory biology courses: BIO 171 (Intro to EEB), BIO 172/174 (Intro to MCDB), and the integrated laboratory course BIO 173. BIO 171 and BIO 172 are taught in a traditional large-enrollment lecture format, with frequent use clicker questions, student-directed questions, graphics and videos, and relevant examples and demonstrations. Online quizzes are used in BIO 171. BIO 174 is a much smaller course that covers the same material as BIO 172, but uses more group work and problem-solving activities.
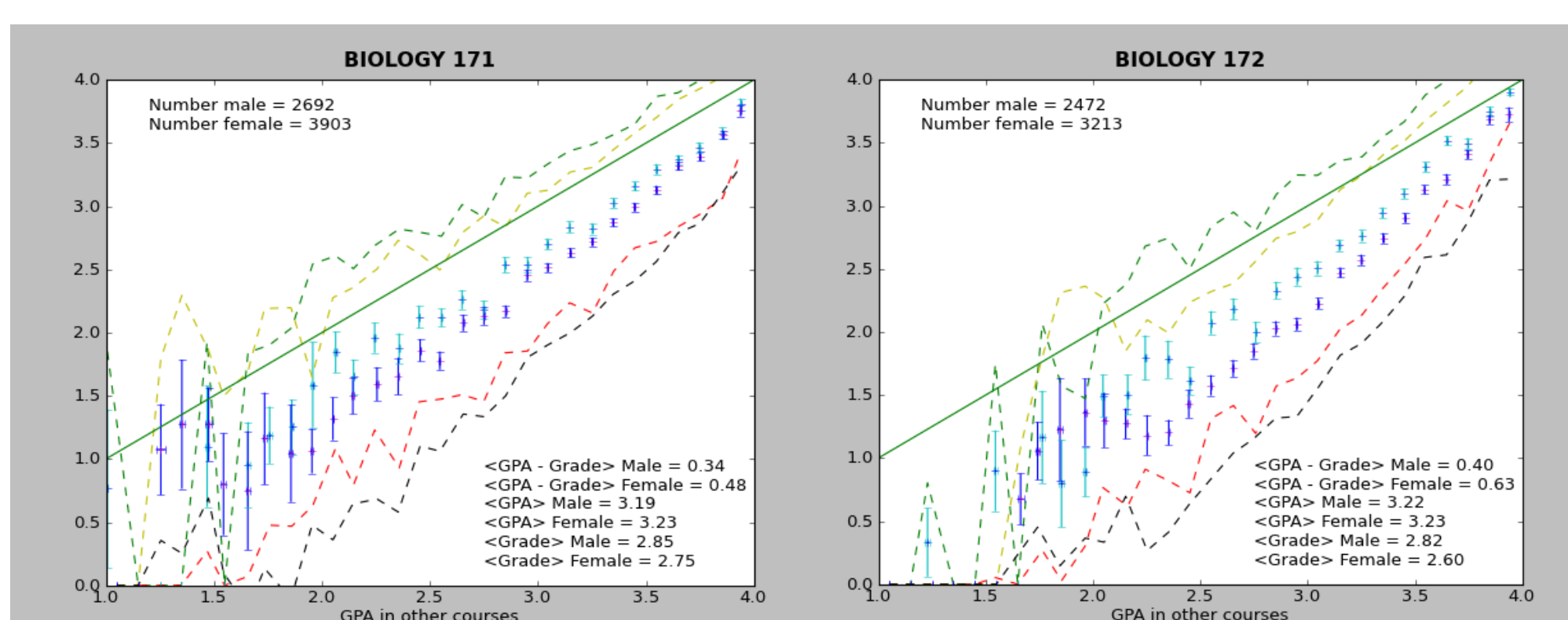
Factors Affecting Performance

Figure 5. Both male and female students experience a grade penalty for taking introductory biology lecture courses. In this analysis, each student's grade was compared to his/her GPA from other courses. The difference (GPA – Grade) is considered the grade penalty for the course. Note that both males and females in both courses experience a grade penalty. The penalty is greater for female students in both classes. Female students have slightly greater overall GPA compared to their male classmates, yet earn significantly lower grades in BIO 171 and BIO 172. The grade penalties and gender differences are slightly greater in BIO 172 than in BIO 171.

Grade Penalties in Other Large Enrollment Classes

Figure 6. Grade penalties for UM classes with enrollments greater than 400 were calculated as described in Figure 5. Note that BIO 171 and BIO 172 are included in the yellow circle of courses with the greatest grade penalties, all with greater disadvantage for females students. BIO 173 (lab) exhibits only a small gender bias and almost no grade penalty.

Role of Sequencing: Does it matter which they take first?

Figure 7. The order in which students take BIO 171 and BIO 172 does not significantly affect their performance in BIO/MCDB 310 (Biochemistry). The figure on the left shows that students do better in whichever class they take second. In fact, it seems that they might do best when taking BIO 172 before taking BIO 171, though this difference may not be statistically significant. These students perform essentially the same in biochemistry (BIO 310 = MCDB 310), whether they took BIO 171 or BIO 172 first.

Follow-up Questions for Further Discussion and Analysis

There are many questions remaining to be asked about the Program in Biology classes, especially with regards to introductory biology. A few are listed below:

1. Where do BIO 305 (Genetics) and CHEM 125 (Gen. Chem. lab) fit in Figure 3? Does CHEM 125 resemble the biology lab course BIO 173? Is the grade range in genetics more like biochemistry or evolution?

2. WHY IS THERE SUCH A GENDER BIAS in student performance in the intro. bio. courses (171/172), as seen in Figure 5?

3. Do we need to address the grade penalties in our biology classes? Can some of that be mitigated by fewer multiple-choice and short-answer exams?

4. Will the sequencing results change when we take into account the term in which the students took intro. bio. and their academic level (freshman, sophomore, etc.)?

5. Does it matter if students take genetics before evolution?

6. Do students with AP credit for intro. bio. do better in the upper-level courses than those who take BIO 171/172? What about students with transfer credits?

7. Does BIO 174 prepare students better for upper-level courses? Do the same grade penalties and gender biases exist for this smaller enrollment intro. bio. course?

Evidence-Based Improvement of Teaching

Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses
Richard R. Hake. American Journal of Physics **66**, 64 (1998); doi: 10.1119/1.18809

Much higher gains *possible* in Interactive Engagement classes, but they're not always achieved. What makes one class work better than another?
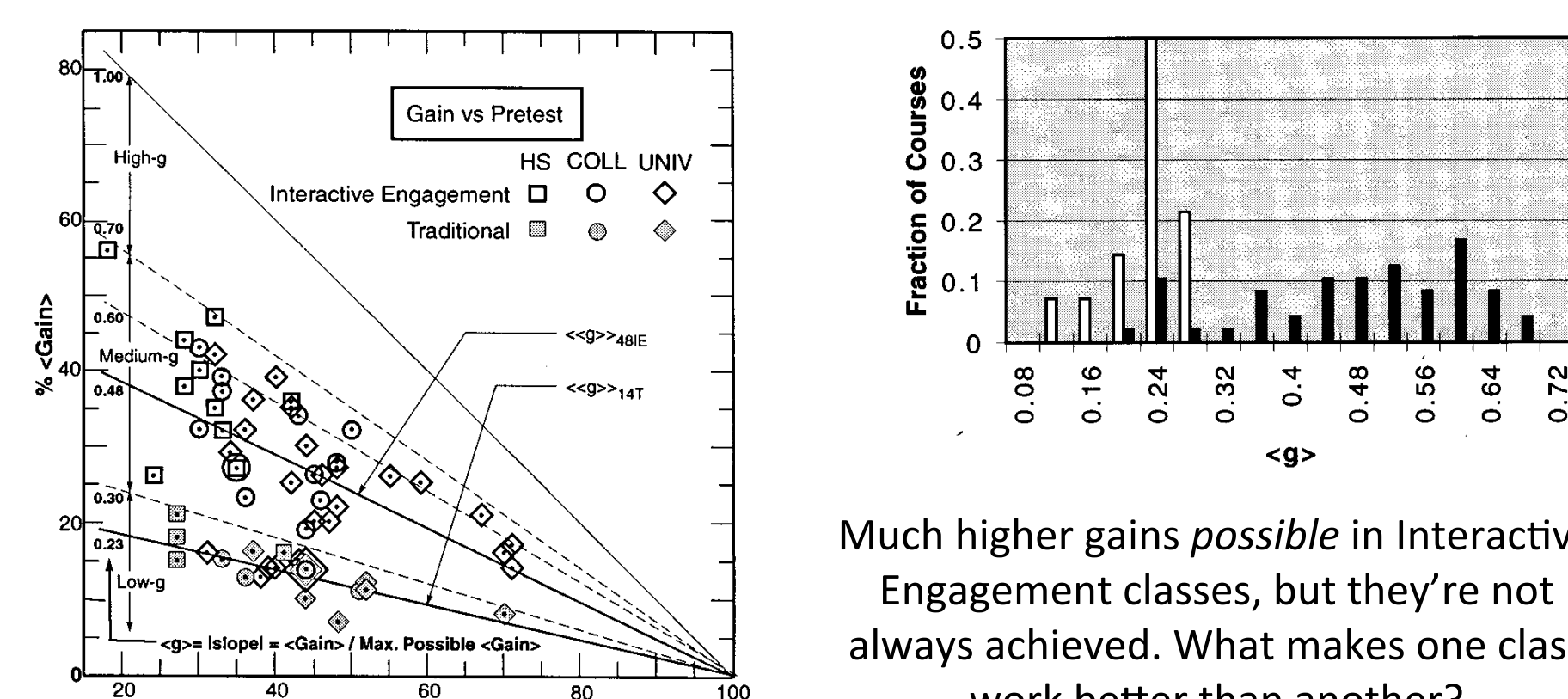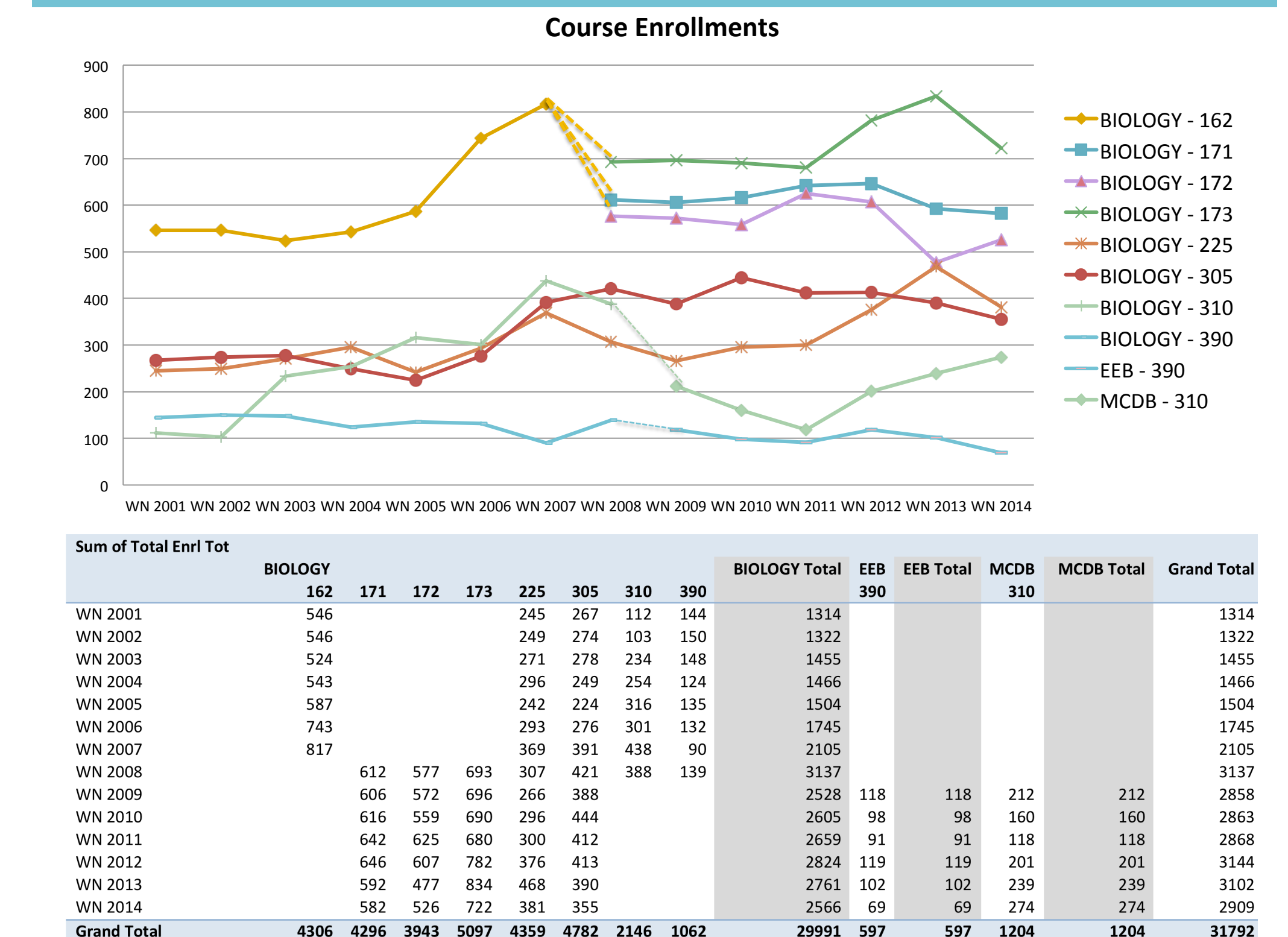
Figure 8. Hake's paper shows that Interactive Engagement (IE) works better than Traditional (T) Lecture style. The figure on the left shows that the normalized gain score for IE courses is 0.48 ± 0.14, but only 0.23 ± 0.04 for T courses. On the right, the white bars show the average normalized gain <g> for the *fraction* of 14 T courses (N = 2084) in each bin, compared to the solid bars from the *fraction* of 48 IE courses (N = 4458) in each bin. In short, **Interactive Engagement works better!**

E^2Coach – Developed at UM; Used in Physics Previously

E^2Coach – using data to personalize education

Expertise of hundreds of students, dozens of instructors and behavior change experts

Detailed information about thousands of students and their current status

MTS

Individually personalized messages: what we all agree we *would* say to each student, if only we could…

The Michigan Tailoring System: a mature open-source software system built in the UM SPH for creating content designed specifically for an individual based on data about that individual

Figure 9. E^2Coach was developed for use in physics, based on a system built in the UM School of Public Health, to provide 'individualized electronic coaching' messages that have been written to improve student success in the course. It includes widgets to help students predict their final grade in the course after each exam and "Problem Roulette," which contains MANY practice problems for the students to do.

Expansion of E^2Coach in Fall 2013

Figure 10. In the Fall 2013 term, E^2Coach was introduced into STATS 250, CHEM 130, and MCDB 310 (Biochemistry), in addition to four courses in physics. These preliminary results suggest that medium to high usage of the tools can improve student performance, especially in stats and biochemistry. We don't yet know if there is a gender difference underlying this data.

Future Reform in Introductory Biology

Researching Evidence-Based Undergraduate Instructional Learning Developments

There are many different types of interactive learning techniques, and much literature about them. The Biology members of REBUILD (Laura Olsen, Ken Cadigan, Trisha Wittkopp) are reading and discussing the papers and reform approaches. Intergenerational reform teams (faculty, postdocs, graduate and undergraduate students) will explore and develop new ways to teach introductory biology courses.

Approaches and extent of reforms will vary, but could include:
1. Continued and expanded use of clickers
2. "Flipped" classrooms, where students are expected to do assigned reading before class, and formal class time is spent doing exercises or problems. This may include the use of podcasts/Blue Review for pre-class preparation.
3. Case-based learning may be implemented for some classes
4. Reading quizzes/ concept quizzes may be developed for online or in-class use
5. Concept maps, concept inventories, etc. may be used.

Assessment will be an integral part of this reform process. Baseline preliminary classroom observations have begun this semester.