Evaluation of Flipped Laboratories in Introductory Biology (Biol 130A)

Research Objectives
This study will provide an opportunity to determine whether the implementation of the flipped classroom format facilitates deeper learning by introductory biology students in the laboratory setting. Pre-lab videos that provide background and instruction regarding each lab will be provided to a subset of lab sections each week in an effort to allow more time in lab for additional active learning experiences for these lab sections. Moreover, this study will allow us to evaluate whether the additional time provided during the laboratory session for additional active learning experiences will provide students with a better understanding of the link between the lab experience and specific conceptual content encountered in the lecture portion of the course.

Significance
This study will allow me to determine if the implementation of the flipped format will facilitate deeper learning by the students in the laboratory setting. Moreover, it will allow me to ascertain whether this approach will provide additional time during the lab to incorporate additional active learning experiences that better link the lab experience to the conceptual content being addressed in the lecture portion of the course.

Currently our Introductory Biology labs follow a standard format wherein a graduate Teaching Assistant begins each lab section with a lecture that contains a review of relevant concepts discussed in the lecture portion of the course, inclusion of any additional new concepts that are specific to the day’s lab experience, and a review of the specific procedures that need to take place to complete the laboratory activities for the day (including any safety items). This lab introduction process can take up to as much as one third of the laboratory period. This often means that students then complete the lab activities often in a compressed amount of time and may or may not have time for a brief review at the end of the lab period. By providing a pre-lab video that includes the content of an introductory lecture, we intend to create more time during the lab period to engage the students in active learning activities that will solidify their understanding more effectively.

The benefits of a “flipped” format have been described in the published literature, however, these applications have typically applied to the K-12 classroom setting or the undergraduate course where lecture-based teaching is the standard. Results of these studies have shown variable effects in different classroom environments, particularly in the sciences. In addition, the use of the flipped approach has not focused on the undergraduate science laboratory setting since it is often assumed that the lab is already an active learning environment. Although this is the case, it has been apparent that one of the shortcomings of many laboratory experiences is the lack of connection between the lab content and the lecture content in the standard lecture/lab science course.

By using a subset of laboratory activities that will be taught in a flipped format in the experimental course Biology 130A, I will be able to examine whether the additional time provided in lab to more actively engage students in connecting their lab experience to the content being taught in the lecture portion of the course will allow the students to achieve a more thorough understanding of these concepts as assessed by standard exam-based assessment. Moreover, by implementing the treatments (flipped format vs. standard format) among the laboratory sections from this course in a single semester, I can generate a more accurate
statistical model that accounts for the specific influence of the teaching format distinct from other variables that typically have a large effects on the variance in performance (e.g. course instructor, teaching assistant, time of day of lab, semester cohort, season). The evaluation on the performance related to the genetics content associated with this subset of labs will provide a concrete basis on whether to more fully implement the flipped format throughout the course or abandon or adjust this pedagogical strategy in future semesters and/or other introductory biology courses.

Background

The Department of Biology at Sonoma State University has engaged in a complete redevelopment of curriculum for the Biology Major. As part of that endeavor the required biology course content for every Biology major has been restructured into a two semester introductory course format combined with a two course upper division core course format. Among these courses introductory content related to genetics has been held together as a key unit in the undergraduate introductory curriculum. The efforts associated with the curriculum changes offer a prime opportunity to engage in more detailed course redesign.

For years, whether in the prior introductory course format or in the new introductory curriculum, a substantial proportion of biology students engaged in Genetics and cell biology content fall below acceptable levels of achievement. For example, the level of Ds, Fs, and withdrawals (DFW) in Fall 2013 taking our introductory Genetics and Cell Biology course was 40%. Because this course serves between 160 to 180 students in a semester, this can produce a large number of students seeking to retake the course. As result, a bottleneck associated with this introductory course creates an impediment in progress towards degree for too many students in the Biology major as well as in other majors (eg. Anthropology, Biochemistry, & Environmental Sciences). Thus, any effort at redesigning the course in Genetics and Cell Biology that may improve student learning has the potential to dramatically impact an identifiable bottleneck in the biology curriculum.

Procedure

Each lab section will be assigned to either a standard format group or a flipped format group. Those in the standard format group will receive conceptual background and procedural instruction regarding each week’s lab activity directly from the graduate teaching associate during the beginning of the laboratory section, students will work through the lab assignment, and students will be provided a set of review questions to aid with their studying after completion of the laboratory assignment at the end of the lab period. Those in the flipped format group will be provided access to a pre-lab video and worksheet that provides conceptual background and procedural instruction regarding each week’s lab activity. These students will be required to complete the worksheet, containing both fill-in and open-ended questions, for the video before being allowed to participate in that week’s lab. Upon completion of the lab, additional lab time will be used for a recitation period where students will be able to work through a series of review questions in a small-group setting and then review with the lab instructor.

For fairness in grading, all students in the lab sections employing the flipped format will be graded as a separate cohort from the students in lab sections employing the standard format. All quiz and test score results for questions related to learning outcomes addressed during the weeks where the flipped format is employed (see Table below) will be included in a separate file.
for the study with all names removed from the data set. Student ID numbers will remain with the data set in case data correction needs to occur. For all statistical analyses, student ID numbers will not be included in the data set complied for the software programs JMP v.11 and SAS v.9.2. A general linear model will be generated to statistically evaluate the effectiveness of the flipped lab format. Impacts of lab format will modeled as a fixed effect on measures of performance from lab quizzes and exams. Treatment variables that include: lab section, teaching assistant, lab time, semester in college, and major will also be included as covariates in order to assess the influence of the lab format treatment on the variance in performance. I will evaluate models based on AIC criteria and significance at an alpha of 0.05.

Comparisons of overall student performance as well as on certain parts of the assessments associated with the experimental phase from this semester will also be compared to performance from students in this course taught in Fall of 2013 (i.e. specific test or quiz questions that are comparable between years). Also, overall rates of grades of Ds and Fs as well as withdrawals will also be compared between years.

Quantitative evaluations of student survey responses regarding student perspectives related to the implantation of the flipped format in the laboratory setting will be evaluated using a 1-4 scale. Standard descriptive statistics will be used to describe the quantitative results related to each query. Qualitative responses regarding the flipped classroom format in the lab will also be collected.

Table 1. Laboratory activities that will be part of this study are listed below:

<table>
<thead>
<tr>
<th>Date (Week beginning)</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Week 9</td>
<td>Genetics Pre-test and Introduction to Lab Format</td>
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<tr>
<td>Week 10</td>
<td>Potato Head Sex (Mitosis, Meiosis, Phenotypes)</td>
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<tr>
<td>Week 11</td>
<td>Drosophila Lab - Mendelian Genetics</td>
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<tr>
<td>Week 12</td>
<td>Virtual Fly Lab – Linkage, Epistasis, &amp; Lethal Alleles</td>
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<tr>
<td>Week 13</td>
<td>No Lab - Holiday</td>
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<tr>
<td>Week 14</td>
<td>Gene Regulation</td>
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<tr>
<td>Week 15</td>
<td>Thanksgiving – Online Assignment for All Students</td>
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<tr>
<td>Week 16</td>
<td>Natural Selection</td>
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</tbody>
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Instruments

Students will take both a pre-exam and a post-exam to assess mastery of the content associated with that portion of the course. Students will also take laboratory quizzes that assess whether students have learned concepts associated with the previous week’s laboratory activities. Students will also use internet technology to access online pre-lab videos. The videos are produced by the professor using Camtasia Studio 8. The laboratory activities that will be used were developed previously and implemented in the introductory biology course associated with genetics for Biology majors the Department of Biology at Sonoma State University during the past 4 years.

Informed Consent and IRB Approval

An Application for Approval of Research on Human Subjects application has been submitted to the Sonoma State University Institutional Review Board. The students will be informed that some weeks they will be using pre-lab videos and other weeks they will experience a standard
lab introduction format. The results of their assessments will be transferred anonymously for use in a broad statistical analysis that includes a statistical model that will evaluate a variety of variables. The variables that will be used in the analysis will be described for them. They will be told that the broad results of the evaluation of the flipped format may someday be included in a publication, but that no association with any specific participants will be made.

We will provide the students with an introduction to the study during lab in week 8. We will provide each student with a written consent form that will allow us to receive written consent on whether to use their results as a participant in the class for research purposes or not. We will only transfer assessment data from the class to the study for analysis for students who have provided written consent. Since the course will be taught using the variable pedagogical approaches as part of the course of instruction, the only aspects added to the student experience by the study are that their assessment results will be part of a broader statistical analysis (and they can opt out of participation).

Data Privacy
All information regarding student performance and responses to assessments are kept confidential as a regular part of the instructional process in accordance with prescribed training the California State University System. The assessment data of each student from the class will be provided to the study data base only according to ID number. Any qualitative response via surveys will collected anonymously. In addition, all analyses will treat results for this study as anonymous data points associated with the variables examined, ID will not be a viable included in any statistical models.