

Biology 202L (Introductory Genetics)

STEM Gateway Course Redesign

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Abstract:

The 202L redesign seeks to improve overall student success in Genetics, contribute to increasing success and graduation rates at UNM, retain underrepresented minority (URM) students in the STEM fields and to promote critical thinking and higher-order thinking in students. The project entails modification of lecture delivery, development of pre- and post-class learning, assessment of student learning at all levels of Bloom's taxonomy and final assessment of student attitudes toward the course design and their learning.

Our project centers around the creation of 202L information “blocks” that are inherent in the structure of the 202L course. These blocks of material were the structure around which all redesigned material was created and this material is centrally located within both a Google Docs file and also a template Learn page, which can be utilized by any instructor teaching 202L in the future.

The redesigned course was partially implemented in the Fall of 2014 and Spring of 2015. It was fully implemented in the Summer of 2015. Partial implementation involved the use of blocks that had been developed in either the Summer or Fall of 2014. By the Spring of 2015, all blocks were developed and used by the instructor teaching the redesigned course. The blocks were all further refined during the Spring 2015 semester. During partial or full implementation, T.A. (teaching assistants) and P.L.F.s (Peer Learning Facilitators) assisted the instructor in the delivery of active learning material during lecture. In all three semesters, the redesigned course was taught parallel to 202L lectures taught in a traditional lecture format.

An important aspect of the redesign has been analysis of student learning, comparing student performance between the redesigned and non-redesigned courses. While the comparisons are accompanied by many variables, we have found that on some types of assessments students in the redesigned courses perform moderately better than those in the non-redesigned courses. The initial assessment has revealed ways in which assessment must be more controlled and also more specific to student background. We have also assessed students' attitudes toward the redesigned course and find that students respond well to the implemented material.

There is still more to do in the redesign of the 202L course. All blocks still include more traditional lecture time than is generally recommended for an active learning-based course. As the course is taught in the Fall of 2015, we are still creating activities for these blocks; especially as one section of the course is being taught in a studio classroom for the first time. This setting requires minimal instructor lecture time and the change in venue has inspired even greater change in the redesign. We have also identified specific activities that really highlight common student mistakes and misperceptions, not previously addressed. The creation of activities that can target these crucial teaching moments is still occurring, even though the redesign has officially ended.

This report summarizes our work on redesign components and our analysis of student learning and attitudes. Included are samples of material developed and assessment raw data. In addition, we have indicated areas that need improvement and refining throughout our report.

Project motivation and goals:

The 202L redesign sought to (and still aims to):

1. improve overall student success in Genetics;
2. contribute to increasing success and graduation rates at UNM;
3. retain underrepresented minority (URM) students in the STEM fields; and
4. promote critical thinking and higher-order thinking in students.

To accomplish these goals, our team set out to:

1. refine and use student learning outcomes (SLOs) to determine the acquisition of information throughout the semester.
2. create 202L information blocks which included pre-lecture learning and active learning activities to be used during lecture time.
3. implement those new activities in select lecture classes and then compare student performance with that of students not provided with the new activities.

Project summary:

Our redesign efforts focused on developing individual blocks of material and these blocks were implemented in partially redesigned courses. A complete set of blocks were implemented in the Summer of 2015. The assignment of blocks is as follows:

(Principles of Heredity)

- Meiosis
- Mendelian Genetics
- Extensions of Mendelian Genetics
- Sex Determination and Sex Linkage
- Gene Linkage

(From Genes to Proteins)

- DNA and RNA structure
- DNA Replication and Repair
- Gene Function
- Gene Expression
- Mutation

(Regulation of Gene Expression)

- Prokaryotic Gene Regulation
- Eukaryotic Gene Regulation
- Gene Regulation in Cancer and Development

(Eukaryotic Genetics and Genomics)

- Recombinant DNA Technology
- Genome Structure and Organization
- Functional Genomics

The following tools were developed for each block of material:

1. An on-line pre-lecture reading quiz that tests comprehension and knowledge gained in the reading assignment. Each quiz is accompanied by a reading guide that outlines specific material to be read and specific figures or in-chapter questions to be studied. The reading assignment is based on material within a chapter of the text.
2. In class activities that focus on difficult concepts and the application and synthesis of knowledge gained from the reading assignment. These activities include multiple choice questions, short answer questions and art and labeling activities. The activities are created to ensure interactions between students and trained facilitators. Work done by students on these activities is facilitated by the instructor, peer-learning facilitators, S.I. leaders and T.A.s.
3. A compendium of on-line tutorial, animation and self-quizzes that students use as necessary to solidify their knowledge.
4. A study guide that details all concepts that should be understood by the end of presentation of the block of material. The study guide is inquiry-based and also highlights end-of-chapter questions within the text that can be used for study.
5. Post-unit course assessment questions. Questions were developed that test basic knowledge and comprehension and others test higher-order cognitive skills.
6. Exam questions that test all levels of knowledge for each block and can initially be used to compare student performance.

Some of our blocks of material also include pre-recorded lecture material over difficult concepts that students do not always understand at the end of lecture. These allow students to review the material at their own pace and to record questions that can be asked later of the instructor.

Members of the redesign team created a template Learn site that is maintained by the 202L T.As. and T.A. coordinator. The Learn site includes blocks of reading quiz questions (categorized by block of material), study guides, reading guides and the compendiums of web-based activities.

Assessment:

1. We assessed student attitude toward the redesign across all redesigned sections, in the Spring of 2015. The results are compiled in Table 1.

Generally, students responded well to the redesign of 202.

Both the in-class activities and in-class assessments were regarded as useful to the overall understanding of material.

While most students found pre-class reading to be useful, there were a few who rarely found that pre-class reading to be helpful in understanding lecture material. This may be based on the fact that two of the pre-class readings were not part of the redesign but instead asked students to read an article from the primary literature and answer questions. This type of reading was specific to the non-redesign instructor's request and was given to all students.

Homework was not part of the redesign but was developed by the co-instructors. It is interesting that more students found that homework did not help prepare them for the exam and so perhaps didn't find the homework useful.

We are pleased to see so many students who found that redesign efforts not only aided in their understanding of material, but also in their ability to analyze and solve problems. It is also rewarding to see that students believe that the redesigned course made them better learners.

2. In the Fall of 2014, we used 4 in-common questions on the final exam in both the redesigned and non-redesigned lectures. The results of that analysis are found attached as Questions 1-4.

Question 1: This question requires students to apply information that they have learned about how genes control the production of proteins and use the table results to construct a biochemical pathway. Students in the redesigned course had the opportunity to work out a similar question in lecture, while students in the non-redesigned course were shown how to construct the pathway by the lecturer. In Blooms taxonomy, this is an “analysis” or “application” question that requires students to make use of knowledge. Most sections of the redesigned lectures scored significantly higher on this question.

Question 2: This question also requires an analysis of information. Neither group of students was directly asked the question during lecture nor was the specific application addressed. Performance varied but two sections of the redesigned course scored significantly higher than the others.

Question 3: The question requires an application of knowledge in a slightly different way. The orientation of nucleotides (5' and 3' directions) was shown in both orientations in the non-redesigned class but not in the redesigned class. This may account for the much better performance by students in the non-redesigned course as the question would be answered incorrectly if the orientation was not carefully analyzed.

Question 4: Students were required to synthesize multiple reasons for the modern description of the historical “one-gene, one-enzyme hypothesis”. The rationale for the modern description was introduced across multiple lectures but, at some point, was emphasized in one discussion later in the course (for both lectures). Students did not score significantly differently between the redesigned and non-redesigned courses. The grading of this question was also inherently variable as individual T.A.s grade their own sections' exams and the grading of the question was highly subjective, as compared to other questions.

3. In the Spring of 2015, one question was included as an in-common question on all final exams. The results of the performance comparison is attached as Question 5. The question asked students to apply knowledge of inheritance patterns. Students in the redesigned sections overall scored an 80% on the question while those in the non-redesigned sections overall scored a 75% on the question.

We are still in the process of analyzing other questions in common on in-semester exams of Spring 2015.

Improvement:

Assessment of student attitudes should not include assessment of anything that is not part of the redesign project. Homework assignments are very specific to instructor and the development of these assignments is not done through the redesign team. We will also begin assessing students' attitudes toward the study guides and reading guides. It will be useful to find out if students feel that the reading guides adequately prepare them for the associated reading quiz. We will also include an opportunity for students to estimate their grade along with their attitude toward different aspects of the course. A comparison of projected grade to attitude will help us parse out the differences between those students

who are truly assessing how they feel about the redesign and those who are assessing how they feel about their overall success in the course.

We would like to incorporate more activities that help students learn how to study and to become better learners. This will include new in-class activities: the development of study cards; creation of practice questions that students may use to quiz each other, outside of class; creation of flow charts that aid students in connecting concepts and creating their own study guides.

The assessment of student success can also be improved. The design of 202 in the Fall of 2105 (see below) will help determine how students in the redesigned course compare with those in a non-redesigned course by eliminating differences between instructors. Our analysis to date has also not studied how redesign affects our URM (underrepresented minority) students. Future assessment will include analysis of students with different ethnic and economic backgrounds. In addition, we will work to determine whether the redesign disproportionately assists first-generation students and older, returning students. All of these populations are significant at UNM and tend to be students who struggle and leave STEM courses.

Expansion and Sustaining:

We have analyzed student learning by comparing performance between redesigned and non-redesigned courses, however, the two types of courses were taught by different instructors. In addition, in the two semesters where the comparison was done, the redesigned course was taught by the same instructor but the non-redesigned course was taught by two different instructors. This set-up allows for multiple variables when considering student learning. We realized that the best context in which to compare student performance is one where the same instructor is teaching both redesigned and non-redesigned lectures. In the Fall of 2015, one instructor is teaching Genetics, with the usual number of students taking the course. In this semester, the lecture structures are as follows:

1. A 50-student, redesigned lecture, held in a studio classroom where students are assembled in groups of 9 at collaborative, round tables. Redesign activities are facilitated by T.A.s and P.L.F.s.
2. A 120-students redesigned lecture, held in a traditional lecture classroom where students work together but with limited ability to group together. Redesign activities are facilitated by T.A.s and P.L.F.s.
3. A 120-student, non-redesigned lecture, held in a traditional lecture classroom with limited student interaction.

All students will be provided the reading guide and quiz, study guide, compendium of web-based activities and assessment for each block of material. The only variable in this structure is the delivery of material. In the non-redesigned lecture, material is delivered in a traditional lecture format and in the redesigned lecture, material is delivered through in-class activity (active learning) and facilitation by instructor, T.A. and P.L.F.

There will be a very specific analysis of student performance. Most questions on exams (which are in common between the three lectures) will be compared. The questions are developed based on the varying levels of Bloom's taxonomy and also structured to focus on concepts that may very well vary between students with different learning styles and level of understanding.

Expansion of the project will then be focused on determining which sections of the course were well-served by redesign and which may be better handled with a more traditional lecture format or with better developed active learning, in-class activities.

The results of the study will also be shared with other instructors teaching 202L in the future and with other instructors that teach within the core courses of Biology. Within our departmental ongoing, weekly discussion of best teaching practices, we will share these results.

This is also the place to mention how invaluable the redesign has been in identifying common student mistakes and misconceptions within the different learning blocks. Addressing those areas has not been the focus of our redesign because it clearly took the redesign, and active learning, to identify where those problems lie. A significant expansion of the project will be to catalog these issues and create specific learning activities to help students work through them. The cataloging will also help 202L instructors who choose not to use the redesigned material. Even if the lecture delivery style is more traditional, instructors will be better equipped to prepare their lectures when armed with information on what is most difficult for students and where students struggle despite the best efforts of instructors.

The 202-specific redesign is sustained by the collection of material within a Google Docs file, that is easily accessed by both instructors within and outside of UNM. The template Learn class is only accessible to instructors teaching within a specific semester and so we've also created the Google file that contains all of the relevant material to redesign. That file holds, for each unit, reading guides, reading quiz question, study guides and PowerPoint slides for all in-class activities. It does not contain the pre-recorded lecture material as that will tend to be instructor-specific.

Challenges:

The primary challenge to our redesign project was a lack of participation by some redesign team members. This was only a challenge in that the time available to those participating was limited and this has hindered data analysis of student performance. The analysis can be done and will take more time than was provided in the redesign schedule. Of most importance is the analysis that will be done regarding performance in the Fall of 2015. The T.A.s for this semester will participate as part of their job duties.

Another challenge has been the diversity of 202L instructors. Comparison was not easy when different instructors taught the non-redesigned lectures. There is variation in how clearly lecturers present in the traditional lecture setting and significant variation in how students feel about those lecturers ability to present. A consistent instructor teaching all sections of 202L in the Fall of 2015 will eliminate that variation.

Within the Biology department, there is resistance to course redesign that incorporates major additions of in-class, active learning. During the initial stages of redesign, it was difficult to find a community of individuals to discuss the redesign. At this point, we have established a motivated group of lecturers who are interested in discussing pedagogy and innovation in teaching. This group meets twice a month and has sparked interest and conversation about course redesign.