Course Portfolio: L211: Introductory Molecular Biology

Joseph Ipe

Abstract

As an associate instructor, I taught supplementary instruction sections of introductory molecular biology (L211). This class introduces several diverse concepts in molecular biology which forms the foundation for advanced studies in biology. The syllabus ranges from evolutionary theories to advanced developmental biology. The concepts are extremely diverse but are biologically interrelated. Establishing such relationships can be intimidating for a student. My goal for this semester was to facilitate a learning environment wherein students understand the individual concepts and also establish relationships between the different concepts. I introduced concept maps as learning tools to aid in achieving my goal. Concept maps were made available only to students that attended the SI sessions. The ability of students to solve specific questions that required them to establish relationships between different concepts were monitored. It was found that a higher percentage of students with access to concept maps were able to solve such questions. The implementation of concept maps had some minor hurdles but those were overcome by making changes in my approach. Overall the intervention was successful and most students found the study tool useful.

Background

L211 is an introductory standalone (no lab sections) lecture class that covers a wide variety of topics in molecular biology. The syllabus covers topics ranging from nucleic acids, proteins, fundamental biological processes, cell biology, signal transduction and developmental biology. The goal of the class is to enable the students to apply the fundamental “rules” of biology and solve biological problems. Basic understanding of molecular biology sets the foundation for several diverse fields like physiology, biomedical sciences, population biology and ecology. (Syllabus: Appendix I)

The class has a total enrollment of 250 students. The class meets two times a week for 75 minute lectures taught by the main instructor. The students have the opportunity to attend an optional 50 minute supplementary instruction section taught by associate instructors (AIs) every week. Assessments are in the form of four non-cumulative mid-semester exams and one cumulative final exam. Additionally, there are four in-class quizzes that contribute to the overall grade. In-class clicker questions are used for real time assessments and also to keep track of student attendance. Clicker points contribute to a minor percentage of the total grade.

The class is open to sophomores, juniors and seniors (freshmen with special permission) who have taken an introductory biology course or equivalent.
The teaching staff consists of one main instructor, two (graduate) associate instructors (AIs) and four undergraduate teaching assistants (UTAs). My role in this course was that of an AI. As the associate instructor, I had to design, prepare and deliver supplementary instruction sections each week on two different days. The supplementary instruction sections are optional and are aimed at reinforcing the major topics taught in the main lectures of that week. The SI sessions also go into details of major experiments and techniques that were not discussed in detail during the regular lectures. The SI sessions expose the students to questions similar to examination questions and aims at preparing them to solve them in a logical manner. A typical SI session lasts for 50-60 minutes.

**Objectives**

My objective for this course was to enable the students to understand the ‘rules’ governing the several diverse biological processes and to empower them to apply those rules in biological problem solving. My aim was to make sure that the students do not merely memorize the facts for the sake of the examination. To achieve this goal, I decided to design my SI sessions in a student-centered manner, providing opportunities for students to interact with me and also with their peers during the session.

**Identification of problem**

One major problem that I identified during my previous experience in teaching the same course was that most students, even the ones that pass the class with a good grade, tend to memorize facts and reproduce them in the examination. These students are not able to recollect or apply the old content later in the semester even though the new content is related to the old content. Since the class was lead by a head instructor, I had limited control over the examination pattern. The only cumulative examination was the final examination. My specific objective was to introduce an intervention that ensured that students remain acquainted with the old content as newer content is introduced to them.

**Validating the learning challenge**

Before the introduction of concept maps, a pre-test and post-test was used to determine the ability of the students to synthesize answers, i.e. to identify relationships between known facts. The relationship that the students are expected to identify was not explicitly mentioned during the main lecture. Four questions were asked in the pre-test and four in the post-test. Pre-test and post-test questions were in reverse order for half the class.
Example from pre/post test:
There are two representative questions shown below. One question required mere reproduction of a known fact while the other required establishing a relationship between two known facts

1. Question 1: The distance between gene A and gene B on a chromosome is 34 map units. What is the recombination frequency between the two genes?

2. Question 2: The distance between gene A and gene B on a chromosome is 34 map units. What is the probability that gene A and B will segregate together? (i.e. how closely linked are the genes?)

   A) 34%
   B) 6%
   C) 51%
   D) 66%
   E) Insufficient data

They were provided the following information in the main lecture (and also in their prerequisite classes)
- Distance between genes are measured in map units
- Lower the number of map units, the closer the genes are on the chromosome and vice versa.
- Genes that are further apart from each other has higher probability of being separated during crossing over.
- Recombination frequency is the probability two genes to be separated during crossing over.
- Linkage is defined as the probability that two genes will stay together after crossing over

The students were expected to establish a relationship between recombination frequency and linkage frequency based on the above information provided to them.

Results:

Question 1: 86.7% (72/83) of the students was able to answer this question correctly. This question required mere recollection of a fact that was presented to them in class.

Question 2: Only 18% (15/83) of the students were able to answer this correctly. This question required the students to find a relationship between two concepts, both of which where presented to them in class.

These results suggest that most students can reproduce facts but fail to establish relationships between known concepts.
**The Intervention**

The Teagle collegium meetings introduced several different classroom assessment tests (CATs). I found CATs to be extremely powerful tools to gauge student understanding and also a good self-assessment and learning tool for the students. Concept map is a CAT that I found well suited to help me with my goal for this class. At the end of the first SI session, four key words/topics that were introduced to them were linked together and presented to them in the form of a concept map (Fig 1). In the subsequent SI sessions, few keywords were picked and the students were asked to insert the words into the existing concept map and link them with connecting words. Students were allowed to discuss with their neighbors while doing this exercise.

![Concept Map](image)

**Figure 1:** Introductory concept map provided to students at the end of the first SI session.

The first four weeks focused on introducing diverse concepts to students. There were several words that were incorporated into the concept map during these four weeks. The students were provided a print out of the previous week’s concept map and they were asked to incorporate the new words into the existing one. First, they were asked to identify relationships between the new words. Then, they identified relationships between the new words and existing words on the concept map. After completing the new concept map, the key relationships were discussed in the class and a powerpoint slide with the best possible relationships were shown to the students. This gave the opportunity for students to identify some relationships that they failed to identify individually or with their neighbor. In some instances more than one relationship between words were possible, in such cases the most relevant relationship was chosen. I made a note
of all the relationships that were identified and incorporated it into the concept map and this new concept map served as the starting material for the next week’s similar activity. From the fifth week onwards the classes became more focused. The number of words introduced each week became smaller but newer relationships were established between existing words. The concept map after the final SI session is shown in Appendix II.

The students attending the SI session filled out a sign up sheet during each session. Since the concept maps were available only to those students who attend the SI session, the students regularly attending the SI sessions formed the study group and the ones who do not attend the SI session was the control group. 25 representative students from both groups were selected for compiling the data shown below.

Assessments

Example 1:
Shown below is a question from the first mid-semester exam.

13. In the image below, male and female flies are shown to have either red or white eyes. You are working in a lab, and produced a mutant strain of fly that added the W gene onto the Y chromosome (the X chromosome would also still contain it), and you continued to work ONLY with this mutant strain of fly. To keep track, you call the genotype of that male fly “WYm” (to show that the W gene is now on the Y chromosome).

You then proceed to mate two flies – a male with the genotype “WYm” with a female with the genotype “ww”. From this cross, which of the following statements would be true?

- a. all males and females will have white eyes
- b. all males and females will have red eyes
- c. only male flies will have red eyes
- d. only female flies will have red eyes

The question required the students to establish a relationship between the individual alleles contained in the organism and the phenotype of the organism (based on their knowledge of mendelian inheritance). This was one of the top tier questions in the exam. The students were taught how to do mendelian crosses and they were also trained to identify the phenotype of a diploid organism based on the alleles of the organism. But manipulating chromosomes by adding alleles was the novelty in this question. The students were expected to indentify the change mentioned in the question and continue to establish a relationship
between the identity of the alleles and the resulting phenotype. The concept map clearly states that combination of alleles can give different phenotypes (Fig 1). The percentage of students in each group that got the answer correct is shown below.

This result shows that more students who had access to concept maps were able to answer the question correctly by making the expected connection between concepts. Even if the student made the connection between the concepts, knowledge of the individual concepts was required to solve the problem. The 36% wrong answers could be due to this reason.

Example 2:

*Where does (i) DNA replication, (ii) Transcription, (iii) Mismatch repair (iv) RNA splicing and (v) Translation occur in a eukaryotic cell?*

- **a. Nucleus; cytoplasm; nucleus; cytoplasm; nucleus**
- **b. Cytoplasm; nucleus; nucleus; nucleus; cytoplasm**
- **c. Nucleus; nucleus; nucleus; nucleus; nucleus**
- **d. cytoplasm; cytoplasm; cytoplasm; cytoplasm; Nucleus**
- **e. Nucleus; nucleus; nucleus; nucleus; nucleus, cytoplasm**

The students were taught each of these processes separately. Cellular transport of macromolecules was not discussed in class. The students were expected to identify the cellular location of each of the processes by establishing a relationship between the template molecule and a cellular organelle. (E.g. DNA replication is duplication of DNA. The template is DNA and DNA is in the nucleus. Thus, DNA replication occurs in the nucleus.)
The relationship between each of these processes and their respective templates was established in the concept maps. The percentage of correct answers in the study group and the control group are shown below:

The above result reinforces the fact that most students fail to make simple correlations between concepts unless they are specifically pointed out to them. The more students who had access to concept maps could make these connections.

**Student Feedback**

Mid-semester feedback (after first mid-semester exam):

The students filled out an anonymous mid semester evaluation form during the SI sessions. There were multiple questions and each questions could be answered in a scale of 1 to 5 (1-Strongly agree, 2- Agree, 3- No opinion, 4- Disagree, 5-Strongly disagree). A total of 43 students returned the evaluation forms.

The following are the results of selected questions:

**Question 1: I make my own concept maps**
The above result showed that most students did not make and maintain their own concept maps. Though visual evidence showed that they participated in the discussion at the end of SI sessions, most students admitted that they waited for my powerpoint slide that had the concept map with the new words added in.

Question 2: I find concept maps useful

Thought the results in the first mid-semester exam strongly suggested that the students who had access to concept maps were able to solve questions that required making connections between different concepts, the students were not sure of the value of concept maps as a study tool.

This result made me rethink my strategy and I stopped providing the ‘filled in’ concept maps at the end of SI sessions. The students were provided print-outs of the previous week’s concept maps and they were asked to fill in the new words onto that template. More time was given for discussion and only those relationships established by students were added on to the next week’s template. This change increased participation and there were more elaborate discussions at the end of the SI sessions. I also started providing impromptu questions that can be solved using the concept maps.

The students were extremely happy with the format of the SI session and they liked the fact that the sessions are interactive.

Some of the student responses for “What do you find most effective during SI sessions?” were:
“The PowerPoint and the way the session is organized”

“Going over specific topics in detail. If I missed something in class I am sure to understand it after SI”

“Joseph will stop and give clear examples if the class does not fully understand. The presented material. He does a great job explaining things”

“Very clear explanation on a concept, step-by-step teaching, sufficient information”

“It is good that he asks questions and really makes us think about the material. It is helpful that he highlights important things”

Student response in “Additional comments: “

“It would be nice if the AI made the concept map and posted it. (I realize this is lazy of me) but there is already so much information to read. I do believe that concept maps would be very useful”

**Reflections:**

I think the intervention by introducing concept maps is well suited to the learning challenge that I wished to address. It was a novel tool for the students but simple enough for them to understand. One of the major challenges I faced was convincing the students about the value of concept maps. The only cumulative exam was the final exam. Students tend to value study tools that enable them to gain more points in exams. Cumulative mid-semester exams would have helped introduce more questions that required relating diverse concepts.

I am extremely happy with the way I planned and designed my SI sessions. Thinking from a student’s point of view helped me make the power points and worksheets in a student centered manner. The collegium meetings changed my approach towards teaching and I consciously introduced CATs that helped me assess student understanding. I tried to promote collaborative learning by asking students to solve complex problems in class as a group. CATs like think pair share was frequently used. The CATs were very well accepted by the students.

Several students did not make their own concept maps partly because I provided them the final version at the end of the SI sessions and also because it was not a graded activity. I could identify and correct this problem after the mid-semester evaluation. Providing impromptu questions that required the use of concept maps helped me convince the students of its worth.
As the semester progressed, more and more students became interested in concept maps and several students emailed me asking for the week's concept map if they happened to miss an SI session.

Overall I am satisfied with my teaching innovation. There were initial challenges but they were overcome to a great extent. I think the students enjoyed the learning experience as well. I would recommend the introduction of concepts maps as a graded learning tool and also the introduction of cumulative mid-semester exams so that students do not lose track of earlier material.
### Spring 2010 Syllabus, Biology L211

**Tentative Lecture Schedule**  
**Instructor: Joe Pomerening**

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Textbook Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 12 &amp; 14</td>
<td>The Mendelian View of the World</td>
<td>Chapter 1</td>
</tr>
<tr>
<td></td>
<td>Model Organisms</td>
<td>Chapter 21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 19 &amp; 21</td>
<td>Model Organisms</td>
<td>Chapter 21</td>
</tr>
<tr>
<td></td>
<td>Nucleic Acids Convey Genetic Information</td>
<td>Chapter 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 26</td>
<td>The Structures of DNA &amp; RNA</td>
<td>Chapter 6</td>
</tr>
<tr>
<td>Quiz 1: Tuesday, Jan 26, in class. Covers material through Jan 21.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 28 &amp; Feb 2</td>
<td>Chromosomes, Chromatin, and the Nucleosome</td>
<td>Chapter 7</td>
</tr>
<tr>
<td>Midterm 1: Wednesday, Feb 3, 7:00 – 9:00 PM. Covers material through Jan 28.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb 4 &amp; 9</td>
<td>The Replication of DNA</td>
<td>Chapter 8</td>
</tr>
<tr>
<td>Feb 11 &amp; 16</td>
<td>The Replication of DNA</td>
<td>Chapter 8</td>
</tr>
<tr>
<td></td>
<td>The Mutability and Repair of DNA</td>
<td>Chapter 9</td>
</tr>
<tr>
<td>Feb 18 &amp; 23</td>
<td>Site-Specific Recombination &amp; Transposition of DNA</td>
<td>Chapter 11</td>
</tr>
<tr>
<td>Quiz 2: Tuesday, Feb 23, in class. Covers material through Feb 18.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb 25 &amp; Mar 2</td>
<td>Mechanisms of Transcription</td>
<td>Chapter 12</td>
</tr>
<tr>
<td>Midterm 2: Wednesday, Mar 3, 7:00 – 9:00 PM. Covers material through Feb 25.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 4</td>
<td>RNA Splicing</td>
<td>Chapter 13</td>
</tr>
<tr>
<td>Mar 9</td>
<td>The Genetic Code</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Mar 11</td>
<td>Translation</td>
<td>Chapter 14</td>
</tr>
<tr>
<td>Mar 15 - 19</td>
<td>SPRING BREAK</td>
<td></td>
</tr>
<tr>
<td>Mar 23</td>
<td>Translation</td>
<td>Chapter 14</td>
</tr>
<tr>
<td>Mar 25 &amp; 30</td>
<td>Transcriptional Regulation in Prokaryotes</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Quiz 3: Tuesday, Mar 30, in class. Covers material through Mar 25.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 1 &amp; 6</td>
<td>Transcriptional Regulation in Eukaryotes</td>
<td>Chapter 17</td>
</tr>
<tr>
<td>Midterm 3: Wednesday, Apr 7, 7:00 – 9:00 PM. Covers material through Apr 1.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Apr 8 - 20  Gene Regulation in Development and Evolution  Chapter 19
Apr 22 & 27  Regulatory RNAs  Chapter 18
Quiz 4: Tuesday, Apr 27, in class. Covers material through Apr 22.
Apr 29  Wrap Session

Final Exam: Thursday, May 6, 12:30 PM - 3:30 PM. 50% Jan 12 – Apr 29, 50% cumulative.
***ATTENTION – IF YOU ARE SCHEDULED FOR A CLASS BEGINNING BETWEEN 1:25 AND 2:25 PM ON Tuesdays, Thursdays, or Saturdays, your final exam for that course may conflict with the last hour of our final. This is because I schedule for a 3-hour final exam period to ensure you will have more than enough time to complete your exam (final exam periods are only blocked off in two-hour slots by the university). IF YOU HAVE A CONFLICTING FINAL EXAM TIME, we will work to schedule you to begin your exam prior to our L211 final exam on May 6th so it will not conflict with any other final exam that follows our L211 final.***

Exam Schedule
First Midterm Exam
Wednesday, February 3, 7:00 – 9:00 PM.

Second Midterm Exam
Wednesday, March 3, 7:00 – 9:00 PM.

Third Midterm Exam
Wednesday, April 7, 7:00 – 9:00 PM.

Final Exam
Thursday, May 6, 12:30 PM – 3:30 PM.

Quiz Schedule
January 26, 2010
February 23, 2010
March 30, 2010
April 27, 2010

All quizzes will be conducted in class on the above dates. You will have 20 minutes to complete each quiz (until the end of the class period).
Appendix II: Final Concept Map