# **Student-Designed Assignments in an Advanced Molecular Biology Laboratory**

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# **Spring 2019**

## Introduction

Students in the two-credit writing-intensive course Biochemistry & Molecular Biology (BMB) 445W, Laboratory in Molecular Genetics, are typically graduating seniors, proficient learners preparing to move into a new, more independent phase of their educational journey. I sought to guide BMB 445W students toward increasing their competency in project design, planning, and evaluation; to take greater responsibility for their learning; and to improve their ability to communicate disciplinary knowledge, potentially to a lay audience. They worked toward these goals by designing their own final course assignment, in which they presented the laboratory work they’d performed throughout the semester in written, graphical, and/or oral forms, addressing a rhetorical situation of their choosing. Thus, my “meta-assignment” asked students to submit proposals that described the purpose, audience, content, and media for their communications, the rubrics by which they wanted their creations to be evaluated, and the timelines and processes by which they planned to work. After completing their respective assignments, students presented their final works in a showcase event.

## Project Design

The experimental work in BMB 445W begins with four weeks of introductory exercises to familiarize students with basic molecular biology techniques, followed by an extended nine-week molecular cloning and gene analysis project. Students record their benchwork in laboratory notebooks and communicate their ideas in discipline-specific lab reports. Problem sets that highlight concepts underlying the techniques also support student mastery of experimental molecular genetics. The final course assignment, described here, both encourages students to review major aspects of the molecular cloning and gene analysis work and induces them to consider and represent their findings and what they learned in original and creative ways.

The meta-assignment introduces students to the idea of designing their own assignments and guides them through the development of a proposal to create a final work. The appendix to this report contains the meta-assignment description and sample proposal given to students in Spring 2019. This description first set forth the rationale for a learning experience that provides greater freedom and responsibility, and then detailed the parts of the project proposal. Students considered what their final product might look like—what “story” they want to tell, and to whom, why, and how. That is, students were prompted to shape the content, format, audience, and purpose as interdependent components of the work and then explicitly describe each one. The meta-assignment then explained how to develop a rubric with appropriate categories for evaluating the final work and a workplan that includes deadlines and deliverables (*e.g*., drafts of the work submitted for instructor or peer feedback). Students chose either to work alone or with a partner; workplans for group projects also described division of labor. The directions informed students of the two hard-and-fast requirements (1) that they needed to develop an approved proposal; and to (2) that they needed to work according to what was approved. (Amendments to approved proposals required additional approval.)

We discussed the meta-assignment in a class session, and students developed their individual proposals with my input. Nearly all student proposals required at least one revision before approval. As students created their works, they solicited feedback from me, a learning assistant, and/or their peers, according to their workplans. Student groups that developed multimedia projects (e.g., narrated PowerPoints) were referred to the Penn State Berks Center for Learning and Teaching for assistance. We devoted approximately four class periods (eight hours) to discussing, generating, sharing, and refining proposals and works. Students reported spending significant time outside of class to developing their projects.

Near the end of the semester, the class voted to present their projects to one another and other students and faculty in an exhibition-style showcase during Finals week. Each student invited one or two guests, who could be science or non-science faculty, students, or prospective students. The showcase was not part of their evaluation, but all student groups voluntarily chose to present at the event. After the showcase, they submitted their final works for grading.

## Learning Outcomes

The nine student groups (seven pairs and two individuals) that worked on the project during Spring 2019 each developed unique proposals that together spanned a variety of formats, audiences, purposes, styles:

* a whodunit graphic novella describing the application of molecular biology to forensics
* a set of lessons to introduce molecular cell biology to school-age (K-5) children
* a facebook page reporting a fictional young scientist’s work to his friends
* a series of emails explaining the unfolding of the lab project to the student’s mother
* a spunky blog written to inform and entertain younger students
* a series of educational modules to teach high school students about gene cloning
* a training module for salespeople pitching a cloning and sequencing kit
* a trivia quiz game for future BMB 445 students (and assorted BMB faculty)
* a magazine feature article for college students interested in the BMB major

All student groups worked according to their workplan and produced high-quality final works.

Students shared their perceptions of the learning experience in Canvas surveys administered before distribution of the meta-assignment description (pre-assignment survey) and after the presentation showcase (post-assignment survey). The first set of questions asked students to rate their skill and experience with items related to the desired learning outcomes (Figure 1): upon completing the assignment, students generally reported greater confidence in their ability to design and plan learning experiences, collaborate with peers, assimilate feedback, and communicate with lay and disciplinary audiences. (Pre-assignment and post-assignment survey data are given in Figure 2.) Furthermore, students unanimously agreed (73% strongly) that the assignment helped them achieve the learning goals of the assignment; helped them increase creativity and encouraged them to “think outside the box” (100% strongly agree); and prepared them for a more independent phase of their educational journey or career (91% strongly agree). 90% of students also agreed that the assignment increased their interest in molecular genetics (10% neither agreed nor disagreed).

In open-ended prompts asking for comments on the overall experience and suggestions to improve the activity, students were enthusiastic (Figure 3). They expressed appreciation for the freedom and independence and for the encouragement to develop their creative, collaborative, and time management skills. They found the experience fun, challenging, and rewarding. Many would have liked the meta-assignment given earlier in the semester so that they would have had even more time to develop their proposals and final works. (The meta-assignment was introduced and discussed in Week 9 of the semester; students were required to have developed an approved proposal by Week 12; and the final products were presented and submitted during Finals Week.) The students also found the showcase event “super helpful” and fun (Figure 4). In addition to seeing their classmates’ projects, they liked the presentation style and setting and enjoyed interacting with both the science faculty and scientific laypersons invited to the event.

**Assignment Learning Outcomes**

After successfully completing the assignment, students will be able to:

1. Create a proposal to outline the purpose, content, and audience of an expressive work.
2. Design a rubric to identify and weight significant criteria for evaluating creative work.
3. Create a workplan with timelines and deliverables to effectively manage workload and deadlines.
4. Assimilate self-assessment and external feedback from peers and mentors for revising work.
5. Communicate scientific and technical knowledge, potentially to a lay audience, via a selected media, genre, and form.
6. Given a project from a peer, discuss, evaluate, and provide constructive feedback for improvement.

Figure 1. Learning objectives for the assignment, as described in the course syllabus.

Figure 2. Survey data. In surveys administered before the introduction and after completion of the final course assignment, students rated their skill and experience with various tasks related to the desired learning outcomes.

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| **Prompt: Reflect on your overall experience with designing, planning, and completing the final project. Do you have any recommendations for improvement or additional comments?** |
| No I think the project was a great way to end the semester! I think it allows us to think freely and more independently. Being able to create our own project is definitely going to be relatable going on in the future where we may will have more independent tasks, and this allowed us to be more independent. I think the creative aspect is something unique to the project itself and it needs to be more like this in certain aspects across the curriculum I think so we can have a well round idea towards all projects we take on. I really wouldn’t change anything about it. I loved it! |
| At first, I was skeptical about the final project and had no clue what I was going to do, but after figuring out that we were going to do jeopardy, I enjoyed it more than most other projects. |
| I thoroughly enjoyed doing this final project. It helped me take a step back and think about what exactly I accomplished this semester. I think the way this project was handled went really smoothly. I loved the showcase! |
| I thought overall it was a rewarding project to complete. The only suggestion I would make is to start talking about the final project early so that it's not rushed in the last couple weeks of classes. That's when a lot of my other projects and presentations were due so it was challenging at times to manage the work load. |
| I would present the idea of the final project sooner in the semester to allow proper planning around schedules. This would allow more time to revise and edit the drafts and proposals and be able to cultivate the idea throughout a longer period of time.  I loved the freedom of the final project and the "guidelines" though! |
| The planning phase of the project is what took the longest and took up most of our time I believe. Since everything was for us to determine and plan before approaching you with ideas it was nerve-wracking to work without structure because we didn't know what you wanted or expected out of the project. Once we got your approval the second time, it was easy for us to come up with our blogs but difficult to choose what to say in our posts versus what not to say. With help from you and our peers, we were able to condense our entries in a way that could be understandable and straightforward to our audience. The only recommendation I have for this project is to introduce it to the class way sooner than you did. This would have been much less stressful if we could have thought about our project starting in early March and worked our way into it because Elis and I at first wanted to do a video but we lacked time so we settled on doing a website that would be easier for us to work on together. Overall though, this was a fun senior project! |
| Challenging but satisfying, at the end, to see such positive feedback. |
| My only recommendation for improvement is to maybe introduce that we have a project proposal somewhat early in the semester so students can start planning and thinking of ideas for their final project. |
| With this project, I believe it helped me as a person to branch out from the more technical side of things and be more creative in my learning, which depending from person to person may be more beneficial after graduation as this creative thinking may assist in any of the future endeavors that might occur. In addition, it also assists us students getting ready for the work force, graduate school, or the medical field by working with others as a team in developing of a product. This skill is valuable to possess as for most of time, one would be working with others to handle a task at hand. |
| I think my group was very good at sticking to the deadlines that we created, but it appeared that other groups had trouble waiting until the last minute to complete it. Maybe have more strict guidelines, but also I think that it helps people learn the skill of time management. |

Figure 3. Student responses to open-ended prompt concerning the overall learning experience.

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| **Prompt: Reflect on your overall experience with the Senior Showcase. Do you have any recommendations for improvement or additional comments?** |
| I think the senior show case was a very creative and a very great idea. I think maybe in the future, since we have a better idea overall, that it could be planned out more in advance. Again it was just an idea towards the end of the semester, but since it went well I think it could go even better next time around when it’s more planned out. I think it was very nice to see a lot of professors and see new faces who are not as familiar to science really enjoying all of our hard work really made it all so worthwhile and I think it would be most beneficial to have it again! |
| I enjoyed the senior showcase and thought it was cool that all of the science faculty came. It was fun to see teachers and students trying to compete against each other in jeopardy. |
| I think the Senior Showcase turned out great! I wasn't expecting that many people, but it went smoothly and overall enjoyable. |
| I thought it was a nice experience and was rewarding. Maybe having more of our peers would be nice especially those who would be taking the class in the future, but I know sometimes it's hard to get students to come to things. |
| No I liked the freedom because each project could not necessarily be presented so it was easier to talk on a one-on-one basis. |
| The highlight of this entire experience was the showcase. I didn't know what to expect from the showcase but I really enjoyed talking about what we did and showing our website to other professors. That style of communication (like poster board presentation style)  even though it was informal I think is something that is lacking in the science department classes because in the real world that's often a way to display your work to a bigger audience in an upbeat environment. I wish we could have presented projects like this in previous classes so that we could acquire more skills on how to present projects in that style better. |
| Wonderful experience, loved every moment. |
| I thought the Senior Showcase was actually super helpful and fun. It was interesting to see what other classmates came up with. It was fun to explain my project to others as well. |
| In having gone through the Senior Showcase, it showed me as a student that not everyone thinks alike where various projects were developed with the premise of the project being very different from one project to the next. It was time where we can get together and not only to reflect on the project at hand for most of the semester, but also see how well we would adjust to the real-world where there are people who may not know the science or the different techniques that are involved in a particular topic. All in all, it was a great experience to have gone through and see the different creative minds that are present. |
| I think that it was a great way to showcase our projects, and I enjoyed the relaxed setting where people could come and visit our table! |

Figure 4. Student responses to open-ended prompt concerning the showcase.

## Discussion

I designed this assignment-to-create-an-assignment as a playful rejoinder to my own tendencies to prescribe (over-prescribe?) the objectives of learning activities and direct (over-direct?) the process of learning. Students, after all, won’t be students forever, and detailed instructions and rubrics are rare in the world beyond college classrooms, in what life assigns after graduation.

Thus, I sought to encourage independent thinking—not just in examining what, but also when, why, to whom, and how. I wanted students to create: a vision, a process, a product.

That students relished the opportunity to engage their creativity was evident from the earliest stage of project. In my meta-assignment, I provided suggestions for form and a sample proposal. Although students found the examples intriguing, they all strove to develop their own unique ideas. As they formulated and then enacted their plans, engagement remained high. Comments such as “*the creative aspect is something unique to the project … it needs to be more like this across the curriculum*” and “*it helped me branch out from the more technical side and be more creative in my learning … this creative thinking may assist in future endeavors*” indicate how the students—all graduating seniors—seemed to sense the relevance of this kind of open-ended assignment to both their education and their lives beyond commencement.

All groups successfully completed the project and not only attended but “loved” the optional, admittedly makeshift showcase event, highlighting the students’ engagement (the dreaded condition of senioritis was kept at bay this term) as well as an (at least nascent) ability to develop and follow their own workplan to generate work they were proud of. Interestingly, they did not report perceiving a significantly greater ability to manage their workload (*c.f.* pre- and post- responses, Figure 2). Perhaps their pre-assignment survey responses belied an overconfidence in their abilities in this respect; perhaps their post-assignment responses are indicative of a more measured self-evaluation. The suggestion, raised by multiple students, to introduce the project earlier in the semester supports this idea. One student commented: “*my group was very good at sticking to the deadlines that we created, but it appeared that other groups had trouble waiting until the last minute to complete it. Maybe have more strict guidelines, but also I think that it helps people learn the skill of time management.*”

This TLI project touches on several other aspects of pedagogical concern. First, I saw no friction within groups during the project—a function, I believe, of their collective involvement with the task, but also of the optional nature of the collaborations. In addition, the project supports university-wide efforts to increase digital fluency; the class leveraged a variety of media and technological platforms as students “created” rather than simply “consumed” knowledge. The method by which the project promoted rhetorical awareness and fostered thinking about communication with non-disciplinary audiences in written, graphical, and oral forms may stimulate interest from those teaching other writing-intensive courses and those involved in the Writing Across the Curriculum movement, particularly at a time when public perception and policymaking demands require scientists to communicate effectively with non-scientists. In a broad sense, by shifting responsibilities for constructing educational experiences and expanding spaces for content, form, and process, student-designed assignments may help instructors and students see learning from a new perspective.

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## Appendix: Meta-Assignment Description and Sample Proposal

**Meta-Assignment: BMB 445W Final Project**

**Overview**

In the final project for the course, you’ll design your own assignment and then create an original work to complete your assignment. This “product” will tell the story of your GAPDH molecular cloning and bioinformatics work in BMB 445W. You’ll tell the story in a format of your choice, to an audience of your choice. You will also decide how to evaluate the success of your storytelling.

You’ll start by developing a project proposal, which I must approve, and then you’ll develop the product itself. Both the product and the process by which you create it are integral to this project.

You may work with a partner or you may work alone for this project. If you choose to collaborate, both of you will receive the same grade.

**Rationale**

This final project is a bit out of the norm for me, and perhaps for you, too. Since many of you are nearing the end of your college career and will be moving into a more independent phase of your educational journey, I want to give you the freedom and responsibility to develop your own learning experience. Through this activity, I anticipate you’ll increase your competency in project design, planning, and evaluation and improve your ability to communicate scientific knowledge. I also hope that in developing your own project and by generating work that’s more “creative” than, say, a typical lab report, you’ll gain a broader perspective on science, communication, and learning itself.

**The Project Proposal**

There are two hard-and-fast requirements for this project: I must approve your proposal, and you must work according to what you propose. If, in the course of creating your product, you wish to alter your approved proposal, I must approve the modification.

Developing the proposal will take some brainstorming (maybe a bit of daydreaming?) and some outside research. Approval will likely require multiple rounds of drafting and revision. Develop your proposal as soon as possible and gather feedback on it from me, your classmates, and other interested parties.

Your project proposal will describe the product you wish to create, the rubric against which your product will be evaluated, and the process by which you will create the product. Each of these components is described below.

**Proposal Part 1: What will you create?**

Imagine what your final product looks like. What’s your story? Who are you speaking to, and why? How will you tell your story? These questions (detailed below) are interrelated—so as you refine and reimagine your product, you’ll want to consider these elements in combination.

1. Content: What will you present?

Naturally, you’ll be communicating essential aspects of your work with GAPDH cloning and plant phylogeny, but you’ll need to decide the scope and depth and how to frame your story. Some of you will want to include some of the fine details—for instance, the use of the Eco47IR gene as a selection tool for subcloning, or BLASTing a genomic query sequence against the mRNA database to identify the intron-exon boundaries, or how MEGA aligns sequences and calculates a phylogenetic tree. Others will use broader brush strokes to provide a higher-level description of the work.

What you emphasize will depend on your audience, format, and purpose.

In your proposal, define your content as precisely as you can—that will make it easier to create your product.

1. Format: How will you tell your story?

You may present your story in any form using words (written or spoken). You may also use graphics or multimedia, but don’t tell your story solely with visual imagery.

Some options: a nonfiction article (for example, for a popular science magazine), a creative essay, an exchange of letters, an interview (written or filmed), an instructional resource or teaching guide, a PowerPoint or TED talk, a video essay, a graphic novella, a poster, a website, or . . .

As you decide on the genre and media for telling your story, explain why that form is particularly suited to your content, audience, and purpose.

By the way, you should have some familiarity with the genre / media you choose—or at least a willingness to learn about it!

Again, providing specifics here will help you think out possible directions for the project and pave the way for the product creation phase of the project. Include an approximate length to help define the scope of your work.

1. Audience: To whom will you speak?

If you choose a more creative genre, you may be presenting to a lay audience who has little knowledge of molecular genetics. More technical forms might target other potential students in the course, or even instructors.

As in the example below, you may speak to yourself, but not solely to yourself. Or you may wish to speak to a particular person important in your life or choose a wider audience.

Depending on your project’s format, you may define more than one audience.

1. Purpose: What do you seek to accomplish with the work?

To inform? Entertain? Persuade?

Your purpose in telling a story is tied to the way you tell it and to whom—and what story you ultimately tell.

Once you’ve answered these four questions for yourself, describe your responses in your proposal. Start with an overview that shows how these elements of the story are interconnected in your proposed work. Then explicitly describe each of the elements (not necessarily in the above order).

**Proposal Part 2. How should your creation be evaluated?**

Define the criteria by which you will define success. Consider aspects of the work such as the quality and development of ideas—this could be the accuracy, scope, and depth of technical content; how you frame your argument (the background and rationale); focus and clarity and the logical connection between your main ideas and supporting details. You might also think about presentation style, mechanics, and/or other appropriate categories.

Assemble a **rubric** based on these criteria.

First, define the criteria and the characteristics of a successful product. Include categories that address the scientific content, the quality of communication, and the impact of the work. Within each category, you may define the various levels of achievement—for example, what constitutes “A” level work, “B” work, “C”, etc.

Then, if you desire, weight the categories in your rubric as you see fit. Or you may choose not to define weights if you believe your work should be evaluated in a more comprehensive or holistic manner. (The example below uses a holistic rubric.)

**Proposal Part 3: How will you create this work?**

As you probably know, a plan helps you organize, manage, and hold yourself accountable. Draft a **workplan** that will keep you on track for successfully completing the project.

This workplan should detail deadlines and “deliverables.” Deliverables will include the outlines, storyboards, rough drafts, sketches, etc. that you’ll create as you progress through the project.

Deliverables also include self-assessments, peer feedback, and instructor feedback that you’ll use to guide your revisions—you must include each of these elements in your proposal for approval.

If you’re working with a partner, please indicate this. Also, detail in your workplan who is responsible for what.

At the end of the project, in addition to the final draft of your work, you’ll submit a portfolio that includes all formative works—drafts, feedback, etc. with the dates of completion. (Save copies of everything!)

**Grading**

I’ll evaluate your project on the final product (judging it against your rubric, 100 points) and the process by which you created it (judging your portfolio against your workplan, 50 points).

I’ll also ask you to evaluate your final project experience. This will give you an opportunity to reflect on what you learned and will help me assess and revise the project for the next class of BMB 445W students!

**Sample Proposal**

**Overview**

I propose a series of diary entries that chronicle the work my classmates and I performed in cloning GAPDH genes from various plants and using the gene sequences to assemble a phylogenetic tree of the plants. I experienced large emotional swings during this lab project, and I believe diary entries would be especially effective at conveying not only what I did, but also what I was feeling during the highs and the lows of the project.

**Purpose:** This story will provide a record of my lab work this spring. It will also provide a record of my emotional state during my hardest but most rewarding semester at Berks. (Graduating in May—Woohoo!)

**Audience:** Since it’s in the form of a diary, I’ll ostensibly be telling the story to myself, but I also will be talking to loved ones who might one day be interested in learning about my experiences as a BMB student in 2019. When I describe the experiments, I’ll use technical language, and I don’t necessarily intend to comprehensively report on the experiments. However, I’ll provide enough detail to tell a complete story of the science and a record of my feelings.

**Format:** A series of diary entries. Since I’ll be writing to myself, I will use technical jargon and the language will be informal at times. However, I’ll be aware of my wider potential audience and will make sure the story is complete and self-contained. For the same reason, although diary writers typically don’t edit their work, I’ll make sure my writing is mechanically sound and of a quality that’s more like a memoir than a diary. I’ll compose my drafts on a Word processor. However, my final copy will be handwritten, with sketches. I anticipate it will include 5-6 entries, each 2-3 composition book pages in length.

**Content:** The entries will contain sufficient detail that I would be able to recall what I did even when I’m a senior citizen. Unlike most diaries, this “excerpt” will contain a beginning (an entry describing the proposal and start of the project), a middle (entries about the nested PCR, subcloning into the pJET vector, sequencing and—ugh!, the bioinformatics), and an end (the Eureka! moment when we found that our phylogenetic tree matched exactly what we expected, except for the *Brassicales* members, which led to all sorts of questions and a possible summer research project). At the same time, I’ll be highlighting my emotional state throughout the project in those moments.

**Rubric**

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|  | **Successful**  **A** | **Marginal**  **C** | **Unacceptable**  **F** |
| **Technical Content: Accuracy** | Conveys all technical content—procedures, results, analysis, or conclusions—with a high accuracy. The science is sound. | Some technical content is misstated, providing an inaccurate portrayal of the experimental work. | Serious errors in the account reveal large gaps in understanding of the scientific material. |
| **Technical Content: Scope** | Does not necessarily provide a comprehensive account of the benchwork, but surveys all important aspects of the cloning, sequencing, and bioinformatics to tell a complete science story. | Omits one or more important stages of the project, leaving a gap in the account of the experimental work. | Fails to address multiple stages of the benchwork. |
| **Clarity** | Organization and effective use of language make for a clear account. Logical connections between sentences, paragraphs, and entries makes the account cohesive. | Organization between and within diary entries and/or on the paragraph and sentence level pose challenges to the reader’s comprehension of the overall story. | Organizational issues and language bemuse the reader and would lead to misunderstanding the account. |
| **Writing Mechanics** | Free of errors in grammar, punctuation, and spelling; uses logical syntax and appropriate diction. | Multiple usage errors and poor style choices detract from the reader’s experience. | The story is a chore to read because it is riddled with errors. |
| **Emotional Effect** | Moves the reader and helps him/her understand and connect to my emotional state throughout the narrative. | Provides insight into my emotional journey, but not much emotional impact. | Fails to move the reader emotionally. |

**Workplan**

I will be working alone on this project.

I plan to write three to five drafts of the work. Each draft will involve substantive revision. I will revise based on self-assessments, two rounds of instructor feedback, and feedback from two or three peers.

Deliverables and Deadlines:

* Proposal Approved by April 3\*
* First complete draft by April 10
* Self-assessment by April 12
* Revision by April 15
* Solicit instructor feedback by April 15
* Solicit feedback from Ernie & Elmo by April 17
* Revision by April 22
* Solicit instructor feedback and feedback from Ernie, Elmo, and/or Oscar by April 22
* If needed, revision by April 24
* If needed, self-assessment by April 27
* If needed, revision by April 29
* Submit final draft, portfolio, and reflection by April 29\*

\* = course deadlines