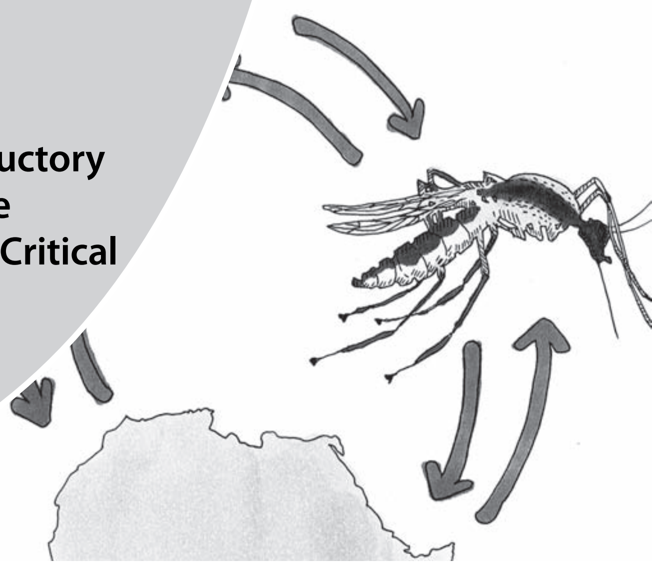
RESEARCH ON LEARNING

Using Iterative Group Presentations in an Introductory Biology Course to Enhance Student Engagement and Critical Thinking



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Abstract

In this study, we examined two types of group presentation assignments for use in a large, introductory biology course. Students were placed into groups of 6 to 8 members, and tasked with researching a topic and preparing a 10-minute in-class presentation. The assignments varied by course section; in the control section, each group's topics were selected to complement the course topic, whereas in the iterative sections, each group's topic would derive from the previous group's presentation. Students' critical thinking skills were assessed before and after the semester's presentations, and exit surveys were conducted. Results show that students in the iterative group performed better than control on exam questions, and overall interest in biology was high in both groups as a result of the presentations. Overall, performing group presentations in an iterative style enhanced learning by mimicking the scientific process of inquiry and discovery.

Key Words: *critical thinking; group assignment; introductory biology.*

○ Introduction

Entering first-year college students invariably have different critical thinking abilities. Fortunately, critical thinking is considered a learnable skill (Arum & Roska, 2011; Huber & Kuncel, 2016; Schub, 2016). Specifically, critical thinking skills include "argument analysis and evaluation, methodological reasoning, and focusing and clarifying questions" (Bensley & Murtagh, 2012). At Simmons College, we require students in the Introductory Biology course to work in groups to independently research and orally present on current topics related to course material. Here, we modified this assignment to determine whether we could enhance established critical thinking learning outcomes by adding an iterative component.

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This assignment promoted critical thinking and engagement in a variety of other ways as well. To begin, it forced communication between the students within their working groups, as well as more formally between the groups and the entire class. As opposed to the didactic model, inquiry-based activities promote verbal and digital communication, creating conditions for student participation and enhanced critical thinking (Brookfield, 2012, p. 195; Garside, 1996). In addition, the creation of a non-threatening small-group climate is fundamental to creating a classroom environment conducive to developing critical thinking skills (Buckley et al., 2015; Neve, 1986). Furthermore, the public communication format required for this assignment solidifies the material presented in class. As Lindsey (1988) eloquently states, "All teachers have probably had the experience of never really understanding the material until they have taught it. The same is true for students." Finally, the current topics assignment had the additional benefit of emphasizing reality, another strategy for promoting higher-level and critical thinking (Neve, 1986).

In contrast to the traditional assignment, our iterative assignment required that the topic presented by a group be generated by the class discussion following the previous group's presentation. We suggest that this iterative element improves our stated vital critical thinking skills of "argument analysis and evaluation, methodological reasoning, and focusing and clarifying questions." Importantly, iterative topic selection imitates "real life" science that typically generates more questions than answers. Here, we describe the assignment, our assessment methods, and benefits in term of student interest and critical thinking seen by using this novel approach.

○ Methods

Group Presentation Assignments

All three sections of introductory biology participated in this study. Student demographics were very similar among the sections; nearly

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all students were female-identifying, first-year science majors. Classes were twice weekly, 80-minute lecture courses, with approximately 70 students each. Sections 1 and 3 were assigned *iterative* presentations, and section 2 was designated as *control*, with presentations related to ongoing lecture topics. The classes were divided into 10 groups of 6 to 8 students, randomly assigned by the professor. The same professor taught all three sections. The mechanics of topic selection are described below.

Deliverables

Students were expected to prepare a 10-minute oral presentation, with PowerPoint slides. Due to the sequential nature of the iterative projects, groups had approximately 5 days to organize, research, and prepare. To maintain equality across all sections and groups, students were limited to selecting topics no more than one week in advance. It was repeatedly emphasized that they were not expected to become experts in their topic, nor were expected to be able to answer every question. They were meant only to provide an organized, factual overview of a topic new to most of the class. The explicitly stated intent was to broaden interest and exposure, not to overwhelm. Presentation requirements included: at least one data figure with discussion, a list of reliable references, and the final PowerPoint to be shared with the professor using Google drive. This way, each group member's contribution was noted in the final Google document via the edit/comment tool. Audience members were required to post to a Moodle message board at least one relevant question (or answer one posted question) per presentation. To encourage in-class questions, students were permitted to post a question they had already asked verbally.

As oral presentations to large groups can be intimidating, it was proposed that group members agree to assign roles (such as presenter, researcher, graphic designer, organizer) to divide the work. This allowed individuals to participate even if they were uncomfortable speaking in front of a large group, and seemed to be appreciated by the more introverted students. Some groups followed the suggested roles; others divided the work by research topic, where each person researched and presented one slide.

Iterative Presentations

The project began with Group 1 presenting on a topic of general interest to the class that was very broad in scope (Table 1). Suggestions for the first topic were brainstormed during class, and Group 1 was left to make the final decision from the class-generated list. Following the first presentation, the entire class was expected to discuss and brainstorm during a Q&A session; this discussion guided the selection of Group 2's topic. In this way, the presentations became iterative, with one topic flowing naturally out of discussion on the previous one.

Control Presentations

In Group 2, the control group, presentation topics were selected by the students, with the professor offering two or three ideas related to the topics covered in class that week, as possible topics for their research. There was no specific link between topics, beyond serendipitous connections common in science (Table 1). In all other ways, the assignment was carried out as in the iterative group.

Expectations and Evaluation

Evaluation was based on the final presented product using the rubric shown in Table 2. Following each presentation, a short student exit survey addressing teamwork, time spent on the project, and respect for group members' time and opinions was collected (see Appendix). Two online forum comments per student over the semester were reviewed, to ensure audience participation. The total presentation was worth 6 percent of their final grade.

Critical Thinking Assessment

Student critical thinking was encouraged at several levels. First, requiring inclusion of a data figure ensured the opportunity to discuss experimental methods, design, and limitations. Second, students were encouraged in the forum to pose novel, unique questions based on the information they heard. Finally, the iterative assignments pushed students to identify missing information, as the basis for the next presentation topic.

Table 1. Retrospective examples of weekly topics selected by the students, in both iterative and control sections. Topic selection evolved throughout the class, based on the interests of the students. Some topic transitions are less obvious than others; these connections arose through class discussions. For example, the toxicology topic (week 6) referred back to week 2's discussion of Alzheimer's treatment because students were interested in drug metabolism.

Week #	Section 1 (Iterative)	Section 3 (Iterative)	Section 2 (Control)
1	Alzheimer's	Lyme disease	Artificial leaf
2	Genetics/Alzheimer's treatment	Climate change and ticks	Lupus
3	Prions and dementia	Lyme—new pathogen	Cancer
4	Stem cells/Alzheimer's treatment	Immune system and HIV	Tay-Sachs
5	Cloning and stem cells	Antiretroviral drugs	GMOs
6	Toxicology	Bacteria vs. viruses	Progeria
7	Genetics of Downs	Vaccines	Bioprinting
8	Genetics of ALS	Polio	Epigenetics

Table 2. Grading rubric used by the professor to evaluate all group presentations.

	1 – poor	2 – good	3 – great	4 – outstanding
Biology content	Minimal, few references, nothing beyond textbook depth	Some good material, some key information missing or sparse	Well researched, biologically focused, accurate information	References thorough, excellent explanation of biology, accurate
Collaboration & Communication	Some group members did not participate or were disrespectful	Everyone participated, some much more than others, some procrastination	Everyone participated. Information & ideas communicated clearly and respectfully	Worked very well as a team, everyone participated enthusiastically and in a timely manner
Presentation	Presentation did not flow, presenters were absent	Presentation generally good, presenters hard to hear	Presentation easy to follow, kept audience engaged	Topic clearly presented, speakers knowledgeable and engaging

Table 3. Representative student feedback from both iterative and control groups. While both groups showed positive feedback, there seemed to be more focus on the scientific content in the iterative groups, and more focus on logistics in the control group.

Iterative Topics	Control Topics
I liked how these projects built off each other.	[Mine] was a topic I already knew a lot about, but other people's presentations were interesting.
Project was a good way to connect what we learned in class to real life.	Great way to get to know classmates.
I like that I could understand more when reading about science topics due to what we have learned in class . . . now I feel more likely to read news about current science topics in the news, because I know I can understand more.	Even though I hated the idea at first, [you] putting the groups together was good because it forced me to work with people I wouldn't have otherwise.
It was interesting to read about science on my own terms, and look at scholarly work and think, wow, we just learned about that, I actually understand what it's talking about!	We never ended up getting together but made it work!

Critical thinking skills were initially evaluated using one open-ended, experimental question (analytical question, $AQ_{initial}$) on the first exam of the semester. A different question, similar in style, was included on the cumulative final exam (AQ_{final}). Each question gave a scenario and asked students to generate a hypothesis and identify variables that could be measured (see Appendix). The questions were graded out of three points. Change in score was calculated as $AQ_{final} - AQ_{initial}$.

○ Results & Discussion

Our exit survey showed that students overwhelmingly felt that both types of presentations increased their interest in biology. In the iterative section, 90 percent of students reported that the assignment increased their interest in biology, and in the section with the control assignment, 81 percent of students reported an increased interest (Table 3).

When the two largest sections were analyzed (section 1, iterative; section 2, control) there was an average decrease in performance on the analytical question from the first exam to the final exam, which correlates with an overall decrease in exam mean from the first exam (mean range 85–90 across sections) to the final exam (mean range 72–76). Although not significant, the iterative group performed better (t-test: $p = 0.066$) on the analytical final exam question than did the section with the traditional current topics assignment (Figure 1).

We argue that iterative oral presentations have an increased potential to engage students. Though this is somewhat subjective due to reliance on self-reporting from the participants, these students were very likely to report that they enjoyed the project and that it increased their interest in biology. We also saw that the iterative version of the assignment resulted in an increased proportion of students who did better on the analytical exam question. Taken together, the iterative assignment addressed important learning objectives for an introductory course: advancing student skills in communication, critical thinking, and information literacy, while promoting student excitement and providing them a more authentic view of scientific reasoning.

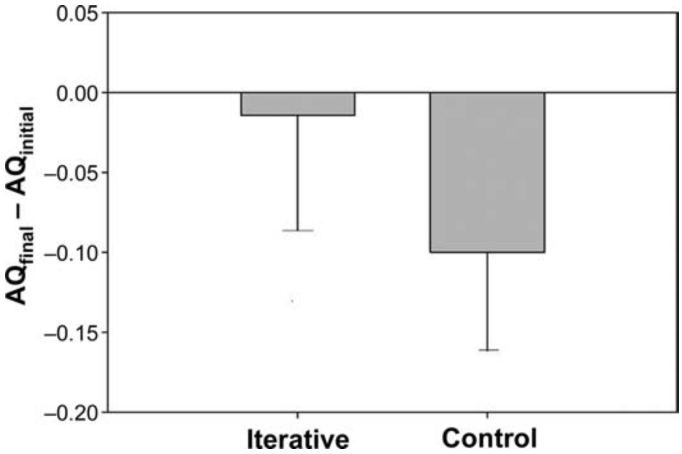

Figure 1. The change in performance over the duration of the course, calculated using $AQ_{final} - AQ_{initial}$. Mean-SE Delta values for the section given the iterative and the control assignments (t-test: n 1 = 63, n 2 = 65, $p = 0.066$, $t = 3.689$, $df = 169$).

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APPENDIX

Initial Question

Analytic question — please be clear and concise.

In step A of the experiment below (Figure 2), the outside surface of a cell is marked with a fluorescent dye so that it is visible under a microscope with high magnification. Keep in mind, you are only able to see the outer surface of the cell. In step B, a laser is used to bleach, or remove, the fluorescent label from one spot of the surface of the cell.

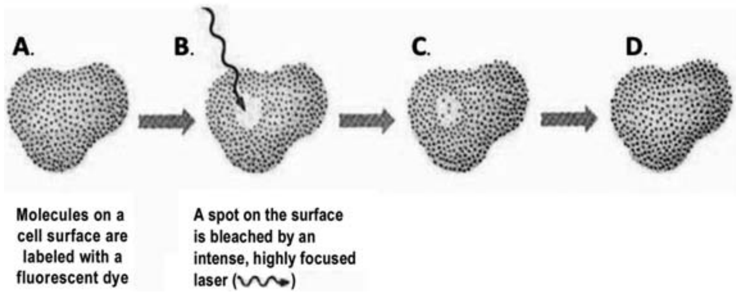
1. Based on your knowledge of membrane composition and behavior, what is happening in C and D? Please present your idea as a hypothesis.
2. Based on your hypothesis, what might be a next question to ask about this system? (e.g., what other variable would you want to test? What other outcome would you want to look at?)

Analytical Question #1

In the experiment below, the outside surface of a cell is marked with a fluorescent dye (Step A.), so that it can be seen under a microscope with high magnification. In Step B., a laser is used to bleach, or remove, the fluorescent label from one spot of the surface of the cell.

Based on your knowledge of membrane composition and behavior, what is happening in Steps C. and D.? Please present your idea as a hypothesis.

What additional information would you need to test your hypothesis?



Final Exam Question:

Analytic question — please be clear and concise.

Paclitaxel (Taxol) is a chemotherapeutic used to treat breast, ovarian, lung, and pancreatic cancers. It is a small chemical molecule that binds to microtubules, and prevents them from depolymerizing. Taxol is not a protein, but it binds specifically to the tubulin protein subunit that makes up microtubules. While Taxol is quite effective, it has serious side effects, including extreme fatigue, hair loss, nerve pain and digestive issues.

1. Propose a *hypothesis* to explain why interference with microtubule function leads to inhibition of cancer.
2. If this drug were the topic of your senior research thesis, you would need to test your hypothesis by designing an experiment and interpreting the results. Based on your answer to (1), what kind of data would you want to collect to do to learn more about Taxol function?

Bio 113 — Group Presentation Exit Survey

Name:____

Group number:__________ Presentation date:________________

Presentation topic:____________________________________

Your feedback—positive *and* negative—is important. Your responses are used as part of grade calculation, but will remain confidential. Please answer honestly!

1. What were your primary duties within the group?
2. Approximately how many hours did you spend working on this project?
3. Please comment on how your group members worked as a team. (If someone stood out as especially helpful, or mostly absent, please indicate that here). Did everyone contribute:
   a. Equally?
   b. In a timely manner?
   c. Respectfully?
4. Do you feel that this project increased your interest in biology? Any other suggestions or comments (use back if necessary)?