



Supplemental Materials

for

Engaging Students in Authentic Microbiology Research in an Introductory Biology Laboratory Course is Correlated with Gains in Student Understanding of the Nature of Authentic Research and Critical Thinking

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Appendix 1

Confirmatory factor analysis for attitudinal survey.

Factor	Number of items	Cronbach's α	
		Pre-semester	Post-semester
1. Interest in Biology/Science	5	0.844	0.924
2. Perceived connection between real life and science	7	0.823	0.945
3. Lab perceived as similar to real scientific lab practices	5	0.926	0.760
4. Perceived learning of biology content through laboratory	6	0.777	0.839
5. Believe that they can understand and do scientific research	3	0.821	0.785

Appendix 2

Representative quotes from written comments section of Purdue course evaluations.

Categories	Quotes
Students learned a lot from the module	<ul style="list-style-type: none">• This course was very fun and informative. We were first year students but our professor treated us with a lot of respect and I feel like I learned a lot in this course.• Professor...takes the time to explain things and answer questions and is always open to different ideas. This class was a great learning experience for me.
Research-based activities were effective	<ul style="list-style-type: none">• I really enjoy the paper discussions. It presents an opportunity for the students to have to think independently about a research topic.• This course is a great lab experience and the poster really helped put it all together. The research was interesting and we learned the skills necessary for biology lab without really knowing it.• I liked how [the professor] worked with us to form our hypotheses and analyze our data rather than just telling us what to do. I feel it has helped me learn the information better because I was prompted to ask myself questions and give answers to those questions. It was much more of a hands-on learning experience than regular biology labs.• Spending a few weeks mastering basic techniques before actually starting to experiment was helpful, so that it wasn't overwhelming to do everything at once. Spending time in discussion during the labs was also helpful for understanding the content.
Teaching methods were useful	<ul style="list-style-type: none">• Providing visualizations for all of the steps in the experiment really helped me to understand why we were doing things the way we did. Modeling ProP with play dough was a great idea, too.• The feedback [the professor] gives on our papers is always helpful and helps...make us better writers. The practice that we always do before a certain task is always helpful.• The lab manuals, quizzes, and demonstrations were helpful to understanding the material covered and prepared the students for future biology labs.
Workload was high	<ul style="list-style-type: none">• The work that goes into this course is much more than a 2-credit hour workload.• A lot of coursework – maybe ease up on the paper discussions and other assignments other than lab reports and the in-labs.• It would be nice to have a little turn-around time between doing the experiments and writing the papers.
Group work opinions	<ul style="list-style-type: none">• Emphasize teamwork on parts of the class outside the classroom for projects other than the poster.• I think that the groups should not be assigned. Something that is such a large part of our grade should be chosen by us.
Suggestions for improvement	<ul style="list-style-type: none">• A little more guidance on the first paper discussion would have been very helpful. Maybe discussing it in class before assigning the questions?• Spending time before each lab going over the purpose of what we were doing that day and how it fit into the larger experiment would be helpful, because sometimes it was confusing trying to figure out the purpose and function of every plate and streak.

Appendix 3

Pre-/Postsemester changes in attitudes.

	Pre Mean ± SD	Post Mean ± SD	Change
<i>Labs perceived as similar to real scientific lab practices</i>			
1. I gained a better understanding of the process of scientific research.	4.75 ± 1.26	5.62 ± 0.57	+0.87*
2. The lab experiences were very similar to real research.	4.33 ± 1.29	5.31 ± 0.97	+0.98*
3. The lab experiences made me realize I could do science research in a real science lab (for instance, at a college or with a pharmaceutical company).	4.46 ± 1.39	5.23 ± 1.11	+0.77*
4. Lab experiments presented real science to students, similar to what scientists do in real research labs.	4.58 ± 1.23	5.50 ± 0.65	+0.98*
5. I learned from the laboratory experiences in the course.	5.00 ± 0.75	5.69 ± 0.47	+0.69*
<i>Interest in Biology/Science</i>			
1. The lab experience made me more interested in biology.	4.92 ± 1.05	4.81 ± 1.27	-0.11
2. The lab experience made me more interested in science.	4.92 ± 1.00	4.96 ± 1.11	+0.04
3. The lab experience made me more interested in a science career.	4.87 ± 0.93	4.65 ± 1.23	-0.22
4. The lab experience made me more interested in earning a Master's degree in a science field.	3.85 ± 1.23	4.04 ± 1.31	+0.19
5. The lab experience made me more interested in earning a Doctoral degree (Ph.D.) in a science field.	4.00 ± 1.39	4.00 ± 1.62	0
<i>Perceived learning of Biology content through lab</i>			
1. I better understood the ideas of biology, in general, as a result of completing the experiments.	4.76 ± 0.86	5.23 ± 0.71	+0.47*
2. I think that the lab experiments were well organized.	4.87 ± 0.99	5.23 ± 0.99	+0.36
3. Having the opportunity to use biology instruments made the course more interesting to me.	5.2 ± 0.65	5.42 ± 0.90	+0.22
4. Having the opportunity to use biology instruments helped me learn course topics.	4.94 ± 0.71	5.11 ± 0.95	+0.17
5. I needed to understand the big ideas behind each experiment in order to do well.	4.60 ± 0.87	5.23 ± 0.91	+0.63*
<i>Perceived connection between real life and science</i>			
1. The skills I learned in the most recent biology laboratory course I took will be skills I will use throughout my entire life.	4.23 ± 1.23	4.58 ± 1.33	+0.35
2. The lab experiments increased my appreciation for the role of scientists in society.	4.79 ± 1.11	5.42 ± 0.81	+0.63*
3. Even if I don't end up working in a science-related job, the laboratory experience in the most recent biology course I took will still benefit me.	4.65 ± 0.99	5.04 ± 0.93	+0.39
4. The lab experiments were related to things I am familiar with in real life.	4.67 ± 0.84	4.42 ± 1.30	-0.25
5. The concepts covered in the laboratory were relevant to the real world.	4.65 ± 0.85	4.58 ± 1.33	-0.07
6. I feel I will use the knowledge I gained from the most recent biology laboratory course I took.	5.08 ± 0.73	4.96 ± 1.08	-0.12
<i>Belief that they can understand and do scientific research</i>			
1. I was good at doing the laboratory experiments in the course.	4.90 ± 0.60	5.27 ± 0.78	+0.36
2. I believe I could accurately explain a biology experiment from the course to another student.	5.00 ± 0.80	5.31 ± 0.55	+0.31
3. I believe I could accurately explain a biology experiment from the course (including the significance of the results) to my instructor.	4.79 ± 0.83	5.00 ± 0.57	+0.21

N = 26, * p < 0.05 One-way ANOVA with Bonferroni correction for multiple comparisons.