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The Effectiveness of Project-Based Labs on Learning the Process Of Science: A Sotl Study

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The Effectiveness of Project-based Labs on Learning the Process of Science: a SoTL Study

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School of Biology
Session Objectives

• Understand the steps used to develop and execute a SoTL study
  – Importance of professional help
• Share the results of my study
American Society for Microbiology’s Scholars-in-Residence Program
SiR requirements

• ASM Scholars are expected to **formulate a hypothesis** about student learning and develop a plan to test their hypothesis.

• ASM Scholars are expected to **conduct research** according to the highest scientific and ethical standards and in compliance with all applicable laws, regulations, and policies regarding protection of human research subjects, human care and use of laboratory animals, and laboratory safety.

• ASM Scholars are expected to **publish results** of their studies or works-in-progress in peer-reviewed literature and share their expertise locally and/or nationally.

• ASM Scholars are expected to **report periodically** to ASM regarding their current position, affiliation, and continued professional development for a minimum of five years after completion of the one-year Scholars-in-Residence Program. This arrangement will ensure proper studies regarding the effectiveness of such programs.
The Process

• Application/proposal
• SoTL institute (4-day, onsite)
• SiR listserv
  – Regular assignments and updates
  – Keep toolkit
• ASMcue – Conference for Undergraduate Educators
## Keep Toolkit

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Examining the Effectiveness of a Project-based Laboratory on Learning the Process of Science in an Introductory Microbiology Course

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Question
Because laboratory activities are expensive and time-consuming, it is essential that they meet educational objectives. Here, I will measure how effective an optional project-based laboratory component is in increasing student understanding of the process of science in an introductory microbiology course for biology majors.

Assessment Strategies
I will compare students who are or are not enrolled in lab on embedded "process of science" multiple choice questions. These questions will be on the midterm and final exams of the affiliated Introductory Microbiology lecture course. Because students may already have a better understanding of process of science could self-select for the lab course, I will normalize scores based on pre-test "process of science" scores, grades in other lab-optional biology courses, scores on content-based exam questions or GPA (Biology or overall).

Annotated bibliography

This paper is relevant to my work because the problem addressed is almost identical to my own. I found upon reading it that the paper was basically a description of Dr. Wimmer's Molecular biology lab course. Another assessment of the effectiveness of the course in meeting its objectives was very limited. There was no statistical analysis of the data and in fact it was not clear how many students replied to his surveys. Most of the results were qualitative and anecdotal. He compared the survey scores from his molecular biology lab course and his plant pathology lab course, which is probably not the best research strategy. However, it did give me hope of getting published.

SoTL institute

• Develop a hypothesis to explore student learning in microbiology
• Design an experiment using their classes to test the hypothesis
• Identify existing resources regularly used to assess student learning
• Understand methods of collecting and interpreting data used to measure student learning
• Understand IRB requirements for conducting research on students
• Identify appropriate venues for publishing their research
Group project: Identify 1-2 problems encountered when trying to:

- Develop a hypothesis
- Design an experiment
- Identify existing assessment resources
- Understand methods of collection and analysis
- Understand IRB requirements
- Identify appropriate venues for publishing their research
The research
The Question

Does an optional project-based laboratory component increase student understanding of the process of science in an introductory microbiology course for biology majors?
BIOL 3380 – Introductory Microbiology

No Lab: 50%

Project-based Lab: 50%
Lab Course Design

• Semester long project on single organism / biosynthetic pathway (pyocyanin)
Experimental Design

• IRB approval
• Pre-test on process of science
  – Not micro related
  – Not in exam setting
• Embedded process of science questions
  – On midterm exam and final exam
  – Includes micro terms
• Data analyzed for lab/no lab
The Pretest
Pretest Sample Question

Which of the following is a prediction of the hypothesis: Eating chicken noodle soup is an effective treatment for colds?

A. People who eat chicken noodle soup have shorter colds than people who do not eat chicken noodle soup.
B. People who do not eat chicken noodle soup experience unusually long and severe colds.
C. Cold viruses cannot live in chicken noodle soup.
D. People who eat chicken noodle soup feel healthier than people who do not eat chicken noodle soup.
E. Consuming chicken noodle soup causes people to sneeze.
Pre-test Results

![Bar chart showing Pre Test Average (out of 7) for Lab and No Lab groups. Lab group has an average of 5, and No Lab group has an average of 6. The difference is statistically significant with P=0.0065.](image)

P=.0065
Incoming GPA

No Significant Difference
GPA - Biology Majors vs. Others

P < 0.1
The Midterm Exam
Mid-term Data

No significant difference
You are trying to confirm that certain kind of bacteria prefers to utilize organic rather than inorganic compounds to generate ATP. What would be the best control to use in your experiments?

A. Culture the cells in media containing organic compounds and then replace the media with one containing only inorganic compounds and compare the rates of growth

B. Culture the cells in media containing only inorganic compounds and then replace the media with one containing organic compounds and compare the rates of growth

C. Split your original culture in half and culture one half in media that contains organic compounds and the other half in media that contains only inorganic compounds and compare the rates of growth of the two cultures

D. Split your original culture in half and culture one half in media that contains organic and inorganic compounds and the other half in media that contains only inorganic compounds and compare the rates of growth of the two cultures
Chemolithotrophs are
A. autotrophs
B. organotrophs
C. heterotrophs
D. phototrophs
The Final Exam
Final exam sample POS question

You observe bacteria growing on the hot water faucet of your sink but not the cold water faucet. Which of the following statements would be the best prediction for a hypothesis test?

A. Sinks are breeding grounds for bacteria.
B. If you put bacteria from the hot water faucet onto the cold water faucet they will die.
C. The bacteria on the hot water faucet most likely comes from your hands.
D. If you swab the sink handles and culture the swab at hot and cold temperatures, you will find more growth at the hot temperature.
E. If you clean your faucet with bleach, you will not have bacterial growth.
Final exam results

No significant difference
Conclusion

• Lab did not improve understanding of process of science (much)
  – Inappropriate assessment?
  – Inappropriate data analysis?
The speed bumps

- IRB approval took almost a year
- Assessment instruments were faulty
- Lots of overlap with other courses
Future Plans

• Repeat with pre and post tests
• Expand to BIOL 3340 – Cell Biology
• Evaluate goals
  – Process of science
  – Performance in class/standardized tests
Acknowledgements

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  – Amy Chang, Director Education Department
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  – Tris Utschig