Facilitating Laboratory Activities Series

PART 1: Best Practices for Planning and Facilitating a STEM Laboratory Class

Laboratory sections can play an important role in increasing the persistence of STEM majors by providing students with opportunities for practical, relevant learning in science and engineering, and pushing them to identify professionally as a scientists and engineers (Graham et al., 2013). Graduates with STEM degrees are in increasing demand across the world; however, as of 2013, less than half of the three million students entering US colleges as intended STEM majors persisted to graduation in a STEM degree (Graham et al., 2013). Laboratory sections provide important spaces where students can gain a better understanding of key course and STEM concepts by applying those concepts in practical activities. This resource will offer a number of specific strategies and suggestions for effectively planning and facilitating a laboratory section.

Basic principles for planning an effective undergraduate laboratory section

Actively creating connections between lecture material and laboratory activities can help build meaning and relevance for your students. Nilson (2010) emphasizes the importance of placing lab activities in context with course concepts and the bigger scientific picture before moving on to the actual activity. This can help students create connections between the more theoretical concepts they learn in lecture, and the practical application of those concepts in their lab section. Here are a few basic principles to keep in mind when planning your lab section:

Strategies	Teaching Suggestions
Design and assess projects that align with your learning outcomes.	Appropriate goals for a laboratory section could include helping students understand theory by observing and verifying concepts, having them go through a research and design processes, helping them improve their powers of reasoning by manipulating cause/effect relationships, and acquainting them with essential lab equipment. If possible, assess these learning outcomes on exams in ways that reference or depend on some of the learning from lab. This sends a clear message to students that the lab learning is integrated, relevant, and worth studying and really learning.
Use inquiry-guided problem- or case-based learning principles.	These types of assignments are often more “authentic,” in that they model the actual process scientists use in professional laboratories to solve problems. Students are pushed to use their own critical thinking skills and inductive reasoning to develop their own strategies for meeting the challenge, which helps to build relevance to lab activities for students. For more on inquiry-based projects, see Part 3 of this resource, and Part 2 of our “Strategies for Covering Content Series.”
Design activities that develop transferrable skills.	Transferrable skills can include collaboration and group work, oral and written communication skills, organization and project planning, and more (Dunne & Ryan, 2010). By participating in activities designed to develop skills that can be transferred into future lab classes or into the workplace can help students understand the relevance of lab activities beyond the immediate concerns of your class.
Create opportunities for collaboration and teamwork between classmates.	Most scientific and technical projects today are cooperative. By creating collaborative activities, your students will not only gain the opportunity to learn from each other, but will also participate in a more genuine laboratory experience. However, it is important to also scaffold these group activities in ways that help your students develop collaborative skills. For example, you could have students practice working in pairs or small groups on simple tasks, then gradually build up the complexity of the collaborative assignments.

Consider equipment you want to expose your students to.	Ideally, students should be exposed to equipment, materials, and procedures they may need to use again in the future. Whichever equipment you use, make sure it is in working order prior to the lab.

Planning and facilitating an effective lab activity
Given that laboratory activities can often be complex, time-intensive learning tasks for students, it is important that each lab class session be designed to run smoothly. Here are a few suggestions on how to plan and facilitate an effective lab activity:

Strategies	Teaching Suggestions
Plan ahead.	Lab activities should be planned at least a week in advance if possible, and the professor and lab assistants or TAs should rehearse the procedure before the lab sections and review the results afterwards. Make sure that the requirements are feasible for students to complete in the amount of time allotted, and that the productive constraints (recommended ranges or limited quantities of materials to work with) chosen for the activity produce the desired results. Have a TA or lab assistant review the assignment sheet to ensure that the instructions are clear for students.
Make sure to train students in lab safety.	Whenever adapting or developing new labs, it is important to also go over safety and have a clear plan for the necessary safety training for students. It can be productive to include TAs in the brainstorming of hazards and safety concerns, since they bring such valuable experience in this area. The safety office for your department may also wish to be involved in reviewing the lab plans and approving the safety education materials that are planned for TAs and students. One way to train students in lab safety is to have your TAs spend some time discussing hazards and safety concerns before beginning any lab activities, followed by a pre-lab quiz to assess students' understanding.
Have students begin each lab by reviewing the previous week's material.	This can help students see how this lab activity fits into the bigger picture of the course, which can build relevance. For example, you could have students free write about what they remember from last week's lab, and then share responses in small groups. Or, you could create a short quiz on the material from the week before, for students to complete at the beginning of their lab section. These short, low-stakes assessments can also be used to encourage attendance or to assess students' understanding of safety instructions for the lab.
Have TAs go over the main objectives with students prior to starting the lab activity.	Having TAs explain and/or demonstrate the objectives, major procedures, and learning outcomes for the lab can help to ensure that the lab runs smoothly for everyone. Consider having your TAs write "Lab Tips" on the board that outline suggestions for completing the lab successfully, safety instructions, and typical pitfalls and mistakes students can run into. For consistency between sections, you can provide your own suggestions for lab tips and safety during TA meetings, then have your TAs use those suggestions to discuss and generate their own lists as a group. Also, during lab, have your TAs demonstrate new lab procedures, equipment, and handling for special materials for students.
Encourage TAs to take an active role in the lab.	Encourage TAs to play an active role in the lab by observing groups and checking in regularly with students. Students may feel uncomfortable asking questions, especially in the first few weeks of the term; therefore, suggest that TAs to avoid waiting for students to approach them, and encourage them to learn students names.
Leave time for review at the end of the lab.	Make sure to leave time to go over the expected results, and to review the activity as a class. This step helps ensure that students understood and learned from the activity, while also identifying students who may be struggling with laboratory or lecture concepts.

Adapted from: Nilson, 2010 & Stanford Teaching Commons, "Laboratory Teaching Guidelines." Includes contributions from Julia Chamberlain, UC Davis Department of Chemistry.

Additional Resources
For information on designing an effective lecture class to pair with your laboratory section, please refer to our series on "Activating Your Lecture."

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References
Dunne, J., & Ryan, B. (2010). Improving the undergraduate laboratory learning experience through redesigned teaching and assessment strategies integrating transferable skills and focusing on feedback. *Teaching Fellowships, 21,* 46-52. Retrieved from http://arrow.dit.ie/cgi/viewcontent.cgi?article=1017&context=fellow

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science, 341*(6153), 1455-1456.

Hood-DeGrenier, J. K. (2015). A strategy for teaching undergraduates to write effective scientific results sections. *CourseSource.* Retrieved from https://doi.org/10.24918/cs.2016.13

Lantz, V. & Fairfield, A. (2016). *Re-envisioning Introductory Biology Labs: Progressive attainment of inquiry-based biology lab skills by biology students.* Retrieved from cms.montgomerycollege.edu/oit/oitdownloadasset.aspx?id=93322

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of research in science teaching, 47*(4), 474-496.

Nilson, L. B. (2010). *Teaching at its best: A research-based resource for college instructors*. San Francisco, CA: Jossey-Bass.

Stanford Teaching Commons. (n.d.). *Laboratory Teaching Guidelines*. Retrieved from https://teachingcommons.stanford.edu/resources/teaching-resources/teaching-strategies/laboratory-teaching-guidelines