Being a Successful Lab Instructor

Resource Packet

Engineering GSI/IA Teaching Orientation
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Developing a Lesson Plan for Labs

Using your lab materials, create a ten-minute pre-lab overview that you could present to students. To prepare you to present a lesson, answer the following questions. For more information on how to create a lesson plan, review the *Guidebook for University of Michigan Graduate Student Instructors.*

1. **Determine your learning goals** for the lesson—What are the most important concepts, ideas, or skills you want students to be able to grasp and apply? Why are these goals important?

2. **Develop an overview presentation**—It should contain an introduction, the main points or the body, and a conclusion.—What background information do the students need to know? What examples would help them understand this information the best? Will you need to demonstrate any of the equipment or software features to aid in their understanding?
3. **Check for student understanding** by designing the questions you will ask during the lecture/overview and while you are supervising student work—What are some specific questions you can ask your students? What higher order questions might you ask students using Blooms Taxonomy as a guide? Write down precisely how you can state these questions, and then paraphrase them, so that you are prepared with more than one way to ask the questions. Try to predict the answers your questions may generate.

4. **Develop a summary**—At the end of the lab, what are the main points that you want to summarize for students? How might you make stronger connections between the data they collected and the data analysis they will need to do for their lab report? How does the lab relate to material that will be presented in subsequent classes/labs?
Facilitating Labs

The Pre-Lab Introduction

Consider the following five elements in constructing an effective pre-lab introduction.

1. Concepts
   - Begin the pre-lab introduction by going over related concepts from lecture. Assigning a pre-lab quiz can often address these concepts and be a great jumping-off point for the introduction.
   - Discuss with students how concepts discussed in lecture relate to the lab exercise at hand. Use class discussion or small group work to help your students make links between theories or principles and lab practice.
   - Help students make connections between the concepts addressed in the lecture portion of the class and their applications in the lab exercise. As the students begin the experiments or procedures, guide them through the principles and concepts being illustrated through the lab. Students should never leave the lab not understanding the point(s) of the lab.

In some upper-division courses, advanced students may be asked to design and carry out their own experiments. In these situations, students should have the conceptual expertise needed to design experiments that test hypotheses directly related to the scientific theories or ideas in question.

2. Experiment/Procedure
   Outline what the students should do during lab:
   - Briefly go over the lab procedure with students before the lab begins. This helps students focus on the tasks and goals associated with the lab exercise.
   - Mention what they need to observe, draw, record, or note. Put overviews or lists of tasks on the board to help students navigate their lab exercises. Be mindful that the lab experience should be a discovery process and should not feel like following a cookbook recipe.
   - List what the students must hand in after the lab period.

Discuss the scientific method (at least once during the semester) to help guide students through the lab experiments. This is especially important if students are designing the experiments themselves.

3. Data Analysis and Interpretation
   - Review or provide examples of relevant data analysis with the students to help them compile their lab reports.
• Allow students to work on sample data sets in groups or with lab partners. The pre-lab assignment can be helpful here (e.g., see a sample pre-lab assignment): give students sample data to analyze and interpret at home, and incorporate it into your pre-lab introduction.

4. Equipment and Safety Considerations
• It is your responsibility to make sure that students are prepared to conduct the lab in a safe manner.
• Give a short lecture or demonstration on lab safety and chemical and waste disposal. You should receive this information from the course coordinator.
• Introduce and/or demonstrate any unfamiliar equipment or materials, noting any possible safety concerns in using them.

5. General Tips
• Choose an effective format for your lab sessions, and use it if applicable each week. Students will know what to expect every week in lab and can turn their attention to the concepts and procedures involved in each lab exercise. Using a consistent format also makes it easier for you to organize and plan the pre-lab part of the lab section.
• Think about time considerations: One of the most important and difficult aspects of the pre-lab introduction is its length. How much time will you spend introducing the material before students begin the lab? The amount of time spent on a pre-lab introduction will vary depending on the material being presented, so try to judge this accordingly.
• Be aware that students tend to get frustrated and anxious to begin the lab if the pre-lab introduction is too long. Striving for an effective presentation while being brief is a sound (and challenging) goal for a pre-lab introduction.
• Use discussion and interaction as part of the lab introduction: Lecture is not the only format for introducing lab material. Often, working in small groups or having a class discussion is more effective in challenging your students to think about the lab. Students often learn as well or better from each other than they do from the instructor alone.
# Experimental Checklist

<table>
<thead>
<tr>
<th>Completed</th>
<th>Administrative Details</th>
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<tbody>
<tr>
<td></td>
<td>Drop/Add policy and class size limit</td>
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<td></td>
<td>When and where the labs meet</td>
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<td></td>
<td>What help is provided? (graders, lab technicians, etc.)</td>
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<td></td>
<td>How to obtain:</td>
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<tr>
<td></td>
<td>- Supplies for each experiment</td>
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<tr>
<td></td>
<td>- Supplies for general needs (pens, paper, etc.)</td>
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<td></td>
<td>- Photocopies and who pays for them</td>
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<td>Find out who is responsible for:</td>
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<tr>
<td></td>
<td>- Insuring that equipment is operating correctly</td>
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<tr>
<td></td>
<td>- Repairing and/or replacing damaged equipment</td>
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<td></td>
<td>- Ordering lab supplies</td>
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<tr>
<td></td>
<td>- Paying for repairs or replacements</td>
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<tr>
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<th>Information Needed</th>
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<tbody>
<tr>
<td></td>
<td>Class list (via CTools or other means)</td>
</tr>
<tr>
<td></td>
<td>Grade book (via CTools or other means)</td>
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<tr>
<td></td>
<td>Course syllabus</td>
</tr>
<tr>
<td></td>
<td>Copy of the lab book (should be free) and experiments</td>
</tr>
<tr>
<td></td>
<td>Complete list of experiments, the instructions for each and the lab schedule.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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<th>Expectations and Class Policies</th>
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<tbody>
<tr>
<td></td>
<td>What is expected of you by the instructor?</td>
</tr>
<tr>
<td></td>
<td>The goals of the labs and what is expected of you:</td>
</tr>
<tr>
<td></td>
<td>- How much interaction between you and the students does your supervisor want?</td>
</tr>
<tr>
<td></td>
<td>- Should you ask probing questions while the students are collecting data?</td>
</tr>
<tr>
<td></td>
<td>- When should you answer students' questions and when should you encourage them to think through the answers themselves?</td>
</tr>
<tr>
<td></td>
<td>Attendance and make-up policies</td>
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<table>
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<th>Grading Labs/Assignments</th>
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<tr>
<td></td>
<td>What is expected in lab reports/Assignments</td>
</tr>
<tr>
<td></td>
<td>How grades are determined (Rubrics/metrics for grading labs)</td>
</tr>
<tr>
<td></td>
<td>Late policies</td>
</tr>
<tr>
<td></td>
<td>Plagiarism policies</td>
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Adapted from the work of Dayna E. Wilhelm, Virginia Tech.
### Experimental Checklist

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<thead>
<tr>
<th>Completed</th>
<th>Facilities</th>
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<tr>
<td></td>
<td>Locate and check the lab where you will be teaching</td>
</tr>
<tr>
<td></td>
<td>Locate the first-aid kit</td>
</tr>
<tr>
<td></td>
<td>Obtain the key(s) needed for your lab room(s) and any outer doors</td>
</tr>
<tr>
<td></td>
<td>Locate where all of the necessary equipment is stored</td>
</tr>
<tr>
<td></td>
<td>Meet the <strong>lab technician and find</strong> out where he/she can be found, especially before, during, and after lab</td>
</tr>
<tr>
<td></td>
<td>Find out the responsibilities of the lab technician/find out any advice they have for you</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Completed</th>
<th>Safety</th>
</tr>
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<tbody>
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<td></td>
<td>Scout out the location and availability of all safety equipment in the lab.</td>
</tr>
<tr>
<td></td>
<td>If any safety equipment is missing or in disrepair, make sure there is a replacement.</td>
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<tr>
<td></td>
<td>Ask for rubber gloves, a CPR mask and a first aid kit for your lab, if necessary.</td>
</tr>
<tr>
<td></td>
<td>Attend any department-sponsored safety seminars.</td>
</tr>
<tr>
<td></td>
<td>Determine hazards contained in your lab (electrical, mechanical and other equipment, materials, radioactivity). Know how to safely handle and dispose of hazardous material.</td>
</tr>
<tr>
<td></td>
<td>Think about your response to a crisis.</td>
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<tr>
<td></td>
<td>Determine department policy for handling injuries.</td>
</tr>
<tr>
<td></td>
<td>Learn how to operate the fire extinguisher in your lab.</td>
</tr>
<tr>
<td></td>
<td>Learn departmental policy on goggles, lab coats, food and drinks.</td>
</tr>
<tr>
<td></td>
<td>Determine the University's regulations and the role that safety offices, such as OSEH might play.</td>
</tr>
</tbody>
</table>
**Lab Contact List** Do: Complete BEFORE Classes Begin
Be sure to check that all names and numbers are correct if you inherit this list from someone else.

Class Lecture Location/Time: _______________________________________________

Your Lab Location/Time: __________________________________________________

Your Office Hours: _______________________________________________________

**COURSE CONTACTS**

Instructor: ___________________________ Office Number: ______________________

Phone Number: ______________________ Email: _____________________________

Office Hours: ______________________

GSI 1: _____________________________ Office Number: _______________________

Phone Number: ______________________ Email: _____________________________

Office Hours: ______________________

GSI 1: _____________________________ Office Number: _______________________

Phone Number: ______________________ Email: _____________________________

Office Hours: ______________________

**CONTACTS FOR EQUIPMENT/SUPPLIES**

Contact 1 / Role (During Lab Hours): _____________________________

Phone Number: ___________________________ Room Number: ________________

Contact 2 / Role: _____________________________

Phone Number: ___________________________ Room Number: ________________

Contact 3 / Role: _____________________________

Adapted from the work of Dayna E. Wilhelm, Virginia Tech.
**Experimental Checklist**

Phone Number: ___________________________ Room Number: ________________

**Sample K-W-L checklist for students to fill in an experimental lab**

Name: ___________________________
Date: ___________________________

**Lab Name**

Instructions: **Before** entering the lab, please fill in the **K** box with what you already **know** and the **W** box with what you **want to know** about the experiment. Pay particular attention to the following aspects of the experiments: (1) concepts behind experiments (2) experimental procedure (3) safety aspects (4) data analysis (5) report writing. At the end of the lab, please fill the **L** box with what you **learned** in lab today.

<table>
<thead>
<tr>
<th>K (What you know)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>W (What you want to know)</td>
<td></td>
</tr>
<tr>
<td>L (What you learned)</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from the work of Dayna E. Wilhelm, Virginia Tech.
Debugging Policies and Procedures Checklist

Teaching Debugging

BEFORE Assigning Programming Projects:

- **Debugging Tools.** Determine which debugging software/tools may be useful and conduct a short tutorial for the students. Example tools include:
  - Print Statements
    - Basic data types
    - Compound data types
    - Use of conditionals to print portions of a data structure
  - Assertions
    - Use of assertions in programming language chosen
    - When they should be used
  - Programming Internals
    - Stepping (into/over functions)
    - Breakpoints
    - Data values
- **General Debugging Guidelines.** Provide your students with “Debugging Tips” page as well as any other debugging guidelines appropriate for your class.
- **API.** Make sure students know how to look up and use the API. Also encourage students to document and write API for their functions.
- **Unit Testing.** Encourage students to conduct unit testing for each function/module.
- **Policies for Debugging Questions.** Determine your policies for what types of debugging questions are appropriate. See “DURING Computer Labs” below. Make sure students are aware of your policies.

Helpful Tools
The following tools may be useful for debugging depending on the environment and programming language used.


Common Segmentation Fault Errors

- Null pointers
- Data not initialized
- Array/vector index out of range
- Some errors are fixed by compiling with “make all” instead of “make”. Try deleting *.o before compiling again.
Debugging Policies and Procedures Checklist

Group Work Policy

**DURING Computer Labs**

- **Help Policy.** Determine your policy for answering debugging questions. One possible policy is to require students to complete/attempt General Debugging Steps 1-3 BEFORE they ask for help. This encourages students to debug before asking for help.

- **Queue Policy.** Determine your policy for the order in which you answer questions. One possible policy is to assign numbers to students who have questions or ask them to write their name in a queue on the white board. This lets students continue to debug/work while you are helping others as opposed to students standing in line.

- **Collaboration.** Determine if students are allowed to collaborate during lab and help each other debug. If collaboration is allowed, encourage students to help each other.

*TIP:* Encourage students to think about why and when the problem occurs. Have them explain to you on paper what happens to the input and the variables as they walk through the program. Ask them if the program actually does what they say it does. If not, when does it veer off. Help guide students through debugging.

**Debugging Tips**

**General Debugging Steps**

1. **Reproduce it.** Make sure you can reproduce the error before you start debugging.

2. **Reduce input.** Determine the smallest input that causes the error. The smaller the input, the easier it will be to find the error.

3. **Isolate problem code.** Isolate the portion of your code causing the error. You can do this by tracing the data’s flow through your program. At the start of each function, do the variables contain the values you expect? Do the functions return what you expect? Isolating the function or lines of code causing the error will help you find the solution.

4. **Experiment.** Hypothesize a potential cause for the bug. Then test to see if your hypothesis is correct by changing the input or code to either rule out the hypothesis or confirm it.

5. **Experience.** Think if you have had this type of error before and what the solution is. Do an online search or talk to others. Sometimes, explaining the problem will help you discover the problem.

6. **Never Give Up.**
Working with Groups

Working with Groups: Strategies for Managing Conflict

You will have to monitor the group dynamics of the teams in order to ensure a fair and productive learning environment in the lab. Some lab groups do not work efficiently because of internal conflicts or problems with group dynamics. Often the reason is a difference in work style. Some students may be highly self-motivated to complete each detail of the lab and will focus intently on that task. Others may be either more passive or leisurely about completing lab tasks on time. When students with different work styles are placed in the same lab group, the more self-motivated students will tend to set the pace, lead the task, and do more of the work. This unequal participation and differences in work style can cause group conflict.

Conflict Scenarios
Below are four common problems when working with laboratory teams and some suggestions for resolving the issues:

- **Unequal work effort on a team.** It is important that all members of a lab group contribute equally, and participate actively in the experiment. If you find that one partner is “hogging” the equipment, you should ask him or her to share responsibility. A subtle way to do this is to ask the partners to switch seats. You might find that one member is not pulling his or her weight. Ask the team to assign each person different roles. If this doesn’t work, address the issue directly. You should watch closely for this kind of behavior when students are working in groups of three.

- **Slow paced team:** Some lab groups work more slowly than others. If a group is lagging behind because all team members are coming to lab not prepared, address the issue with the students and consider a participation grade penalty. If a group makes a mistake and must redo part of the experiment, help them to work more efficiently. If the group understands their mistake and time is running out, consider having them obtain data from another group so they can complete the analysis. Have the slow group explain their error and how to correct it. Most laboratory activities have been timed to allow students to finish on time, so it is inappropriate for students finish late or make up the lab. Make sure that you as the GSI do not cause them to delay because of a lengthy pre-laboratory lecture.

- **Team members not getting along.** If a lab group is not getting along, identify the root of the problem: is one student prepared and the other not? Is there a personality conflict? After identifying the cause, discuss the issue with them maturely and quickly; if no resolution is likely

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1 Portions of this section adapted from Allen, O’Connell, Percha, Erickson, Nord, Harper, Bialek, Nam, 2009
within the class period, remind them that it is their responsibility to complete the experiments in a timely manner and do your best to help them finish the day’s work. If the issues persist beyond one to two laboratory periods despite your intervention, then explore changing the grouping. (Be sure to discuss the change with the other group involved before making the change.) You may have to pay more attention during this particular class to help the students complete the day’s work, to communicate, and to prevent them from distracting other groups.

- **Plagiarism between team members.** Discussion between group member and across groups about physical principles is an important part of learning in the lab and is encouraged. However, sharing of answers or direct use of someone else’s results is not in the spirit of ethical collaboration. It is up to the GSI to be clear about course policies on plagiarism, and to be vigilant enough in the classroom to help students recognize and understand what is considered cheating. If an incident of data or result plagiarism occurs, remind the students that it is not allowed and describe to them the course policy penalty. It is always a good idea to report issues of plagiarism to your GSM or the course instructor including documentation on the date, the details of the incident, and the outcomes of the incident.
# Bloom’s Revised Taxonomy

The purpose of this model is to classify thinking based on six cognitive levels of complexity.

<table>
<thead>
<tr>
<th>Bloom’s Taxonomy</th>
<th>Sample Question Stems</th>
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</table>
| **Creating**     | • What would happen if …?  
                   | • Suppose you could … what would you do …?  
                   | • How would you estimate the results for …?  
                   | • How would you test …?  
                   | • What could be done to minimize (maximize)? |
| **Evaluating**   | • Is there a better solution to …?  
                   | • What changes to … would you recommend?  
                   | • How effective are …?  
                   | • What do you think about …?  
                   | • How could you determine …? |
| **Analyzing**    | • Why did … changes occur?  
                   | • How is … similar to ….?  
                   | • Can you distinguish between …?  
                   | • Why do you think …?  
                   | • What is the relationship between? |
| **Applying**     | • How would you use …?  
                   | • What examples can you find to …?  
                   | • What factors would you change if …?  
                   | • Would this information be useful if you had a …?  
                   | • How would you apply what you learned to develop …? |
| **Understanding**| • Can you describe in your own words …?  
                   | • What do you think could happen next …?  
                   | • What was the main idea …?  
                   | • Can you distinguish between …?  
                   | • What differences exist between …? |
| **Remembering**  | • What is …?  
                   | • How would you explain …?  
                   | • How would you describe …?  
                   | • Can you recall …?  
                   | • How would you show …? |

Sample Questions and definitions adapted from the following websites:
http://www.cccs.edu/Docs/Foundation/SUN/QUESTIONS%20FOR%20THE%20REVISED%20BLOOM.doc

### Sample Verbs for Bloom’s Taxonomy

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<tr>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
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<td>Arrange</td>
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<td>Calculate</td>
<td>Break down</td>
<td>Appraise</td>
<td>Assemble</td>
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<td>Construct</td>
<td>Combine</td>
<td>Argue</td>
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<td>State</td>
<td>Translate</td>
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<td>Test</td>
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Being a Successful Lab Instructor

Engineering GSI Teaching Orientation
January 7, 2012

Bill Lloyd (billlloyd@umich.edu)
Courtney Peckens (cpeckens@umich.edu)

Goals for the Session

You will be able to:
- Have a better idea of what to expect when leading a lab
- Identify principles to effectively prepare for lab sessions
- Apply these principles via interactive discussions and case studies
- Formulate thought-provoking questioning techniques
- Identify resources to support lab instructors

What makes teaching a lab unique?

Grading Issues – Concurrent Session B

Presenting Lectures
- Organizing Group Work
- Asking meaningful questions
- Leading hands-on learning

See Resource Packet, Pg. 15-16

Teaching Problem Solving – Concurrent Session B

What should an ideal lab look like?

Think

Pair

Share

General Principles for Labs

What does the instructor do before the lab?

Read
- Assigned activity in the lab manual
- Familiarize yourself with theory, concepts and terms
- Develop supplementary materials (handed out, guided questions)

Know
- Familiarize yourself with the equipment and/or software
- Ask your GSI/As/teachers about problems or limitations of equipment/software
- Be aware of safety issues

Perform
- Carry out the exercise/analysis at least a week before the class session
- Identify potential student problems
- Make a list of anticipated student questions and answers
- Think about the timing of each task in the exercise

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See Resource Packet, Pg. 15-16

Teaching Problem Solving – Concurrent Session B

What should an ideal lab look like?

Think

Pair

Share

General Principles for Labs

What does the instructor do during the lab?

Introduce
- Begin on time
- Provide brief introduction to the day’s activities
- Demonstrate difficult techniques/procedures

Interact
- Walk around the room and make yourself available to students
- Ask students questions based on your list of anticipated questions
- Inform the entire class if there is a recurring problem or misconception

Conclude
- Walk around the room and make yourself available to students
- Ask students questions based on your list of anticipated questions
- Inform the entire class if there is a recurring problem or misconception

Adapted from “Instruction at FSU: The Florida State University Academic & Professional Program Services A guide to teaching and learning practices”
Case Study Analysis

Case Study 1: Sam in a computational lab
Case Study 2: Jamie in an experimental lab

- What are the issues in these cases?
- What can the instructor do to improve this situation? Generate several possible suggestions.

Be prepared to share your responses with the group

Case Study Overview

Case Study 1: Sam in a computational lab
- Extremely familiar with the course material (minimal effort)
- Consistently refers students back to manuals, textbook, etc
- Sam is concerned that students only complete half the lab

Case Study 2: Jamie in an experimental lab
- First-time teacher in sophomore-level lab
- Groups of students slow to do work (or get material wrong)
- Jamie concerned that students are not learning

Common issues in labs

- Instructors are often
  - Not familiar with concepts, lab exercises, and/or techniques
  - Unable to help students understand material
  - Giving answers instead of making students think
  - Unavailable to students outside lab

- Students are often
  - Unprepared and spend lab time reading manuals & instructions
  - Lacking conceptual understanding
  - Unable to design experiments to meet objectives
  - Unable to timely analyze data and write reports


Strategies for Ensuring Student Preparation

- Assign advance readings
- Require pre-lab write ups
- Give short quizzes
- Discuss important laboratory procedures
- Create K-W-L checklists
- Pose questions using Bloom’s taxonomy

Adapted from Instruction at FSU The Florida State University Academic & Professional Program Services A guide to teaching and learning practices

K-W-L Checklists

Know it, Want to know it, Learned it

- Great way to find out student needs (see page 12 in Guidebook)
- Have students enter class with a list of what they know and want to know for the lab
- Start class with a survey of what needs to be addressed from the KWL checklist
- Review the “Learned it” items at the end of class

- How might you use this approach in your lab?

See sample KWL checklists in your packet
What questions can you pose to students? (Bloom’s Taxonomy)

Low order thinking

- Remember
- Understand
- Apply

High order thinking

- Analyze
- Evaluate
- Create

Develop checking questions

- Think about a lab assignment for a class you will teach
- Using Bloom’s Taxonomy, brainstorm as many checking questions as possible from the ‘Remember’ and the ‘Create’ levels

Solving Problems in Labs

- When solving problems
  - Have the problem solving process unfold to reveal solution
- You need to:
  - Guide student to figuring it out themselves
  - Support effort but acknowledge mistakes
    - Emphasize learning
- Students need to:
  - Struggle, persist, struggle some more!

Summary

Before the Lab

- Read
- Know
- Perform

Ensure students are prepared

- Pre-labs
- K-W-L checklists
- Ask questions (Bloom’s Taxonomy)

During the lab

- Demonstration
- Description
- Interaction

Resources

- “Leading a Lab Section” Resource Packet
- GSI Guidebook (Part Six: Leading Laboratory Sections)
  http://www.crlt.umich.edu/gsis/gsi_guide.php
  - Laboratory Safety
  - Strategies for Managing Discussions with Groups in the Laboratory Class
  - Grading Laboratory Reports (with sample rubrics)
- Concurrent Session B
  - Grading: Policies, How-to, and Tips
  - Teaching Problem Solving Skills
  - Handling Office Hours
- Engineering Teaching Consultants
  http://www.engin.umich.edu/teaching/crlltengin/gsi_serv/etcwebrequest.html

Any Questions?

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General Principles for Labs
What does the instructor do before the lab

- Prepare a short overview of the lab

Outline learning objectives
Plan the main body of the lesson
Plan to check for understanding
Develop the introduction

http://www.crlt.umich.edu/gsis/P2_5.php

Managing Groups

- Desired students skills:
  - Leadership.
  - Time management.
  - Communication.
  - Problem solving.

- Effective skill development of teamwork:
  - Individual accountability.
  - Interpersonal skills.
  - Self-assessment of personal and team functioning.

(Woods, Felder, Rugarcia, Stice, 2000)