Ghulam Ishaq Khan Institute of Engineering Sciences and Technology (GIKI)

Faculty of Engineering Sciences (FES)

ES Pedagogy – Lab Instructors' Handbook

What is this Handbook About?

Laboratory classes provide students with first-hand experience with course concepts and with the opportunity to explore methods used by scientists in their discipline. Leading a laboratory session has particular challenges and opportunities that differ from those in a standard classroom environment.

At GIKI-FES laboratory classes are typically led by graduate student TAs. The TA needs to know and review the experiment, plan clear explanations, and create questions to stimulate student thinking. In addition, it is the responsibility of the TA to ensure that safety standards are followed. This handbook contains a variety of resources to help TAs insure that they, and the undergraduate students they teach, get the most out of the laboratory class.

What are the Typical Goals of a Laboratory Class?

Potential **goals** of laboratory classes include:

- Develop intuition and deepen understanding of concepts.
- Apply concepts learned in class to new situations.
- Experience basic phenomena.
- Develop critical, quantitative thinking.
- Develop experimental and data analysis skills.
- Learn to use scientific apparatus.
- Learn to estimate statistical errors and recognize systematic errors.
- Develop reporting skills (written and oral).
- Practice collaborative problem solving.
- Exercise curiosity and creativity by designing a procedure to test a hypothesis.
- Better appreciate the role of experimentation in science.
- Test important laws and rules.

- Develop an appreciation for research in the field.

What Should I Consider When Preparing to Conduct a Lab?

As you **prepare** to conduct a lab, consider the following questions:

- Will I be able to do the lab myself before class?
- Am I familiar with the materials and equipment?
- What are the safety considerations?
- Would it help if I gave my students a handout highlighting key theoretical, procedural, and safety points?
- How can I link this lab to the professor's lecture?
- How can I clearly communicate the criteria used in grading the lab reports?
- What kind of preparation should my students do before they come to lab?
- What tips can I give my students, so they can complete the lab successfully within the time allotted?
- Would it be helpful if I demonstrated new techniques to the students?
- How will I monitor student progress in the lab?
- Where might my students run into difficulty completing the experiment?
- What kinds of questions should I ask my students to stimulate their thinking and to encourage deeper understanding of the experiment?
- How can I help the lab pairs/groups to work together well?

What are Some of the Best Practices to Follow During the Lab?

- Establish the specific goals of the lab (write them on the board)
- Prepare an outline (on the board) of the lab activities
- Do not hesitate to explain things more than once or answer questions that you may consider simple (this will likely save you from headaches later on)
- Demonstrate new techniques to the class or small groups
- Review safety issues for the lab
- Visit with each student individually during the lab
- Ask specific questions of the students in order to monitor their progress during the lab

- Provide ample feedback to students during the lab

What are Some of the Best Practices to Follow When Grading Lab Reports?

Grading Lab Reports (suggestions for providing constructive, formative feedback)

- Ensure that your grading scheme is consistent with course policy.
- Determine whether students understood the lab.
    - Assess whether many students missed a critical concept.
    - Evaluate whether students drew reasonable conclusions from the data they collected.
    - Reward creative and rational but unconventional thought in application of principles.
- Read, evaluate and return lab reports in a timely manner with cogent feedback.
    - Help students improve by telling them how they could have done better.
    - Focus comments in specific areas rather than on the report as a whole.

What Makes a Good Lab TA?

In their feedback to TAs, students indicate that they appreciate lab TAs who:

- Summarize the theory and procedure briefly before the students begin the lab.
- Demonstrate new techniques.
- Relate the lab to the lecture and to real world applications.
- Are willing to help and answer questions.
- Walk around and check with students to make sure that they are making progress.
- Ask questions that make students think more deeply about what they are doing and why.

What Safety-Related Matters Should I Consider?

Safety is always an important concern in teaching laboratories. Consult the faculty lab coordinator with questions about departmental safety policies. In particular, make sure that a brief “Lab

Guidelines and Safety Instructions" page is added to the lab manual and also posted in the lab room for easy access. Such a page must include clear instructions/info on:

Lab Environment and Conduct

Handling Equipment

Reporting and Returning Equipment

Preventing Electric Shock

Preventing Other Bodily Harm (e.g., Soldering Precautions)

Fire, First Aid, and Emergency Numbers

Also make sure that emergency equipment (fire extinguishers, first-aid kits) are easily accessible and known to students.

Are there any Training Courses I can Take for Lab Instruction?

Apart from FES organized trainings/meetings, it may be possible to find free online courses for improving lab instruction skills. One such course is offered free by Coursera (with a certificate).

Teaching in University Science Laboratories (Developing Best Practice)

What is an Open-Ended Lab?

A lab experiment may have different levels of "openness" in that how much it leaves to the students (see Tables below). In planning a lab course, special attention should be given to the experiments - such that they gradually become more open-ended.

Table-1. Level of Openness according to Schwab-Herron

Schwab/Herron Levels of Laboratory Openness			
Level	**Problem**	**Ways & Means**	**Answers**
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

Source: McComas (1997)

Table-2. Scientific Enquiry Rubric

Establishing the level of independence and autonomy expected of students to carry out an assessment task	
Level of Enquiry	**Description**
0	The problem, procedure and methods for achieving solutions are provided to the student. The student performs the experiment and verifies the results with the manual
1	The problem and procedure are provided to the student. The student interprets the data in order to propose viable solutions
2	The problem is provided to the student. The student develops a procedure for investigating the problem, decides what data to gather, and interprets the data in order to propose viable solutions
3	A "raw" phenomenon is provided to the student. The student chooses the problem to explore, develops a procedure for investigating the problem, decides what data to gather, and interprets the data in order to propose viable solutions

Source: Fay *et al.* (2007)

What if I Have More Questions?

Faculty Lab Coordinators and/or members of the ES Trainings Unit can be approached for further queries.

Sources:

- Science Teaching Reconsidered, National Academy Press, 1997
- Center for Instructional Development and Research, University of Washington
- Teaching Resource Center, University of Virginia
- Center for Teaching, Vanderbilt University