Chapter 8
Teaching with Practicals and Labs

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Over the last 50 years, medical education has seen an increase in time devoted to didactic teaching and a significant decline in the amount of time devoted to laboratory teaching and learning. The reasons for this are multifaceted, and the end result is not only unfortunate but ignores sound educational and learning theory. We hope that the fact that you are reading this chapter indicates your interest in reversing this trend and that you will find the information helpful as you incorporate laboratory exercises into your teaching repertoire.

Benefits of Laboratory Teaching

Laboratory teaching is one form of active learning, or the process of having students engage in an activity that forces them to reflect on ideas and how they are using those ideas. Knowledge is gained through a cycle of hands-on experience with reflection guided to conceptualization and then returning to application. When complemented by self-assessment the student's understanding and skill are further enhanced.

Laboratory teaching requires a change from teacher-focused lecturing to student-focused learning. Far from relieving the instructor from responsibility, laboratory teaching can increase the effort and time required of teachers, at least early in the transition from didactic lectures. The benefit? Increased student interest, attention, and knowledge retention. Most, although not all, studies suggest enhanced information transfer as evidenced by improved exam scores compared to students taught in didactic curricula. In addition, the majority of laboratory exercises are group learning events. This facilitates better solutions to problems, increased mastery of conceptual reasoning and retention compared to learning alone. These exercises can also develop critical skills in communication and team dynamics.

Laboratory teaching is often an opportunity to involve clinicians early in the science curriculum. The potential advantages are great – the students' education

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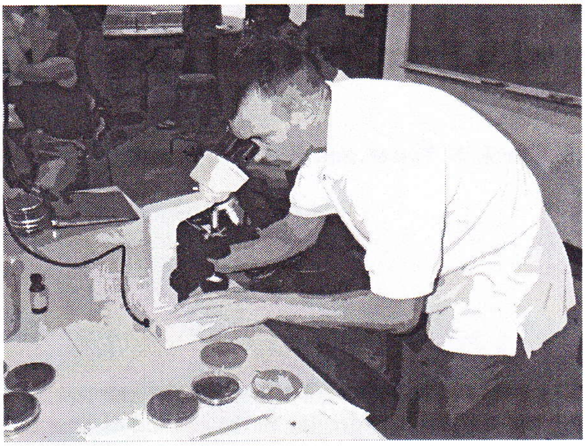


is enhanced by participating in an active learning exercise, the basic scientists are rewarded by interested and motivated students who can apply core concepts, and the clinicians benefit from early exposure to students, thus increasing student interest in their field.

Examples of Laboratory Teaching

Before we get into the nuts and bolts of how to conduct successful laboratory learning opportunities, here are a few examples of places they might be incorporated into an undergraduate medical curriculum. A word of caution – time in an undergraduate curriculum is scarce, and the addition of hours to an already overloaded schedule is often impossible. However, some schools have been able to use well designed laboratory teaching to decrease overall curriculum time. Creativity and cooperation among instructors along the basic science and clinical continuum are required to determine whether laboratory teaching is feasible, whether it can supplant current didactic curriculum, or whether it can be added without increasing student curricular hours.

Gross Anatomy

Clearly, gross anatomy is one of the prime examples of laboratory teaching, although it has changed with the advent of computer simulation and prosected models as many medical schools have moved away from cadaver-based dissection. This specific example pertains to a small exercise within the overall gross anatomy course. At our institution, clinicians, primarily surgeons, participate in the gross anatomy lab in order to focus the students on why learning anatomy is important. Several times during the semester, these clinicians come to the anatomy lab to demonstrate procedures on the cadavers – central line insertion, chest tube insertion, tracheostomy, and laparoscopic cholecystectomy. The students are given a handout before each session that describes both the technical details of the procedure and the relevant anatomy. Clinicians teach the procedure at the "bedside" of each cadaver, allowing interested students to perform the procedure. Clearly, the first year students will not become proficient in chest tube placement after this exercise. However, they have a better understanding of why time spent learning anatomy is important, and they sincerely appreciate the early interaction with clinicians.

Biochemistry/Physiology

A significant percentage of people with diabetes are unaware of their condition. The majority of medical students will treat patients with diabetes in their practice, and many will have the opportunity for initial diagnosis. To highlight some of the management issues facing patients with diabetes and teach about glucose metabolism, first-year students participate in a blood glucose lab in the biochemistry course in our curriculum. Students come to class after an overnight fast, learn how to use lancets to draw blood for measuring their own blood glucose, and take a baseline reading. They then eat breakfast provided for them, either high fiber, high simple sugar, or high fat. Glucose readings are taken throughout the morning, and students compare their glucose values with each other. Thus they are able to understand why dietary modification is an important part of diabetes management. They participate in discussions led by a diabetes educator, nutritionist, family practitioner, and biochemist.

A similar laboratory centered around the diagnosis and management of metabolic syndrome is held at the Indiana University School of Medicine. The initial lab teaches students how to draw blood from one another. Students then measure fasting blood triglycerides, high-density lipoproteins, glucose, blood pressure, and central obesity on each other. They are then randomized to eat a regular meal or a meal that follows the National Cholesterol Education Program Step I or II diets. Often with repeated measurements, discussion about physiological, nutritional, and behavioral components of the syndrome ensues.

Clinical Procedures Laboratory

There is a laboratory rotation at the Medical College of Wisconsin that was developed to provide students with sufficient exposure and experience in caring for patients with life-threatening disease. The rotation includes having the students read chest radiographs with examples of traumatic pathology, placement of chest tubes and performing a cricothyroidotomy in a mannequin, placing skeletal traction devices on one another, and reading computed tomographic scans. All skills are performed with a faculty instructor in a small group setting in the context of case-based scenarios.

The key to this type of lab experience is the integration of didactic discussion with the laboratory and simulation experience. Furthermore, allowing the students to work in small groups makes them active participants in the educational process. Providing students with multiple ways to learn the material increases their enthusiasm as well as their understanding of the concepts. Similar experiences exist in many other places; some may be an entire course or rotation, while others are smaller components of larger rotations that may combine several different learning experiences.

This is clearly not an exhaustive list. Other successful laboratory exercises include performing electrocardiograms during a cardiac physiology unit, measurement of pulmonary function before and after exercise to demonstrate respiratory physiology in action, participating in noninvasive ventilation to learn about various ventilator modes, and others. Orthopedic labs use power tools and clamps purchased at the hardware store, and porous hard foam to simulate bones.

Developing Goals and Objectives for Laboratory Teaching

It is tempting to jump on the laboratory exercises bandwagon based on enthusiastic student response and belief in a good idea. BEWARE – laboratory exercises are meant to be part of an educational program, and must have clear goals, objectives, and outcomes assessment. Without these, they might be fun, but may not result in improved knowledge or skill, and will certainly require precious faculty time. The following mnemonic is helpful in constructing objectives.

SMART Objectives (Features of Objectives)

1. Specific.
2. Measurable.
3. Achievable.
4. Realistic (or results oriented).
5. Timeframe.

Goals and objectives for laboratory teaching will depend on the level of the student and where the laboratory is placed in the curriculum. They will also depend on whether the laboratory exercise is designed to supplant or enhance current curriculum.

A couple of examples illustrate the range of possible objectives. In the case where the exercise is supplanting didactic, teacher-based learning, existing goals and objectives will likely need to be covered. In the case where the exercise is

enhancing current curriculum, existing goals and objectives should be modified or additional ones developed. Several broad goals are possible, including skill acquisition, integration of basic science and clinical concepts, and early introduction of clinical faculty to medical students.

If the goal is skill acquisition, the objective would be demonstration of technical competence or proficiency. This is exemplified in the clinical procedures rotation above; the students are expected to demonstrate correct performance of a cricothyroidotomy and chest tube placement on a mannequin. For the clinician involvement in gross anatomy described above, the two goals do not relate to skill acquisition despite the fact that the laboratory experience is skill-centered. The goals of the lab are recognition of the importance of anatomy and early exposure of first-year medical students to practicing clinicians; the objectives are naming important anatomic structures relevant to each skill and individual conversations between students and clinicians. Similarly, the goal of the glucose lab is to understand the importance of diet and nutrition in the management of diabetes, with the objective of demonstrating differences in blood glucose after ingestion of different meals.

Assessment of Laboratory Teaching Exercises

It is important to consider assessment of student learning, or performance, as a well defined aspect of the educational experience. Both formative and summative assessment strategies may be applied to the laboratory setting. Assessment should be linked to the goals, objectives, and instructional methods in a manner that makes intuitive sense. If the objective is to identify the anatomic structures of the hand, then the assessment tool should include some form of labeling activity. For labs designed to teach skill acquisition, the appropriate method of assessment should be demonstration of the skill or a formal Objective Structured Assessment of Clinical Skill

Table 8.1 Matching of goals/objectives with assessment methods for lab exercises

Objective	Assessment method
Skill acquisition	Skill demonstration OSCE OSATS
Knowledge acquisition	Multiple choice examination
Decision making/critical thinking	OSCE
Influence or determine perception or opinion	Survey Questionnaire

(OSCE) or Objective Structured Assessment of Technical Skill (OSATS). If the laboratory exercise is designed to enhance knowledge acquisition, a traditional multiple choice question (MCQ) examination is sufficient. To assess deeper understanding and decision making, an OSCE can provide excellent formative and summative information. For laboratory exercises that are designed to influence perceptions, surveys or questionnaires are best (Table 8.1).

How to Set-Up a Lab Exercise

Laboratory set-up consists of two parts – instructor preparation and space/equipment considerations. Although space and equipment are clearly important, it is far more likely that instructor preparation will not get enough attention. Many teachers, comfortable with teacher-centered didactic instruction, will either not feel the need or not know how to do any preparatory work for a student-centered laboratory exercise. Inexperienced leaders of these exercises often make the assumption that facilitating student-centered learning is something that anyone who has been in an instructor/teaching role can do. The instructors or facilitators should receive a copy of the goals and objectives for the laboratory exercise, as well as the assessment tool, before the lab. They should be familiar with the conduct of the lab, and for a skills lab should be able to perform the skill with the available equipment. The students do not want to hear "well, this isn't really the way I do it" or "I'm really not sure why they are having you do it this way."

Instructors may need an instruction or refresher on "how to teach" active learning. A part of this introduction may need to address biases against active learning:

1. It lessens overall quality – the students could be listening to me lecture rather than doing this silly grade-school exercise.
2. Teaching does not occur unless knowledge is transferred from one individual to another.
3. An instructor's job requires that all material must be covered in the allotted time.

Specific behaviors that promote success in an active learning environment include:

1. Moving around the room and interacting with multiple students.
2. Asking directed or targeted, open-ended questions of specific students.
3. Asking students to reflect on what they have found, what it means, why it happens/happened.
4. Ensure that all students have a chance to participate.

Student preparation is also key. One of these tenets of active learning is that not all learning occurs within the classroom setting. The students should receive any necessary background material prior to the lab exercise, along with a copy of the goals and objectives of the exercise.

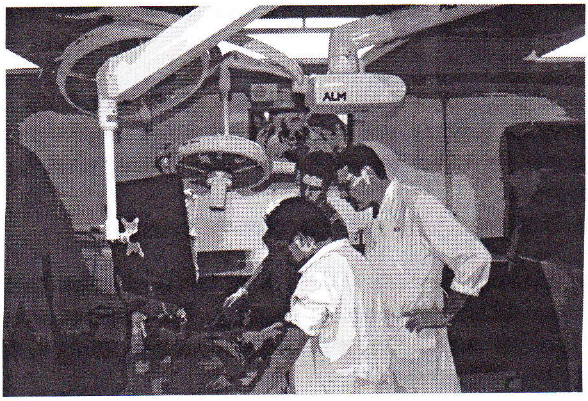
Space and equipment considerations and constraints may guide the lab design, although some may be lucky enough to be without constraints. Labs with a single user group require a larger space and less equipment; those with multiple smaller groups can make use of several smaller areas but require more equipment and most often more instructors or facilitators. Grounded electrical outlets with power from either ceiling or floor, special plumbing filters for biohazard material, sinks, freezers, work tables and cabinet space are all additional considerations. Demonstration videos are a nice alternative to live demonstration, particularly when expensive materials are needed; this requires specific AV and computer equipment.

Consumable supplies can be ordered, but can often be recycled from various places in the hospital. We work with our operating room and supply distribution center to appropriate all usable outdated or expired supplies. This helps keep lab costs down, always important but even more so if the lab is an addition to existing curriculum rather than a replacement. Other ways to reduce costs include collaboration between groups to use all parts of a cadaver and homemade simulators rather than commercially available ones. Wooden slats, plastic wrap, foam and foam tape make a reasonable "simulator" for teaching chest tube placement for a much lower cost than commercially available simulators. Additional options for lowering cost include sharing more expensive resources across several rotations.

Conducting the Lab

Now the fun begins! It is at this point that the focus switches from the teacher to the student and true student-centered, active learning occurs. Make the students commit to an answer prior to performing the exercise or lab – they will retain the information discovered during the lab much better when required to think through the problem and verbalize the answer beforehand. If possible, encourage the students to work in small groups to benefit from each other; however ensure that groups are not dominated by a single student.

For skills or procedures, an initial demonstration is imperative. Following the demonstration, some students will want to jump right in and others will want to observe a few more. To a point, this is fine, and likely reflects different learning



styles. The instructor's job is to ensure that each student gets enough opportunity to learn and practice. If a student is having difficulty, break the skill down into component tasks and demonstrate each one, having the student practice with immediate feedback.

A potential downside of a student-centered learning environment is that students will not discover or learn the particular point envisioned by the instructor. Under these circumstances you should re-evaluate the exercise and improve preparation. It's important to clearly delineate the objectives and assess how they will be met. However, problems may also be specific to a particular group of students, so don't change things too quickly. Gaps in achievement of lab objectives can be easily overcome by an attentive instructor. At the conclusion of the lab, the instructor should summarize to ensure that the key points have been made and all of the goals and objectives met. A short summation speech is one way to do this, although it can also be done by eliciting responses from the students and supplementing anything that is missed.

After the Lab

Similar to lab set-up, there are two aspects to consider after the lab is finished. First, the assessment must be complete – often an evaluation is worthwhile even if an MCQ exam or skills demonstration has been the primary method to assess the learner. Prepare good session evaluation forms to get feedback from both students and the instructor. This can be a tremendous help to improve future labs. Furthermore, these evaluations have importance in documenting academic scholarship for the instructors, thereby providing more incentive for faculty participation.

Supplies should be inventoried, and may need to be reordered prior to the next lab. Cleaning, maintenance, and ongoing evaluation of nonconsumable supplies are all necessary to determine whether capital expenditure is required for new equipment.

Pitfalls

The primary result of an unsuccessful laboratory exercise – whatever the reason for lack of success – is that the students will not learn what is intended. Almost all pitfalls are avoidable with a little preparation; it would be a shame to have the work invested in an active learning exercise not result in excited and accomplished learners (Table 8.2).

Table 8.2 Potential pitfalls in laboratory teaching

Pitfall	Undesirable outcome
Lack of goals and/or objectives	Waste of faculty time No learning occurs
Unprepared or uncomfortable instructors	Disinterested students No learning occurs Instructor attrition
Learning objective not covered	No learning occurs
No assessment strategy	Inability to judge success of experience Unclear if learning occurs

Summary

There are many opportunities to incorporate these exercises into medical education. With a little preparation, the change in focus from teacher-focused lecturing to student-centered active learning in a laboratory setting can benefit both.

For Further Reading

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