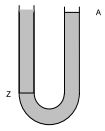
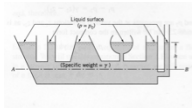
THE ROLE OF EXPERIMENTS IN INDUCTIVE TEACHING

Essentials of Learner-Centered Teaching

Example: Lecture vs. **Experiment**



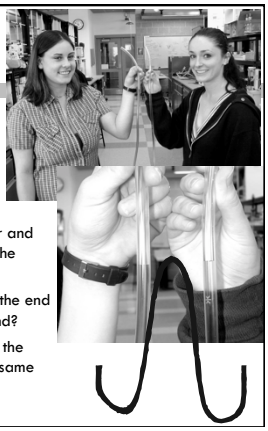
Hydrostatic pressure is the pressure exerted by a fluid at rest due to the weight of the fluid. Consider the system shown below, in which a liquid with a known density (ρ) fills a U-shaped tube. It is assumed that the pressure is known at some point A (such as a surface exposed to atmosphere), and is desired at a point Z. The hydrostatic pressure difference between two points in the same fluid is given by .



$$P_Z = P_A + \rho g\left(h_A - h_z\right)$$

Where h_A and h_z are the measured elevations (from a defined reference point) of points A and Z, and g is the gravitational acceleration.

Example: Experiment



1. Start with a plastic tube filled with water.
2. Have 2 people hold 2 inches from each end of the tube and pick it up.
3. Holding the ends next to each other and examine if the water levels are at the same height.
4. What happens if one person holds the end of the tube higher than the other end?
5. How high can you lift the middle of the tube while keeping the ends at the same height?

Discuss – What was learned

- Fluid levels are always at the same height.
- Pressure difference required for fluid to flow
- Manometer tubing –
  - Only open ends matter
  - Pressure balances within the U loops.
- Did you have fun?

Next Steps

- Mini-lecture relating experiment to equations
- Reading outside of class
- Assign homework problems
  - Manometer
  - Pressure at top of loop

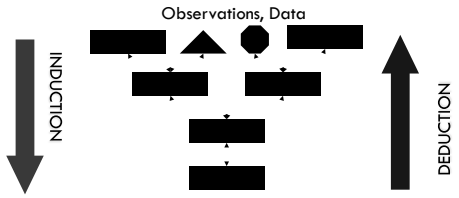
$$P = \rho g h$$

$$\frac{\mathrm{d}P}{\mathrm{d}z} = \rho g$$

Discussion

- How do you think this would help your students learn the principles of statics?
- What is the purpose of a lab or demo? (introduce ideas, reinforce ideas, etc.)
- Group Discussion (no worksheet)

Induction vs. Deduction



Induction is the natural human learning style

Felder's Observations

Inductive

- **Provides motivation for theoretical material**
- **Natural learning method**
- **Better for long-term retention and transfer of concepts**

Deductive

- **Implies material is straight-forward (i.e., obvious)**
- **Students feel they could never derive equations alone**
- **Better for short-term retention**

Advantages

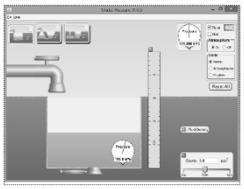
(Prince and Felder, 2006)

- Learner-centered approach
  - Students required to take more responsibility for learning
- Constructivist approach
  - Students construct own version of reality rather than version presented by teacher
- Team-based cooperative learning outside class
  - Active learning, primarily self-directed

Increases motivation
Better long term retention
Increases confidence

The Role of Experiments in Inductive Teaching

- Hands-on experiments
- Remote experiments
- Simulations

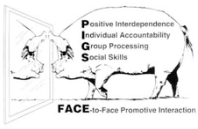


Experiments in Inductive Teaching - Recommendations

1. Align activity with learning objectives
2. Begin a topic with the activity
3. Use "guided discovery" structure
   - Allow students to "discover" engineering principles
   - Provide enough guidance/structure to keep them moving and to prevent major wrong turn

Experiments in Inductive Teaching – Recommendations (con't)

4. Follow up with
   - Mini-lecture or lecture
   - Reading
   - Homework
5. Use cooperative learning to promote accountability and interdependence



Inductive vs. Deductive Experiments

Feature	Deductive	Inductive
Placement in the course or curriculum	After topic is mastered, sometimes in standalone lab course	Before topic is introduced, integrated into course
Goal, related to concepts	Reinforcement, Application	Discovery, motivation
Length of experiment	Long, thorough	Shorter; mastery is not expected at the end of the experiment
Lab handout	Usually assumes mastery of material	Guides students through explorations and observations, gently leading them to "discover" general principles

References

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- Ma, J. and Nickerson, J., "Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review", ACM Computing Surveys, Vol. 38, No. 3, Article 7, September 2006.
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