Active Learning with Lecture Tutorials

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What is a lecture tutorial?

Lecture tutorials are worksheet-based activities for students to complete in small groups during class time. These activities are scaffolded to encourage discussion, reveal misconceptions, and practice problem solving skills.

Lecture tutorials are not homework. The benefit from these activities is the discussion and understanding that is generated.

What students do in a lecture tutorial

During a lecture tutorial, students will:

- Work with a partner or in a small group.
- Discuss questions and answers. **Understanding is most important.**
- Collaborate between groups if stumped.
- Ask clarifying questions of the instructor or teaching/learning assistants.

What instructors do in a lecture tutorial

During a lecture tutorial, instructors will:

- **Not sit back and enjoy their morning beverage of choice.**
- Circulate around the room; listening in on all groups.
- Answer clarifying questions.
- Encourage discussion using probing questions.
- Uncover and challenge misunderstandings.
- Provide opportunity for student talk.

Transitioning from novice to expert

Encouraging thinking and problem solving more like an expert is the goal for lecture tutorials.

Students, as novices, cannot easily solve new problems on their own, but can solve a good number of problems with assistance. This difference in capability is referred to as the **zone of proximal development (ZPD)** (Vygotsky, 1978).

Scaffolding is a strategy that allows students to work within that ZPD. This can be designed into the learning tutorial. Initial problems may offer more assistance, but subsequent problems withdraw assistance so that students can independently solve problems. Instructors also can provide scaffolding when individual students are outside their ZPD.

Educational research on lecture tutorials

Using Retrosynthetic Graphic Organizers and Molecule of the Week Activities in Organic Chemistry Tutorials *J. Chem. Educ.* 2019, *96*, 1640−1645.

- Students who participated in tutorials scored higher on related synthesis problems.

Increasing Learning in Introductory Geoscience Courses Using Lecture Tutorials *Journal of Geoscience Education*, 2008, *56*, 280-290.

Research on a Lecture-Tutorial Approach to Teaching Introductory Astronomy for Non–Science Majors *Astronomy Education Review*, 2005, *3*, 122-136.

Designing a lecture tutorial

Pick a topic! The topic should be challenging.

What makes it challenging? Do students have common misconceptions? Do students struggle relating it to prior knowledge?

Design a problem that addresses that challenge. How do you provide scaffolding initially and later remove it?

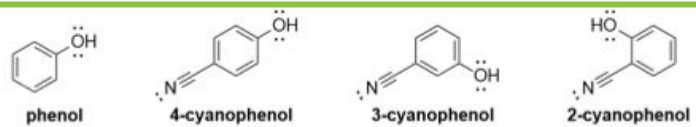
Example

Used in my classroom when introducing structural factors that affect acidity.

Scaffolding

The Actual Question

The strength of acids can be rationalized by the stability of their conjugate bases. Stable conjugate bases (products of the acid-base reaction) are lower in energy and are favored at equilibrium. The number of conjugate base resonance structures that delocalize formal charge correlates with the stability of the conjugate base. Other factors that affect acidity include: bond polarization/strength, molecular polarization and orbital overlap.



phenol **4-cyanophenol** **3-cyanophenol** **2-cyanophenol**

1. Draw the reaction of phenol with sodium hydroxide, show all products. Include all formal charges & lone pairs.

2. Draw all resonance structures for the conjugate base of reaction #1 that delocalize the formal charge (You must draw out electron arrows that convert one structure into another).

3. 4-cyanophenol (pKa 7.7) is approximately 125 times more acidic than phenol (pKa 9.8). Propose an explanation why it is more acidic than phenol. *(Hint: Repeat the steps you did in #1 and #2.)*

Small group task: draft a lecture tutorial

In a small group, spend the next 15 minutes drafting a lecture tutorial.

As you come up with problems, think about:

- How do you scaffold the activity to make thinking visible?
- What misconceptions and challenges you expect students to encounter?
- How do the students confront their misconceptions and replace it with scientific thinking?
- Can you situate the activity in an authentic context?
- How do you envision this played out in a classroom?

Topic / Learning Outcome(s)

Replace this text; Describe your topic and desired learning outcomes to be practiced in this learning tutoria.

Misconceptions / Challenges

Replace this text; Identify key misconceptions and challenges related to your topic that you wish to address.

Related Concepts / Authentic Context

Replace this text; Identify what prior knowledge your anticipate students will use as part of the learning tutorial.

Problem with Scaffolding

Replace this text; Author a problem that addresses your topic, keeping in mind the anticipated misconceptions, challenges and related concepts. Include scaffolding to support students' problem solving process. Include structures, schemes and/or pictures too.

Problem without Scaffolding

Replace this text; Author a problem that addresses your topic, keeping in mind the anticipated misconceptions, challenges and related concepts. Reduce/omit scaffolding. Include structures, schemes and/or pictures too.

Share your first draft

- What is your topic?
  - What challenges do students face?
  - What common misconceptions exist?
- Describe your problems/activity.
  - What scaffolding did you include? Anything excluded?
- How does this play out in the classroom?

Good practices for implementation

- Correct answers are great, but achieving understanding is best. Encourage discussion as much as possible.
- Give credit for participation over answers.
  - Credit for effort
  - Credit for critical thinking
- More instructors are always a good idea.
  - 1 instructor per 30 students maximum.
  - Utilize TAs or volunteer learning assistants, but train them on how to interact with students.

Useful technology for enhancing the activity

- PollEverywhere (or your favorite clicker tech)
  - With very large classes, making contact with every group may be impossible.
  - Use clickers to gauge student progress and understanding at predetermined points (ZPD).
  - Keeps students progressing through the tutorial with the right ideas.
  - Incentivizes student participation.
- Gradescope (online grading)
  - Incentivizes student participation.
  - Provides feedback on student performance.

Implementing lecture tutorials online

- Not easy, but not impossible to implement lecture tutorials online.
- Breakout rooms can be used to facilitate small group discussions.
- Instructors can circulated between breakout rooms to encourage discussion and assist students.
- Challenge: large classes = larger groups due to technology limitations.
- Challenge: hard to interact with all groups when in breakout rooms.