

Lecture-Tutorial: A Revised "How-To" Guide

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Background

Lecture-Tutorials for Introductory Astronomy (Prather et al. 2013) are **POST**-lecture, Socratic-dialogue-driven, highly-structured collaborative learning activities designed to: (a) elicit students' conceptual and reasoning difficulties, (b) confront their naïve, incomplete, or inaccurate mental models, (c) resolve their contradictions, and (d) demonstrate to students the power of THEIR new knowledge. Lecture-Tutorials (LTs) are based on the topics faculty most often cover, require about 10-20 minutes of class time (5-8 minutes per page, on average), and are designed for easy implementation into the traditional lecture portion of courses. Following is a bulleted "how-to" guide for implementing Lecture-Tutorials into your class.

The Bulleted How-To Guide

What You Do Before Class:

- Do the Lecture-Tutorial **yourself!!** We cannot over emphasize the importance of this. When doing the LT yourself, be sure to:
 - Write complete answers in your best "Astro 101" language. That is, use words (not math), and write the answers you hope a good student would write. Especially for instructors who are using LTs for the first time, or recently started using them, having your full answers in class with you will make it easier for you to help students when they get stuck. Doing the LT yourself will also give you insight into what students will be struggling with. In addition, when students see that you have actually done the same work you are asking them to do, you get a lot of "street cred" from your students. Lastly, if you have a projection device like an Elmo, you can display elements of complete and well-written answers for your students using your own LT responses.
- Only **after** completing the LT, go to the *Instructor's Guide for Lecture-Tutorials for Introductory Astronomy, 3e* (Prather et al 2013; see Additional Resources, below, for link to free download). Compare your answers to the ones in the guide. Read the basic background knowledge students need before they can do the LT. Also, find insights into common student reasoning difficulties, questions you can ask students to get them back on track, as well as a set of scaffolded, conceptually challenging, multiple-choice questions (aka Think-Pair-Share questions) you can ask them before and after they complete the LT.
- Create your lecture slide-set so that it emphasizes the background knowledge of the LT. Every type of representation used in the LT should be included in your lecture! Remember that LTs are **POST**-lecture activities designed to reinforce and strengthen student understanding—not discovery learning activities. You can download all of the images for the *Lecture-Tutorials for Introductory Astronomy, 3e* from the CAE website (see Additional Resources section, below).

What Happens in Class (The Basic Outline):

- You lecture for approximately 20 minutes using the slide-set you made that emphasizes the background knowledge of the LT and that includes all of the types of representation students will see in the LT.

- Ask your students the scaffolded, conceptually challenging, multiple-choice questions (aka Think-Pair-Share questions) provided to you either in the *Instructor's Guide* or the ones you've written yourself. These questions should demonstrate to the students that they did learn some things from your lecture (lower-level questions), but also that they aren't quite fully prepared for test day (higher-level questions)—this will help motivate your students to engage in the LT.
- Have students work in pairs (three at the most) on the LT. Provide them with a sense of urgency to complete the LT—so they stay on task—by saying something along the lines of "This is a short activity. I'm only going to give you about x minutes." Or, "This is a long activity. If you don't get after it, you'll run out of time."
- Give student's additional timestamps throughout the activity to keep them working diligently. The LTs take, on average, 5-8 minutes per page. Walk around your classroom, and observe where in the LT your students are. When the majority of your students have moved from the first page of the activity to the second (about the 5-minute point), say, "If you're still on the first page, you're falling behind," or, "If you're still on the first page, you might want to speed up a bit." Continue this for each page of the activity ("If you're still on the second page, you're falling behind." etc.) until they reach the last page of the LT. When you see that about half of your students are on the last page of the LT, say to your class "Raise your hand if you're on the last page or done," or, "Raise your hand if you're done with question x," where "question x" is a couple questions before the end. The idea here is that the majority of your class should be raising their hands—this projects to those students who are not that they are working a bit behind the pace of most students. At this point, tell students they have a couple more minutes.
- Call "Time!" This works well to get the whole class to stop and to give their attention back to you.
- Debrief the LT. Give students a few minutes to ask questions, but don't let them ask "What's the answer to question x?" Especially early on in the semester, model for them what good questions sound like. When asking for help, students should be describing to you the reasoning difficulties, or struggles, their group was having when trying to answer the particular question they are asking you about.
- Ask your students a series of questions, increasing in difficulty, that represent the types of questions they'll be asked on test day. There is a set of these for each LT in the *Instructor's Guide for Lecture-Tutorials for Introductory Astronomy, 3e* (Prather et al 2013; see Additional Resources, below, for link to free download). When you're done, tell students "If you're getting these questions wrong now, you're going to get them wrong on test day unless you do something about it between now and then. Do you have any more questions?" This is also a good time to remind your students that if they want some additional help, they can also come to your "Help Sessions" (more commonly referred to as "Office Hours," but Help Sessions sound so much more friendly and inviting!).
- Continue on with your next topic.

What Your Students Do (Put This List on Your Classroom Screen for Every LT):

- Work with a partner!

- Read the instructions and questions carefully.
- Discuss the answers and your reasoning with one another. Take time to understand it now!!!!
- Come to a consensus answer you each agree on, and write it down now!
- If you get stuck, or are not sure of your answer, ask another group.
- If you're still stuck, raise your hand, and I'll help.

What You Do While Your Students Are Doing the Lecture-Tutorial:

- This is your chance to actually get to know your students!
- Listen to their conversations. You'll be amazed both at how cool it is to hear them engaged in discussions about astronomy, as well as by the wrong things they say.
- Keep track of their incorrect ideas, and use them as distractors on your exam questions.
- When a group does raise their hand, the first step is to ask them to read you the question word-for-word—this will solve the problem 60-70% of the time.
- If they still need help, avoid going back into lecture-mode. Try to keep the Socratic dialogue going. What are the questions you could ask them to help get them back on track? Doing the LT yourself and then reviewing the *Instructor's Guide* (see Additional Resources, below, for link to free download), beforehand, are key in helping you figure out what students may struggle with and in helping you decide what questions to ask—along with listening to your students' conversations and you gaining experience over time!
- Make sure groups are collaborating. Especially early on in the semester. If one student asks you a question, ask a different group-member to explain the trouble they're having answering the question, or what they think the problem is. Have your students go sit next to someone new a few times early on in the semester so your students don't feel "trapped" with a person that doesn't work for them.
- **Always be in pursuit of the Teachable Moment!**

Additional Resources:

Lecture-Tutorials for Introductory Astronomy, Third Edition. (Prather et al 2013):

<https://www.pearsonhighered.com/program/Prather-Lecture-Tutorials-for-Introductory-Astronomy-3rd-Edition/PGM275203.html>

Instructor's Guide for Lecture-Tutorials for Introductory Astronomy, Third Edition (Prather et al 2013)—click on the Resources tab for free download:

<https://www.pearsonhighered.com/program/Prather-Lecture-Tutorials-for-Introductory-Astronomy-3rd-Edition/PGM275203.html>

Images from *Lecture-Tutorials for Introductory Astronomy, Third Edition* (Prather et al 2013):

<https://astronomy101.jpl.nasa.gov/workshopmateriallist/>

Research on a Lecture-Tutorial Approach to Teaching Introductory Astronomy for Non-Science Majors (Prather et al 2005):

https://astronomy101.jpl.nasa.gov/files/Lecture_Tutorials_AER.pdf

Teaching and Learning Astronomy in the 21st Century (Prather, Rudolph, & Brissenden 2009):

<https://astronomy101.jpl.nasa.gov/files/Teaching%20and%20Learning%20Astronomy%20in%20the%2021st%20Century.pdf>