Rica's Crash Course Outline for Implementing *Lecture Tutorials for Introductory Astronomy*

First, read this. (*Seriously. Do NOT skip this part.*)
https://astronomy101.jpl.nasa.gov/teachingstrategies/teachingdetails/?StrategyID=9 This is the Center for Astronomy Education's "how-to" guide, written by some of the tutorial authors.

Now here's my hasty attempt to describe the experience, with context, in my classroom.

1. Set up the necessary background information in a short (~15 minutes) mini-lecture.
   a. I used to require textbook readings and reading questions prior to nearly every class period. Then in class I'd lecture to set up the tutorial. Now I'm dumping the textbook completely, using only the Lecture Tutorial (LT) workbook, and flipping my class. So this first item will soon change to be something like "Have the students watch the appropriate mini-lecture video beforehand and complete the pre-class lecture questions."
2. Start with a couple of good Think-Pair-Share (TPS) questions (see my TPS implementation writeup here http://tiny.cc/implementTPS and card here http://tiny.cc/TPScard).
   a. Begin with an easy one that you expect most everyone to get on the first try. Even if they don't get it on the first try, proceed with the "pair-share" part of the procedure and take a second vote (where they definitely should be >80% correct). This helps them recognize that they are beginning to "get it" and builds a little confidence.
   b. The second question should be more difficult but still something that was completely covered in the background materials. Make sure it's something that we would expect them to get correct because it really has all been covered, but is just complex enough that, in practice, *many will not get*. This is what you want! We instructors know from experience (and now a large body of research!) that reading and lecturing aren't enough. The students need to see that even though they've had all of the information they need to get it correct, they're simply not ready yet. More specifically, they need to see that their definitions of "studying" – which typically involve reading, paying attention in lecture, and taking and reviewing notes – and expectations of "success" are inadequate.
      i. Link this to the summative assessments. In my course the tests are all multiple-choice questions and I repeatedly frame the TPS questions as "this is what test day will be like so you need to be honest with yourself now and see if you're ready." In this way the students see that you are matching your learning sequences very carefully to the assessments and repeatedly giving them a "free" way to find out, before it counts against them, whether they are ready for the assessments.
      ii. When the majority of them bomb this second TPS question, DO NOT do the "pair-share" part! Stop it there and say something like the following to help them acknowledge the disconnect and provide motivation for taking the LT seriously. "Hmmm...well that didn't go so well. Curious, since you've had everything you need to get it right. Clearly we are *not* ready for the test yet. Good thing we have more tools in our toolbox! Let's do some practice and then reevaluate our progress. Turn in your Lecture Tutorial workbooks to page..."
3. Explain the "rules" for how these activities work (or just remind them if you're well into the term). Display these rules (http://tiny.cc/LTslide) on the screen while they're working.

    a. Work in pairs.

    b. Read the instructions and questions carefully.

    c. Talk to each other and discuss your answers.

    d. Come to a <u>consensus</u> answer you both agree on and write it down.

    e. Answer the questions *IN ORDER*.

    f. If you get stuck or are not sure, ask another group.

    g. If you get really stuck or don't understand what the question is asking, ask me for help.

4. Give them a time limit.

    a. For example, "You have about 20 minutes." This generates a sense of urgency. Base your time limit on these two things: (1) the LTs are designed to take approximately 5-8 minutes per page and (2) *you have already done the LT yourself, behaving like a good Astro 101 student instead of an astronomer with an advanced degree*, forcing yourself to <u>frame your thought processes like them and using the language of a good Astro 101 student</u>. In this way you better understand the struggles they will experience and roughly how long they will take to resolve the conflicts.

    b. Say "Go!" (Seriously. *Nothing* else works like that specific word. Humans are seemingly pre-programmed to respond to it and take action accordingly.)

5. Walk around – *with your own completed LT* – monitoring and listening, but *DO NOT insert yourself into their discussions!* DO make sure your body language indicates you are receptive to questions and are enjoying the activity along with them.

    a. As much as you want to help them, short-circuiting their discussions and thought processes by inserting yourself (even if you think you're just guiding them) only impedes their progress. They must struggle on their own. They must explore the options to reconcile cognitive conflicts on their own. They are only receptive to meaningful input – and ready to think carefully and critically about it – when they have reached that mental space on their own. Otherwise you're just "cluttering" their already overtaxed brains. (Don't take that personally! *Do consider how you would respond* in a similar situation if someone randomly interrupted you when you had a time limit of only a few minutes.)

    b. You may also find it helpful to carry a notepad and make notes about their incorrect responses and reasoning. This helps you write good distractors for new multiple-choice questions to be used during TPS and/or on assessments.

    c. EXCEPTION: Sometimes you might need to interrupt the whole class at once. For example, I will "Pause!" my whole class if I see that the majority are making the same mistake in the same place. Then I can make an announcement and offer everyone some guidance for getting back on track all at once. I also may know to expect this because I've both worked the tutorial myself and have seen it happen in multiple classes, e.g. Q1 in "Luminosity, Temperature, and Size" and Q2 in "Milky Way Scales."

6. Give them a first page time stamp.

    a. When 2/3 of the class is finished with the first page give them an indicator, maybe something like "If you're still on the first page you're starting to fall behind!" to let them know whether they're pacing themselves appropriately.

    b. They also need to see that they can't simply drag this out and force you to cave because they're not all finished. You gave them a reasonable time stamp (see #4.a above) and they need to understand that you expect them to take it seriously and you'll be holding

them to it. Now, that's not to say that if you said they had 20 minutes and something unusual happens, you can't make an adjustment. Of course you can! Just make sure you're not letting them dictate how long you spend. That sets a precedent that shows that you weren't serious about the time limit and now they know they can manipulate you...because you've already let it happen at least once.

7. Students will either raise their hands if they need you (see #3.g above) or they might simply wait until you circulate back around to where they are in the room.
    a. Many of their questions can be remedied by simply asking them to read the question aloud (no kidding; this fixes about 75% of the issues).
    b. If their questions are deeper, make sure you are guiding them and not simply giving answers. Remember when you did the LT yourself? Did you try to anticipate where they would struggle? Did you try to anticipate the types of questions they would have and at what point they are likely to occur? This is a large part of what you need to make sure you are *guiding* them instead of doing the work for them. You then need to employ the Socratic method to steer them back on track.
    c. Sometimes it is okay to simply confirm their answers. That is, if they have already answered a question and – especially if it's correct – are now second-guessing themselves, you can simply give them the vindication they need without further ado.

8. Keep up with time stamps.
    a. For example, when 2/3 of the class is on the third page, tell them so ("You should be on the third page or farther by now!").
    b. When about 2/3 of the students are either on the last page or finished give a final time stamp *with an important visual*: "Raise your hand if you're on the last page or finished!" You may want to say it a couple of times to get everyone on board and paying attention. If they're not already looking around to see how many hands are up, tell them to do so. "Keep them up and look around. Okay put them down. You have about two more minutes." This shows them that nearly the entire class is about done (because you won't do that if 2/3 or more won't be raising their hands!) and lets the slow-movers know their pace isn't keeping up with the rest of the class.
    c. And of course make sure that all of this is keeping within the time limit that you originally established (see #4.a above) or very close to it. Otherwise students may notice a large discrepancy and call you on it, likely by manipulating you into making an adjustment that isn't reasonable and destroys the flow of the learning sequence you've planned. In a worst-case scenario these kinds of time and classroom management issues can even show up in student evaluations. This is why it's so important for you to get your initial time limits (in #4.a) as realistic as possible so that you may only need small adjustments that your students don't even notice. Sure, you may not get it right the first time...or even the second. But if you took your job seriously in #4.a and read the CAE's teaching strategy article listed first, you probably aren't too far off or need too much in the way of adjustment. Now it's more a matter of you getting used to holding them to it regardless of whether every single person gets finished (see #9 below). If they don't get finished, it's homework (see #11.d below).

9. Call time when you said you would.

a. Even if everyone isn't finished. That's the point. They need to understand they have a job to do and a reasonable amount of time to do it in if they focus and stay on task (see #s 4.a and 8.b above). And you will not bog down the rest of the class waiting for everyone to get finished; you gave them time stamps for a reason.

10. Go into "debrief" mode.

   a. *DO NOT simply go over the tutorial and NEVER post answers!*

      i. Going over the tutorial models for them that (1) they don't need to do it themselves, (2) it isn't important for them to experience the mental struggles, and (3) they now have "free time" to sit back and wait (text, surf, Facebook, Twitter, etc.) while you do all the work because they can just copy down the answers at the end.

      ii. Posting answers similarly destroys the pedagogical value (see previous item). Besides, both CAE and Pearson (the publisher) will come calling if you post answers. They actually do look for this kind of stuff since it (1) destroys the pedagogical integrity and (2) the publisher can claim you're violating the copyright of their instructor's manual that accompanies the LT workbook.

   b. I give them an opportunity to ask "questions about the questions." For example, this means they cannot ask something like "What's the answer to number six?" because that's not a question about question number six itself. One could, however, ask something like "In number six we said we agree with Student 1 but we're still not convinced that's right. Student 1 says that only part of the Moon gets light during some alignments and that's what causes phases. But isn't the answer to question 5 'c'? And if so, doesn't that mean Student 1 can't be right?"

      i. Notice that this requires the student to (1) commit to an answer and (2) articulate the reasoning behind it, *even if they think it might not be correct*. That is exactly what I want them to practice. Remind them, "If you're wrong, don't you want to know it *now*, while you still have time to fix issues and get back on track before it impacts your grade? That is part of what the debrief is for."

      ii. This is very difficult for students to do at first (and heck, sometimes it's hard for some of us!). But it's what I expect and I need to not only model that for them, but give them repeated opportunities to practice. I can give them an example and I can tell them that "it's okay to sound awkward – everyone is a beginner at first; why would anyone expect you to sound so fluent already? This is our safe space to practice and get feedback, judgment-free." When a brave student starts and then falters make sure to encourage them with a smile and something like, "You're doing fine. Say more words like that. I'll try to help you sort it out." I try to remember to thank the first person brave enough to attempt it and put themselves out there in front of everyone. Sometimes it's also appropriate to get other students to jump in and help that first student try to articulate his/her thoughts since they often struggled with the same issues and have a pretty good idea of what the student is trying to ask.

      iii. Engage in a discussion, Socratic style, where it's often appropriate to include not just that one student but the entire class in the answers to your questions. Do this such that you lead them to conclude the correct answer on their own.

      iv. After that discussion, ALWAYS make sure that you reiterate the correct answer. Sometimes the students get wrapped up in their own thought processes because the discussion "pinged" something for them and they miss hearing what the correct answer actually is.

11. Manage your time during the debrief.

    a. How long you spend is really up to you: how much time can you afford given the other things you want to do that day?

    b. Just remember: the debrief isn't about you! It's up to them to ask the questions they need to. It is NOT your job to go over the tutorial (see #10.a above) or re-lecture (why? you did that already and it didn't "fix" everyone…). If they're done asking questions, we move on. If they don't ask any questions, we move on. That was their chance to get issues cleared up if they needed to. They are responsible for their own needs.

    c. It's entirely possible, of course, that students do continue to ask questions right up until the time limit you had budgeted for the debrief period and there's still no end in sight. Obviously it's your call but don't be afraid to shut it down by letting them know we have to move on right now but they do still have other avenues and opportunities to get feedback on it; this isn't their only chance (office hours, help sessions, appointments, email, discussion boards, study groups, tutoring, etc. – whatever is appropriate for your class). They need reminding of this continually during the term.

    d. Wrap up the debrief by reminding them that if they didn't finish the tutorial, it's homework. They're still responsible for that material – it will be on the test – so it's up to them to make sure it all gets covered. Also remind them of the opportunities to get additional help and feedback (see previous item). I typically wrap up by saying something like, "And what can you do if you have questions later or decide you want to check other answers?" I make *them* tell *me* so they see that *I am not the provider of information* – our classmates know what to do.

    e. Occasionally you get may complaints about how students are left "never knowing the answers." If that happens it's usually due to at least one of the following: (1) not doing the debrief, (2) not clearly reiterating the answers to questions addressed during the debrief, (3) not reminding them of the purpose of the debrief and that it's up to them to ask for help and clarification if they need it, i.e. you're not a mind-reader, and (4) not continually reminding them that they DO have other avenues by which they can get answers: office hours, help sessions, discussion boards, email, etc. (see letter c above) and that it's their responsibility to use them. I tell my students, "I understand, sometimes you just want to check your answers. So if you come to a help session with a <u>completed</u> tutorial (and I will check to see you actually did it first!), *I'll let you borrow <u>my</u> LT workbook so you can check it right there and don't even have to otherwise talk to me if you don't want to, ha ha!*"

12. Do a few TPS questions to check progress.

    a. Remember how, before the LT, you ended on one that didn't go very well? Now we check to see if we're on track. It's usually best to ask the same question just with one thing changed, e.g. "redshift" instead of "blueshift." But you may not want to use that as the first question; keep reading.

b. You may choose to "scaffold up" to a question like that one you ended on before. That way you're sequencing their processing of the steps by starting with an easier one and working up to a harder one, building confidence, etc.

c. Make sure to ask more than one question! They need multiple exposures and repeated practice to ensure they're ready for test day (tell them that!).

d. Move on to a new topic after doing the questions you feel are appropriate.