# Some notes on using the activities in the order in which they came to me

Each activity ends with a statement to do a poll on the group performance. This takes them to a Microsoft form where they are asked to rate themselves and the other members of the group on a scale from 0-10. I can look at these early to see if there are any group dynamics problems and head them off. At the end of the semester, I can look at the trends over time and I use that as part of determining their Professionalism grade (10% of their final grade). The other components are attendance and my observations.

Stars and galaxies is not a theme. It doesn’t have a single story running through it. It is just the second half of the average textbook. These activities do form a theme – the story of stellar evolution based both on collecting data and drawing conclusions based on it.

I don’t give exams. I have convincing evidence that exams are not a valid measurement of understanding. They measure performance, not understanding, and performance is not tightly coupled to understanding they can sometimes develop in opposite directions. All my assessments are formative, and in the moment, based on discussions of what they have done as a group. Being formative, they are embedded in the activities as part of the learning process. Each question or activity is graded on a scale from 0 to 2. There are half points in between because the point of formative assessment is to give them feedback on their thought process and allow them to incorporate that feedback into improving their answers. So the half points are there because, if they succeed in their second try, they can get half their points back.

My general approach to this course is called Cognitive Apprenticeship. It was created by John Seely Brown, and you can find tons of information about it online. It also fits into Danny Edelson’s views about authentic practice. There are two main ideas:

* Skills should be acquired in a context that reflects that in which they are to be used
* Put students in the middle of a problem that you are fairly confident they cannot quite accomplish on their own.

Let them try first, give them feedback on what they did and how to improve it, and let them try again to get some of their points back. It is very similar to an electrician or carpentry apprenticeship.

Usually, this means project-based instruction and that is what I do in my physics classes. But there are no projects in astronomy. People usually end up using some variation of designing a Martian habitat, or a spacecraft for a long voyage. Those are not astronomy. Thos are engineering. So I came up with a variant: center activities on a Big Question. By that I mean something that is intrinsically interesting but students can’t for the life of them figure out how to answer. That then disassembles into a series of smaller questions, exploring different aspects of the answer to the Big Question. After all, that is what astronomers do so it is authentic practice. They do not design habitats.

The Big Question here is: Do stars evolve over time, and if so, how? Each activity is focused on one smaller question that we need an answer to in order to go further along the story of stellar evolution.

Each activity begins with informal messing around with the phenomena which, over the course of the activities, gradually becomes collecting rigorous data and drawing conclusions supported by that data.

I do not give lectures. I used to very much enjoy giving lectures, but implemented as they typically are, they don’t do very much for understanding. Schwarz and Bransford’s paper, *A Time for Telling*, shows that lectures can be a very powerful learning tool but they have to come at the right time. The right time is *not* when the professor has a need for them to know something The right time is instead when the student has identified a need to know that thing. As these activities are designed to mostly land in the students’ zone of proximal development, those opportunities come fairly often. That is why the discussions come *after* they’ve worked on something and not before.

If this is starting to sound like scaffolding, it is. But the majority of people in Physics Education and Astronomy Education research think a worksheet is scaffolding. It is *absolutely not*. A worksheet creates an *opportunity* for scaffolding. But scaffolding itself is contingent, depending on both what is happening in the moment and what the student has revealed about their current understanding. This is why they try first and then ask. Trying helps them identify gaps in their knowledge and skills, and you can then address each student’s specific needs in a useful context. This happens largely during the assessment discussions, but if they ask before the checkpoint that is also an opportunity and one in which I impose no penalty for being wrong. In any case, you have to make it up in the moment. There is no way you can make prepared scaffolding that addresses every issue a student might have. So you have to be confident in your knowledge of the material and your ability to be flexible in how you approach the discussion. They aren’t all the same and they don’t all go the same way.

If this is also starting to sound impossible to implement with a large number of students, it is that as well. You cannot do this approach in a 300 seat lecture unless you have an army of learning assistants. The outer limit for me seems to be about 6 groups so I am fortunate our classroom physically cannot hold more than 24 students. Three or four students to a group is ideal. Two is a disaster when one is sick, and five usually leaves one without anything to do.

Sometimes groups interact with each other to draw on each other’s knowledge. I don’t have a problem with that and in fact I encourage it. It is part of the process of learning to collaborate to reach a common goal, a major feature of doing actual science, a major non-science goal of the course, and the most important thing that employers want students to be able to do when they graduate from college.

Each activity should conclude with a reflection on what we learned and how we learned it. Their understanding of what it means to do science will evolve over time, and that is *the* goal of the course. Astronomy is not the point, rather it is learning how to question events and data based on a knowledge of what “doing science” means.

These activities draw heavily on simulations and some real data. That is because I cannot count on having a room with appropriate lab equipment. But the advantage is that it makes them portable.

Do not expect to do these activities in a single class meeting. I long ago gave up the idea of a single, complete activity for each class. You can’t do anything interesting that way. My activities are research-like experiences that spread out over several days.

If this is not a format you can easily implement, all is not lost. The activities separate fairly neatly into discrete pieces, perhaps in need of a short prelab instruction.

I am willing to help anyone anywhere with implementations. Just contact me at [pcamp@ggc.edu](mailto:pcamp@ggc.edu) or 404-429-6796.

A note on forming groups: you don’t have to do it this way, but it is kind of fun and sets the tone for the course. I got the idea from Eric Mazur. Decide how many groups you will need to make. Choose that many animals – cat, dog, rabbit, bird and so on. Tell them you are going to come around and whisper a word to each one and they should remember it. Tell them an animal in the sequence you have decided. Then tell them without using words, without using picture or drawings, only using noises and gestures, find the other animals who are like you. That is your group. Go find a place to sit and trade contact information. There is a point underlying this. I figure that if people who know each other are present, they will sit together. But Kevin Dunbar has collected data that indicates the more heterogenous the group, the more likely it is to generate creative solutions. I don’t know their abilities coming in so the best I can do is randomize it. Later on, if I notice some people racing ahead while others are struggling, I might modify the group membership. Middle school kids are all over this. College students are embarrassed to be seen acting silly. They need to be encouraged, so if people are milling around not doing much of anything, I start demonstrating – some people are this (flapping my arms), some people are this (hopping like a rabbit). If I do it, they generally will do it too.

I am including a Powerpoint presentation that I always give on the first day to help them understand some of the cognitive science underlying the course design. That usually gets acceptance for far enough into the course that they are able to se what they are learning. I also use it as a set of principles to refer back to whenever I see them experiencing these things for themselves during the semester. I just use the slides as reminders of what I want to do next so I have included some notes with each slide. It is the only lecture they will get in the course because I give the world’s best lecture on why lectures are bad (well, sort of).