Curriculum for the Pre-Major in Astronomy Program Seminar

What follows is a resource for teaching the Pre-MAP seminar, the keystone course of the Pre-Major in Astronomy Program. The purpose of this document is to:

- help future Pre-MAP instructors prepare their own course based on methods and ideas from former Pre-MAP instructors
- introduce new or prospective instructors to the Pre-MAP program

The Pre-MAP Seminar has three main teaching goals, and one program-wide goal:

Teaching Goal	Methods to Obtain Goal
Allow students to have a scientific research experience	Pair students with research mentors for a short (5 week) research experience
Teach students programming concepts for their research projects	Teach three programming objectives: Read data, Write data, Plot data in either Python or IDL after introducing UNIX and Emacs.
Introduce students to the many aspects of scientific research	Assign reading and writing to investigate science communication (from informal to formal), discuss how to communicate their own research, help create a research talk
Get students off to a successful start in their science major	Teach effective study habits, time management, how to approach exams and problem sets. Create a nurturing learning environment among their peers, graduate students and faculty members by having informal group building activities.

Ideas within this document come from many places including online sources, books, previous and current Pre-MAP instructors, graduate students and professors at the University of Washington, and from discussions and material from The Center for Instructional Development and Research (CIDR, http://depts.washington.edu/cidrweb/). We attempt to give credit where it is due, please contact us (uwpremap@gmail.com) if any omissions are found.

Pre-MAP Seminar Description

The Pre-MAP Seminar is a bit of a boot camp for first quarter freshman and transfer students (we assume no astronomical or programming background). The course is divided in three parts. In a twelve-week quarter, the first five weeks students will learn the necessary programming and scripting languages to be able to start research with their mentors. The second five weeks are devoted to doing research in pairs with volunteer research mentors. And the last two weeks are reserved to prepare and present their progress to the Astronomy department. Meanwhile, Pre-MAP students will be learning about the communicative side of scientific research while building a support network to take with them throughout their college careers.

Day	Topics Covered
1 & 2	Introductions
3 & 4	Unix, Reading Science I
5 & 6	Projects, Emacs
7 & 8	Interpretive Language, Reading Science II
8 & 9	Reading and Writing data, Plotting data
10-20	Research, Interviews, Reading Science III
20-22	Communicating Science, Research Presentations
Final	Optional Group evaluation

Teaching the Pre-MAP Seminar

We suggest the best way to teach computing is through a problem-based pedagogy with mini-lessons interspersed to guide the students toward the basic demands of astronomical research. Computer exercises should be designed to be goal-oriented, rather than building a repository of IDL commands, for example. Written assignments should activate prior knowledge while driving the student to think like a professional astronomer. Group building activities, informal field trips designed to expose the students to scientific research, and career presentations are suggested.

A note on computing comprehension: It will be difficult to be sure every student comprehends and is able to reproduce what they learn in the first few weeks. It's best to be honest with the research mentor that while you will be teaching the students the basics of UNIX, Emacs, and IDL or Python, they are only getting a few chances to apply them so expect to re-teach or let them have an Emacs reference card near-by.

Increased Expectations of the Seminar Instructor

The planning of the seminar takes longer than a typical class since project mentors must be selected and willing to submit projects (see our Research Mentor Guide for more information). If the Pre-MAP staff or organizing committee is sufficiently large, splitting the teaching tasks with the mentor recruitment tasks will make the seminar more manageable.

Besides teaching the material in this course, it is generally assumed the instructor will work to gain the students trust to become a go-to academic mentor for the incoming students throughout their college career. This should be explained several times throughout the quarter and reflected in the design of the syllabus, probably in the office hours and contact information section. A weekly informal "check in" with each student works very well to establish this connection. For this reason, as well as the importance of sanity to graduate students, no more than 12-14 students per instructor is recommended for this seminar.

Office Hours

Often an after thought, office hours are very important and often the only time to have one-on-one interactions with Pre-MAP students. One-on-one interactions between students and others in the department will add to their feeling of belonging and acceptance. Explain to your students that office hours are not for those who can't handle the material on their own; it's to learn more in a setting that is different than a classroom. Here are some guidelines to follow when designing your office hours.

Timing: Office hours should be scattered to accommodate students' packed schedules. For example, Tuesday & Thursday course schedules often have a X:30-Y:20 followed by Y:30-Z:20 time slots. Office hours on these days should run from Y:00-Z:00 to allow the students who have the X-Y class to come after it and those that have the Y-Z class to come before it.

> *Study Hour:* On more than one occasion, students would help each other on homework even though they were not taking the same class

Content: Semi-structured office hours can be a helpful way to get students to come. Choose a relevant topic to go over or re-do something that was already done in class. In high school, going to see the teacher outside of class time is often negatively associated or thought of as an activity reserved for slow students. Another problem associated with office hours is that they demand the student be able to articulate their question or the problem they are having. Possible semi-structured office hours: PowerPoint, IDL plotting in color with legends, how to study for a midterm, how to do a problem set.

Study Hour: Previous instructors have noted that a quiet supervised study hour in a conference room has gone a long way for everyone's productivity. Requiring students to attend one may be enough to get them to like the idea and help develop focused, efficient studying instead of simply "working hard." Blocking off a time in the computer lab where the instructor will be around to answer questions outside of class will also help shape their studying and working habits. This would be a good time to bring other Pre-MAP staff members in to meet the students and help them one-on-one.

Cohort Building

One of the goals of this program is to have students start their STEM careers with a strong support network. Mentoring can happen at many levels so having the class interact outside of the traditional educational roles will be beneficial to building a sturdy network. Previous Pre-MAP students and other undergraduates should also be invited to some programs and efforts to integrate the Pre-MAP students within the department will help them feel as equals and more likely to approach faculty when they need support. We recommend a kick off event mixer with the entire department and graduate students invited (not all of them will come). Breaking the ice in this way will make Pre-MAP students more comfortable asking them questions and advice later. We have several examples of students approaching the members of the department that they met at such events.

With one activity a month, students can make time for them but also not feel too bad if they need to miss an event due to work or another function. Our first kick off event is at the campus observatory, we take the students on a Pre-MAP Leonids viewing (or just star gazing in November), and our final "outing" is a planetarium show and movie night on campus.

Writing assignments

We include five writing assignments that will help explore the equally important side of research, communicating results. The writing assignments start with reading and reacting to two articles written for the public. They will then practice reading and understanding a *Astrophysical Journal* paper. The last writing assignment has them communicating their own research experience. These assignments also allow students to feel confident in the class if they have low self-confidence in computer programming. In addition to these assignments, the students must interview a faculty member (in any department). This helps them bridge the gap between student and professor; it helps them realize that professors are people too!

Programming exercises

The astronomy department at the University of Washington has IDL and Python programmers. For this reason, we have students choose their research projects two and a half weeks before they start research with their mentors. That way, we can split the class into IDL programmers and Python programmers. This also had the advantage of letting the mentors assign background reading, from a 100-level text book or a Wikipedia page on Active Galactic Nuclei. A specific writing assignment from these topics would be ideal, but having mentors prepare something far enough in advance for the instructor to produce a writing assignment isn't very realistic.

We provide three programming exercises and recommend one and a half to two weeks for them all to be accomplished. Each exercise accomplishes the same teaching objectives in either Python or IDL.

Message Board

To help build confidence in each other, we had our students post twice a week to a course message board. We use Catalyst Tools (http://www.washington.edu/lst/web_tools/gopost) which is able to use the registrars' database to restrict message board access to only those enrolled in the seminar. One post addressed what they struggled with or how they got stuck that week and how they figured it out. The second would be a response to someone else's post and you will explain how they solved the problem differently. It was very difficult for many of them to remember to post every week.

> STUCK: studying efficiently for midterms. I found out that while studying with other people is helpful, I have to acknowledge when its not helping and not be afraid to leave. I ended up spending four hours writing up strategies to solve example problems with a study buddy, and didn't learn anything at the end. Not so helpful! So this week my toughest experience was studying for my physics midterm.

> The best way without a doubt that I've found to study midterms is to set interim goals for myself. Maybe it will work for others too- I just focus on one aspect of a class, like notes from the lectures, and study those for a day or two. Go through all the materials in this way, and then move to practice problems. LOTS of practice problems. At least for physics, they seemed to get easier as it went for

Practice Presentations

The last class day before the final presentations was taken from the research mentors and used for them to give their talks to each other. We played a warm up theater game to ease some nerves, and the instructor encouraged the other students to ask "practice questions" and gave each student a note on how they did with suggestions.

Lab Tours

To introduce our students to other STEM fields on campus, we organized graduate student tours of labs. These were fun, though hard to coordinate with the students' busy schedules. We recommend doing this portion only if there are staff members willing to help out, it shouldn't be all in the hands of the seminar instructor.

Scope and Sequence

Day 1	Introductions: The Seminar, The Computer Lab, The Department
Day 2	Purpose of Science Discussion, Learning UNIX
Day 3	Applying UNIX, Learning and Applying Emacs
Day 4	Project Presentations, Writing about Projects
Day 5	Discuss and Choose Projects, Finish UNIX
Day 6	Purpose of Science Discussion, Python or IDL in the Command Line
Day 7	Reading and Writing Data
Day 8	Reading and Writing Data
Day 9	Plotting
Day 10	Research
Day 11	Research
Day 12	Research, Faculty Interview
Day 13	Research
Day 14	Research
Day 15	Research
Day 16	Research, Scientific Paper Jigsaw
Day 17	Research
Day 18	Research
Day 19	Research, Communicating Science
Day 20	Research
Day 21	Practice Presentations
Day 22	Research Presentations (no lesson plan)

Day 1

Students will be able to:

- use their computers
- get around the astronomy department
- understand the structure of the seminar and Pre-MAP

Get to know each other icebreaker

15-20 minutes

> **Icebreaker: Non-verbal Introductions**
>
> Divide the class into pairs. Each member of the pair should communicate to their partner as much about themselves as they can without speaking or writing (though drawing pictures are allowed).
>
> After about ten minutes, everyone will verbally introduce their partner, allowing the partner to make corrections and fill in details.

from http://www.mwls.co.uk/

Icebreakers are informal games or tasks that the break tension in the beginning of a course. They promote group interaction and help prepare the class for interactive lessons. There are many icebreakers that can be used as introductions.

Introduce the Pre-MAP Seminar

30 minutes

Students have come to be in the course through a variety of paths and all together do not know the format or what will be expected. The term "seminar" may be understood differently among the students. This is the first time to lay out why the seminar exists, what will happen, what will be expected of them, and why. Handing out a syllabus is the typical way instructors pass logistics on to their students at the UW. . A sample syllabus can be found on our website.

Beyond the logistics, the cohort should understand that Pre-MAP isn't just a seminar; it's a program. They will be interviewed in subsequent years to help us make Pre-MAP better, we will be working to advise them on every aspect of college to help them succeed. We will use their images and have them write short bios on our website and will ask them to be involved in a group evaluation instead of a final.

The instructor is also not the only member of the Pre-MAP staff. We have several staff members comprised of graduate students, post-docs, administration, and a faculty member. They will become acquainted with everyone throughout the quarter and their time at the UW.

Before leaving for the tour and the computer lab instruction, hand out and explain the first writing assignment. The handouts for all assignments and any accompanying materials can be found on our website.

Tour the Astronomy Department

10 minutes

A large aspect of Pre-MAP is to help the students feel (and be treated) as equals throughout the department. A tour of the department will help them explore the area without having to look lost. It is also a chance to orient them to find your office and the department office. Making the department aware that you will be taking 10-15 students trampling through is a good thing to do before hand.

Become Acquainted with the Computer Lab

20 minutes

Back in the computer lab have the students log into a machine and give them some time to play around with it. This will allow them to realize the UNIX environment is not too far off from Mac OS or Windows. It will also show them that they will be working out their own solutions to challenges; not simply following the instructor's to do lists.

This is a good time to talk about lab usage. We loan students keys to the building and computer lab and they have their own computer accounts. The first thing many will want to do involves the passwd. After showing them the terminal, explain that passwd will not let them see what they are typing.

While they're using the terminal, have them type firefox &. The pesky "&" will taunt the students throughout the quarter.

Reflection

Have the students share with each other what they are finding on their computers.

Writing Assignment 1: The Cosmic Perspective

A Note on all assignments: Please see our online repository of handouts for templates to give to the class. What follows below is scaffolding for the instructor.

Purpose

This read and response assignment is designed to activate any prior knowledge of astronomy while exciting the student about the possibilities of astronomical research. The words jump off the page as Tyson puts astronomy into a societal context. He also has lots of order of magnitude calculations in the background to show size scales. This introduces the student to how astronomers think on order of magnitude scales. The questions they are to address are the same in the second writing assignment. This will get the student to assess why they are interested in science while gathering perspective on why scientific research is important.

Located online: http://www.naturalhistorymag.com/universe/161367/the-cosmic-perspective

Audience: Another college student

Grading Criteria

Informal, amount of thought/effort put into response.

- 0 – no opinion or original thought presented
- 5 – satisfactory opinion or original thought presented
- 10 – well thought out, clearly some time was spent thinking the arguments over

Models: This is the first assignment, there are no models, grading on style should be lenient.

Length: At least 500 words, no more than 1000.

Format: Informal, typed

Time: Four days (assigned on Wednesday due on the next Monday)

Presenting the Assignment

Explain that writing about science is a very important part of scientific research. All of the writing assignments are aimed to explore several ways of communicating science. This first reading is from a magazine sent to all members of any natural history museum in the United States. These are generally college-educated adults who seek informal science education for themselves and their families. Your task is to read this article, think about it, and write out your reaction or your response. Be prepared to discuss it in the beginning of class on Monday, even though you have until 5:00pm to electronically turn it in.

Day 2

Students will be able to:

- begin to critically read and discuss science articles
- see the use and derivation of an order of magnitude calculation
- use basic commands to control files in UNIX

Today the class will start with a mini-lecture on lab notebooks followed by discussion about the writing assignment. The discussion will start with an icebreaker allowing them to hone the ideas for their papers if they wish to touch them up before turning them in this evening. The discussion will end with an example of an order of magnitude calculation before they start navigating the UNIX operating system. When they have some experience, the class will shift back to a mini-lecture to introduce the astronomical terminology of the programming exercise. The fastest computer users will have around 20 minutes today in class to start the exercise under instructor supervision. Some may not get to it. The class ends with a simple writing reflection that may or may not be turned in.

Lab Notebooks

10 minutes

With a gift from the UW Bookstore and funding from the Kennilworth grant, we were able to purchase lab notebooks for all of our Pre-MAP students. We require the following rules to teach good practices for the future and to instill the idea that what they are doing is serious and important. *The following was adapted from http://www.drjbloom.com/Public%20files/Laboratory%20Notebook%20Booklet.pdf*

A perfect lab notebook would allow someone else to repeat what you have done (if they had your training). The purpose of this style is primarily for you to go back to when you prepare to publish your results or apply for a patent. Here are basic rules for a scientific lab notebook:

- Lab notebooks should be bound with all pages numbered; no page should ever be torn out.
- The first page or two is reserved for a table of contents that you will maintain as you use the notebook.
- Each page should have a title and date.

- Permanent ink only (non-erasable pens, no pencils). Do not use whiteout; simply cross out your mistakes (so you can still read it) and correct them.
- Don't worry about saving paper. Start new ideas, sections, research, etc on new pages.
- Having a glossary of jargon is a good idea, but not required.
- Summaries of the work done thus far are good to have.
- If you have to continue previous work in another section, make a note on the pages "continued on page..." and "continued from page…"
- Print out important emails, notes from meeting with research advisors, plots, etc. and affix them into the notebook. If you attach plots, note the directory path to the data or the printed file. Use of Scotch tape is acceptable in this class and typically for undergraduate research. Staple, glue, or rubber cement is the best option since it is more permanent and usually required.
- If you are running a program, list the tasks for an example run. Such as, where the input files are stored and what parameters you are using and why.

The Cosmic Perspective Discussion

30 minutes *The following was adopted from First Day to Final Grade*

Setting up a room with a circle of chairs or sitting around a conference table is the best way to have a discussion, that way everyone can see each other and are facing each other. Avoid prompting the discussion with wide-open or very basic questions. For example, don't ask, "what did you think of the reading?" The point of this discussion is to have the students think not only about the content of what they read (that should addressed in their response), but about how the article communicated science.

Question Prompts:

1. Who was Tyson writing to? What was the audience's education level? How old are they?
2. How did Tyson use scientific findings for the article? How or why do you think he choose the examples used in the article?

Choose one of those types of warm up questions before discussing the ones from the assignment. Take the last five minutes of the discussion to summarize their contributions and ask them to write how the group differed from their own opinions in their notebooks. This will help them contextualize their next reading and writing assignment that is similar, but a much longer text.

Thinking Like an Astronomer
10 minutes

A way to make sure students will start to understand how to think like an astronomer is by taking this quote:

> "There are more stars in the universe than grains of sand on any beach, more stars than seconds have passed since Earth formed..."

And explaining how Tyson probably calculated it, and how these types of calculations are very useful in astronomy:

1. The Sun orbits the center of the galaxy at a speed that depends on how much mass is within the galaxy. Our galaxy probably has 6×10^{11} times as much mass as the Sun.
2. If the Sun is the average mass of a star, there are about 6×10^{11} stars in our Galaxy.
3. The Hubble ultra deep field found around 10,000 galaxies in about a 13 millionth of the sky: 1.3×10^{11} galaxies in the Universe
4. If our galaxy is typical, there may be $(6 \times 10^{11}) \times (1.3 \times 10^{11}) = 10^{22}$ stars in the universe.
5. Earth formed 4.5×10^{9} years ago. There are about 3.15×10^{7} seconds in a year, so it has been 10^{17} second since Earth formed.
6. There are about 100,000 times as many stars in the universe as there are seconds that have passed since Earth has formed.

So there are more stars in the universe than there are seconds that have past since the Earth formed. How would you calculate how many grains of sand there are on the beaches of Earth?

To engage some active learning, here are three multiple-choice questions to end this part of class, have students answer them and check their work with the person nearest them (see our online resources for a PowerPoint file).

We used Peer Instruction in Astronomy as the source for the following questions

The expression "order of magnitude" corresponds to

a. one factor of ten. $
b. one factor of two.
c. a factor of 2.5
d. two factors of ten.

At the start of the 21st century, the number of human beings alive on Earth was approximately 6,000,000,000 or

a. 6 to the 9th power
b. 6 to the 9th power of ten
c. 6 times ten to the 9th power
d. 6,000 million
e. both c and d. $

Estimate the answer to 3.04 x 5.3:

a. 1.6
b. 16$
c. 160
d. 1,600
e. don't know

Introduction to UNIX

30 minutes

In the computer lab, have the students log into their accounts an open up a terminal and double click on the **Computer** icon to show them a directory containing folders. Activating prior knowledge will help boost student confidence in using computers. Boosting student confidence in computers should be a daily goal. The user interfaces students interact with daily are much easier to deal with than what they are about to attempt. First help them move around the directory tree, perhaps call it a folder tree in the beginning, then show them how to do it with the command line.

If you give the students the handout when you begin, the ones who learn best from following written instructions can cruise ahead, while the ones who learn from examples can follow step by step as you go over the basic functions of UNIX. To slow the students down, we've added questions to check their understanding in the following tutorials. With out these speed bumps, many students will whip through the tutorial and become confused and frustrated when doing the first assignment.

While they are working, point out the `man` and `info` commands and encourage them to play around with the different options in the hand out. Other tricks, like the highlight copy and click paste will help them learn the less fundamental aspects of UNIX.

Go step by step through the handout explaining the meaning of the commands and their use to the part of the class that is paying attention. This act is extremely difficult and sometimes makes the instructor feel like a street vendor. Pay attention to the students who follow verbal instruction and group them in the computer lab in the future. As time went on, we found answering an individual's question loudly was the most efficient way to instruct the class. The lab dynamic is something that will change from class to class and from instructor to instructor. We suggest the best way to teach in this setting is to start with whichever method the instructor feels most comfortable and adjust to the classroom response. For example, the instructor gives instruction to the entire class in the first 10 minutes and lets them get to work. Then, several students ask the exact same questions individually. Instead of insisting the students stop what they are doing and listen in the first 10 minutes, we've found it more productive to say "get started, I'll come around to answer your questions as you reach them, there should be a lot" and answer each question as they come up to the entire class. The negative side is that some students work much slower than others, we suggest making the fast students slow down and answering the questions when about half the class is at the same place.

More UNIX commands like `ssh`, `history`, `scp`, and `chmod` may be taught as throughout the seminar and are good fodder for semi-structured office hours or for research mentors to teach as necessary.

Day 3

Students will be able to:

- practice using UNIX to manipulate data files
- edit text and data files with Emacs

Basic Astronomy Terms

10 minutes

Once they've finished the handout, go over the astronomy background necessary to the UNIX Exercise (page 16). Below is what we feel are the most important concepts to address. This isn't an introductory astronomy course; more information on these concepts would be a great thing to go over in a semi-structured office hour. Absolute magnitude will come up in the second programming exercise, so no need to talk about the two today.

RA and Dec: The same type of measurement as longitude and latitude. Keep the explanation simple, for example, they don't need to know where 0 RA is or the need for epochs. They only need to know how to translate the data file to the star chart, show an example of how to find a star on the star chart. Explain degree/hour minute sec. They'll have the rest within the next couple weeks in their astronomy courses. It should be noted that sort don't treat the negative signs correctly, so southern hemisphere data will be a little off.

Vmag: A measurement of how bright a star *appears* to be. We recommend presenting magnitudes by first ignoring negative magnitude. For example, the brightest star in the sky gets 0, everything dimmer gets 1, 2, 3, etc. Until wait, there is a brighter star than 0, we have to go to negative numbers (the Sun is a star, or Sirius is brighter than Vega). A difference of one magnitude is 2.5 times brighter/fainter. The V band is how bright the star looks with 520 nm filters on.

Parallax: This is an inverse measure of distance, so small parallax means large distance. Spending the 10-15 minutes to explain what parallax is will distract already overwhelmed students.

Peer Instruction: Below are a few multiple-choice questions to ask students to work together on (also from *Peer Instruction in Astronomy)*:

Using the magnitude system of astronomy, how would the brightness of an 8^{th} magnitude star compare to a 7^{th} magnitude star?

a. 10 times brighter than the 7^{th} magnitude star.
b. 10 times dimmer than the 7^{th} magnitude star.
c. 2.5 times brighter than the 7^{th} magnitude star.
d. 2.5 times dimmer than the 7^{th} magnitude star. \$

Four stars magnitudes are 10, 7, -1, -10. Which star appears brightest from the Earth?

a. the first.
b. the fourth $
c. the second
d. the third

Star X is known to be 10 parsecs away from us and star Y is 50 parsecs away. Which star has the greater parallax angle?

a. Star X $
b. Star Y
c. Neither – their parallax angles are the same.

Which of the following stars is closest to us?

a. Procyon (parallax = 0.29 arcsecond)
b. Ross 780 (parallax = 0.21 arcsecond)
c. Regulus (parallax = 0.04 arcsecond)
d. Sirius (parallax = 0.38 arcsecond) $

Programming Exercise 1: Learning and Applying UNIX

10 minutes

Toby Smith developed this activity and the accompanying handout

Purpose

The first UNIX exercise makes the student apply commands from the handout in non-trivial ways. Several of the questions force the student to re-think how they would solve a problem and adapt their thoughts to tools they have available.

Materials

All-sky star charts
`BrightStars.dat` – About 5,000 stars that are brightest in the sky
`NearStars.dat` – About 5,000 stars that are closest to the Sun

Star data should include:
`RA:` Right ascension (sky coordinate) in HMS
`DE:` Declination (sky coordinate) in DMS
`Vmag:` Magnitude in the V band (Apparent magnitude)
`B-V:` Color (B magnitude - V magnitude)
`Parallax:` Trigonometric parallax in milli-arcseconds (MAS)
`uRA:` Proper motion in RA (uRA cos Dec) in MAS/yr --Not used in these exercises but left for future
`uDec:` Proper motion in Dec in MAS/yr -- instructor development

Time: Give students one week and supervised time in class to complete this assignment

Presenting the Assignment

The students are mostly taking the introductory astronomy course for majors so they will learn the contents of the data table thoroughly in time. For now it's best to explain simple concepts so it won't cause much of a hurdle when learning UNIX.

The data tables have the brightest and nearest 5,000 stars. Have them discuss with a partner how the two tables could be different. And then call on a volunteer to explain the answer.

Introduce the assignment by asking them the first question. How would they normally figure that out? Given a table of 5,000 stars, they can find the answers to these questions with UNIX commands. Given time to start in class, the students are then set to answer seven questions using the UNIX tools learned by going over the hand out. They make sense of what they have found by identifying the name of the star in each case. Allow them to discuss which UNIX commands they will use and be sure to walk around helping with pipes and other problems. This will also be a good time to remind everyone about the message board.

Let the students begin the assignment; they may get the first question done. They'll have half the next class to continue their work.

Reflection

Have the students spend the last couple minutes writing in their notebooks answering the following question (also remind them about the website photos for next class):

If you were trying to explain UNIX to a friend, what part would be most difficult?

Emacs

30 minutes

The focus of this lesson is to introduce basic text editing of Emacs (the type of text editing they are used to) without using the mouse. The students will write their short bios for our website within a template. They will learn to search and replace and to spell check (word, regions and buffer). This will introduce the minibuffer and get them ready for the second Emacs lesson: to use rectangles and define macros. The second lesson is a pipe dream and has yet to be incorporated into the lesson plans.

Once again we are keeping with our theme of adding to previous knowledge by introducing the features they would expect in a text editor. To maintain student interest, we chose to have them turn in something that will be used or is useful to them.

Materials

The file bio.txt is a table row for the students page on our website. Table row tags will have to be added after stitching all the files together.

```
<td width="400">
<img src=./images/cohort_5_portraits/FIRSTNAME_sm.jpg class="student" width="150"
align="left">
<p style="text-align:left">  <font class="student">FIRSTNAME LASTNAME:</font>
DELETE THIS TEXT AND WRITE YOUR BIO HERE!

</p>
</td>
```

Day 4

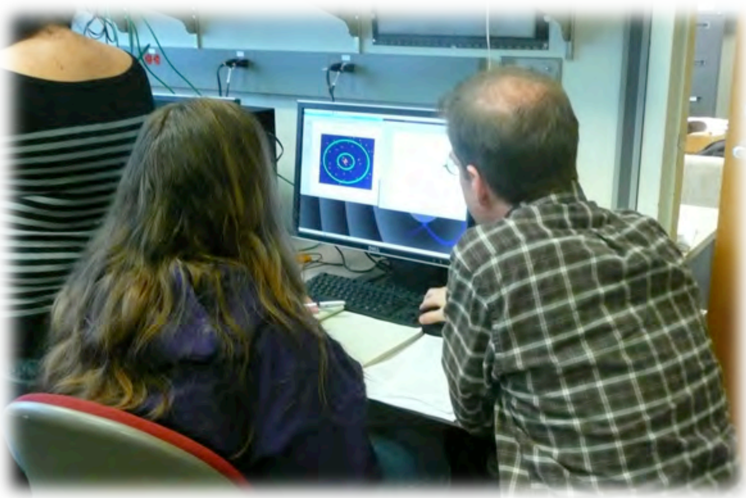
Students will be able to:

- Write about the projects available to them

Before the students leave, hand out Writing Assignment 2.

Today graduate students, post-docs, and faculty will pitch their projects to the students. Prepare the students by giving them an agenda with room for notes. Ask them to structure their thoughts while they listen. Here are some things they can think about:

1. Do you find the topic interesting
2. Would you like to learn some of the skills that you'll be using on the project
3. You like the idea of working with the research mentor



Preparing the Mentors
The mentors should prepare a 5-7 minute pitch with room for 3 minutes of questions and preparing for the next speaker. It may be helpful for them to address the following questions:

- Will the research, if carried on after the seminar, lead to a paper or a poster?
- What will students get out of it?
- How "real" is the research?
- What will they do?

The mentors' goal here is really to talk style over substance: e.g, get the students excited by using words like "research" and "black holes" in the same sentence.

Mentors also may not know the level of the students. The pitch should be at a general level, but they shouldn't talk down to the students or have so many technical aspects that the students won't understand. For example, avoid "as a function of redshift" in favor of "over cosmic time."

Day 5

Students will be able to:

- Choose their projects
- Apply more UNIX functions, such as lpr, man and info

Choosing Research Projects:

The first thing to realize is the students will probably be more than happy to do any of the projects. The next thing to realize is how hard it is to do multivariable optimization on the fly one's head. After four years of Pre-MAP we have learned groups of two are more beneficial to students than groups of three. Before class, gather the first three choices of each student and make a spreadsheet (bold and blue represents the project assignment), for example:

	Stu 1	**Stu 2**	**Stu 3**	**Stu 4**	**Stu 5**	**Stu 6**	**Stu 7**	**Stu 8**	**Stu 9**	**Stu 10**	**Stu 11**	**Stu 12**
Proj 1			**1**		3				**1**			
Proj 2	**1**		2	**1**							3	2
Proj 3		3		3	2	3	2	2	2	**2**	**1**	3
Proj 4		**1**						**1**				
Proj 5	3			2		**1**			3	1		**1**
Proj 6	2		3		**1**	2	**1**	3		3	2	
Proj 7		2										

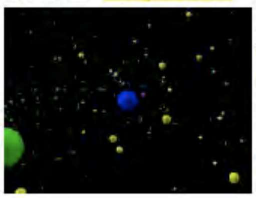
Next, do the easy ones: project one and four were simple while project seven was roundly rejected in lieu of the other projects. The next step was to open up a discussion, do students want to work together or are really dying to work on one project (that is, try to estimate any weighting). Instructor intuition is important here, are there conflicts in personality between students and possibly students and faculty? We suggest weighing first choices over students working together they'll have lots of chances to work together in their academic careers.

Conflicts
We've found that students will act whatever age they are treated. So we suggest treating them as adults by letting them work out conflicts on their own before the next class with the caveat that the instructor will make the final decision if there has been no resolution.

For example, we had a conflict with the project assignments of Students 6,10,11, and 12. Student 10 had very little preference between 1st ,2nd , and 3rd choices, while student 12 had vast differences between 1st choice and the others. Also, student 6 and 10 strongly wished to work together. The obvious choice was to maximize first choices by splitting up students 6 and 10. We decided to give them the weekend to discuss it on their own, anticipating they'd come to the that conclusion without having any ill feeling toward a partner we could have "forced" them to work with.

4. Solar System Cinema

Advisor: Toby Smith



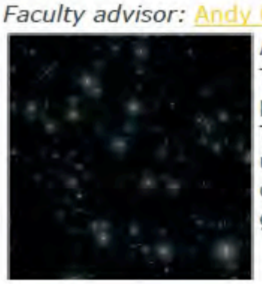
In 1987 Bruce McCormick characterized scientific visualization as "the use of computer graphics to create visual images which aid in understanding of complex, often massive numerical representation of scientific concepts or results." Nowadays, pretty sophisticated scientific visualization can be done with a modest desktop computer.

We live in a busy place. This image is a frame from an animation of a camera following the Earth (blue sphere) in one orbit around the Sun. The other objects are Near-Earth Objects (NEOs) color-coded by distance from the Earth. The relative sizes are not to scale.

Utilizing simple computer tools, and a bunch of CPU cycles, Pre-MAP students will create animations of solar system phenomena. We will will use data sets that we will create through computer simulation as well as empirical data from spacecraft missions. By the end of the project we will have pretty movies and increased generalized computer skills.

5. Building a High Redshift Universe

Faculty advisor: Andy Connolly



A new generation of wide-field astronomical surveys, such as the Large Synoptic Survey Telescope, will soon address many fundamental questions about nature of our universe; the properties of dark matter, the nature of dark energy, and the evolution of large scale structure. To solve these questions we will need to understand many aspects of the: what does the universe look like at high redshift, how well can we measure the shapes of galaxies if they are only barely resolved, how do changes in surface brightness or evolutionary history influence the galaxies we observe.

To address these questions we will create a view of the high redshift universe by building galaxies from local surveys such as the SDSS and shifting them to higher redshift. In this project you will learn about different types of galaxy, how star formation influences their colors and shapes, how dust changes our perspective and how the same galaxy at low and high redshift can look completely different depending on the assumed cosmology and the type of telescope we observe it with.

Writing Assignment 2: The Sky is Falling

Purpose

This writing assignment is designed to match the first writing assignment but increase its complexity. "The Cosmic Perspective" put science in a very positive light while "The Sky is Falling" is typical of a fear inducing science article that are readily found in popular press. Scientists are portrayed as mavericks or unwavering academics. Scientific facts and research outcomes are handed down to a public that is not expected to, or interested in, understanding the methods. It is important that the students express their own thoughts and opinions and work to convince each other what the differences are between this piece and Tyson's. If everyone seems to be on the same page at the end of the discussion, a fun example of the fear inducing message can be read aloud if you have them take turns reading the last sentence of each paragraph of the introduction.

Audience: Another college student (to be written at about the same the article)

Grading Criteria

Informal, amount of thought/effort put into response.

- 0 – no opinion or original thought presented
- 5 – satisfactory opinion or original thought presented
- 10 – well thought out, clearly some time was spent thinking the arguments over

Models: Feedback from the first assignment

Length: At least 500 words, no more than 1000.

Format: Informal, typed

Time: Seven days

Presenting the Assignment

We suggest a minimal amount of introduction to this article. This article came from the Atlantic Monthly, a popular magazine that has several topics. Gregg Easterbrook is a fellow at the Brookings Institute, an author, writer, and columnist for ESPN.com.

Day 6-9

Students will be able to:

- use Python or IDL to read, write, and plot data
- begin to understand arrays and for and if statements

The programming exercises (found on our website) take students differing amounts of time. It's very important to stress patience when students learn programming techniques. We believe students first experience with programming, research, and science should be welcoming and exciting. Keeping students positive while they struggle with programming techniques is a daily cheerleading task. Here are some suggestions:

"The goal here isn't to be fluent at this, it's to introduce you to it. Think of learning IDL or Python like you learn a foreign language… our goal is for you to be able to ask someone what their name is and where they are from, you'll learn more as you do research this quarter."

"Programming is hard, science is hard. It's ok to be stuck, but not ok to be mad at yourself for it."

Group the students into their research pairs and have them get started on exercise one, handing out the next exercise when they have this one completed or at the end of day 7. The timing is lax because of the nature of people programming. The time they put in may not be linearly related to the progress they make. If they work alone, for example, they could spend a lot of time doing integer division and not know where they went wrong. With three exercises and two weeks, we find that students will accomplish the tasks while working in groups. Several students meet in the computer lab outside of class to finish up assignments. We also suggest allowing late submissions for the programming assignments.

Day 7

Continue with the programming assignments after a 30-minute discussion on "The Sky is Falling." The structure of this discussion is the same as the first, except also ask them to compare the articles' tones; they may notice Easterbrook's use of fear to hook his readers. Below are the question prompts from day 2.

Question Prompts:

1. Who was Easterbrook writing to? What was the audience's education level? How old are they?
2. How did Easterbrook use scientific findings for the article? How or why do you think he choose the examples used in the article?

Choose one of those types of warm up questions before discussing the ones from the assignment. Take the last five minutes of the discussion to summarize their contributions and ask them to write how the group differed from their own opinions in their notebooks. This will help them contextualize their next reading and writing assignment that is similar, but a much longer text.

Day 10-20

Students will be able to:

- do astronomical research with their mentors
- communicate their research to others

Congrats! You've now finished the bulk of your role as the instructor. Your role now is to make sure students and mentors are meeting each other's expectations while assigning and grading the work below. This usually involves a weekly "how's everything going" chat with each party.

The structure of each class begins with 10 minutes or of announcements while the mentors file in. Then the research mentors meet with their research groups for the rest of the period (we've often had to remind the groups when class was ending).

This guide only includes material that's been tested on students at least once. Except for this paragraph. One thing we will be adding for our next cohort, we'd also like to mention here as advice. The only negative comments we receive from mentors (and they are seldom) about their students is that they require too much hand holding, come late or miss class, or fail to meet obligations set by the mentor. We think most of this can be addressed positively by teaching students how to be mentored before this becomes a problem. Next year, we'll adapt CIDR's mentoring bulletin for our students (http://depts.washington.edu/cidrweb/Bulletin/Mentoring.pdf) and have them discuss it with their research mentors on the first meeting:

If you are Being Mentored ...

Decide on your mentoring goals

- Identify what you could gain from a mentor
- Consider your own skills, knowledge, working style
- Explore the breadth of possible career options
- Expect mentoring relationships to change over time

Set realistic expectations for mentoring relationships

- Recognize how different mentors will have different contributions to make to your learning
- Develop agreements about shared responsibilities and credit (for example, authorship and intellectual property)
- Identify department and UW resources for mentoring pairs

Broaden your network of mentors to align with your goals

- Know that it's not necessary for all your goals to be met by your research advisor
- Learn about faculty interests through seminars, journal clubs, social events
- Consult with other students and faculty in your department, and with individuals from other departments, institutions, and disciplinary or professional organizations
- Identify and initiate mentoring relationships with individuals who will help you meet your goals

"*A mentor should be a good listener, a role model, and a troubleshooter, willing to give advice and provide guidance, but ready to stand back and let the student proceed.*" - Dr. Nina Roscher, Professor of Chemistry, American University

Day 12

Continue with research as scheduled and email or post the following assignment:

Writing Assignment 3: Faculty Interview

An instructor of academic achievement courses at UW mentioned that in the current courses with social sciences focus, students are required to do a "faculty interview". The students are required to meet with a faculty member from one of their classes and write up a report about it. They can talk with the faculty member about anything, but they are not supposed to say it is for a class project. She called this a "transformative moment" where the responses from the students were incredible and after talking with some of the faculty they were just as pleased. Students asked everything from questions about class, to why they decided to go into their field. We tried this with our latest group of Pre-MAP students to a similar effect.

> *…through the assignment I realized how meaningful a meeting with a person in the field I am interested in can be. Not only did I meet a very interesting and accomplished person through this assignment, making a connection in the industry, I also got an inside look on how to succeed…*

Purpose:

By placing students in an informal (though possibly still intimidating) interview situation, we hope students will begin to view faculty as people they can approach for help and mentorship in the future.

Audience: Another college student

Grading Criteria

Informal, amount of thought/effort put into interview

- 0 – no opinion or original thought presented
- 5 – satisfactory opinion or original thought presented
- 10 – well thought out, clearly some time was spent thinking the arguments over

Models: None

Length: About 500 words, no more than 1000.

Format: Informal, typed

Time: Seven days – we suggest reminding students that they may need to set up appointments with the faculty they choose.

Presenting the Assignment

The purpose of this assignment is not to give students a logical gain of information or a new tool; it's to increase their confidence within school. It's difficult and can be insulting to explain that to students. We decided to just leave the purpose vague, as if the point is simply to learn about the path a faculty member has taken to get to where they are. This was a successful experience for more than half of our students, though to some, it was perhaps too vague of a prompt.

For example:

Your next writing assignment is to interview a faculty member and write a report about it. You can ask whatever you'd like; the only rule is that you may not tell them you are doing this for a class project. The report should be about 500 words.

Possible questions: "Aside from working towards a degree, most benefitted you most in succeeding in astronomy" "What made you realize you could do it?"

No more than two people can interview the same faculty member and each person must do their own interview. Please email me your faculty choice and I'll confirm. You may need to set up a time to talk with them, or go to their office hours.

Day 14

Hand out the writing assignment and guide on day 14; the Jigsaw activity takes place a week later on day 16 in lieu of research.

Writing Assignment 4: Scientific Journal Paper

Purpose: To finish the scope of telling the story of science, the final and most intensive science reading will be from a scientific paper. We have two very simple goals when introducing students to a peer-reviewed publication.

1. They have a good first experience reading a scientific paper
2. They feel they understand the paper and that they taught themselves.

Students need to feel very quickly that they have the capability to do and understand science on their own. These goals should be considered when choosing the paper.

In order to reach these goals, we chose activities that will have them work in groups, speak scientifically among their peers (which will also be good practice for their upcoming research talks) and exploit other mental tools besides logic to understand the results of the paper.

We looked to choose a paper from the Astrophysical Journal that builds off current knowledge, is short, and does not contain too many complicated ideas or jargon. In a quick brainstorm, we choose the discovery of Sedna paper ("Discovery of a Candidate Inner Oort Cloud Planetoid") by Brown et al (ApJ 2004, 617, 645)

Audience: This is a split writing assignment, the ten questions: another college student. The write up summary: A member of the information seeking public.

Grading Criteria

Ten questions: ½ a point per correct answer
Write up: Informal grading

- 0 – no opinion or original thought presented
- 2.5 – satisfactory opinion or original thought presented
- 5 – well thought out, clearly some time was spent thinking the arguments over

Models: None provided, though they can read science blurbs online.

Length: 300 words

Format: Informal, typed

Time: Seven days for ten questions, two days for 300-word write up

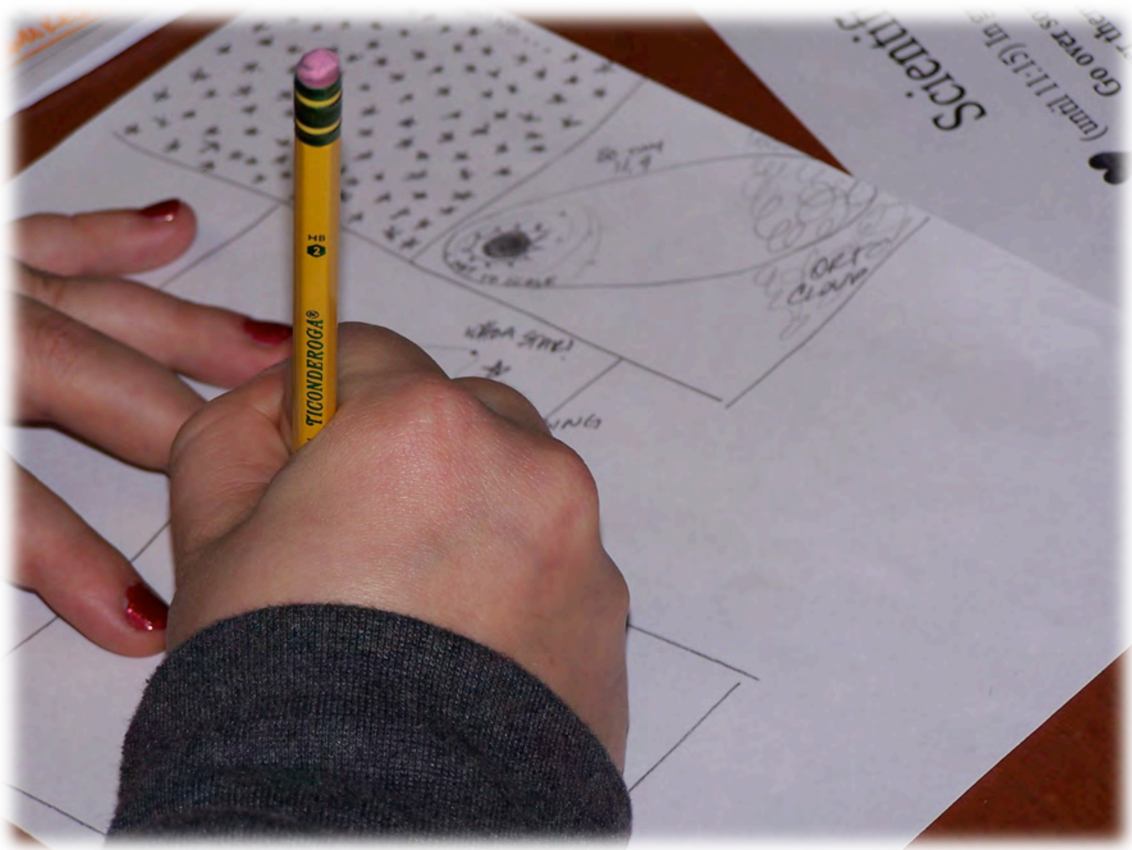
Presenting the assignment

Reading the Paper

Before the students read the paper, they should have an idea about its layout. Since all the time in class is taken by research, we provided a handout, "Understanding a Scientific Paper." This handout explained the layout, posed several questions to slow down the reading and aide comprehension, and listed an informal glossary of terms and confusing passages.

Understanding the Paper

We replaced an entire day of research with the activity to go over the paper, though it could be accomplished in 50-60 minutes (not the full 80 minutes). We broke the students up into groups for a "Jigsaw" activity.



Day 16

Students will be able to:

- understand the complex ideas presented in a peer-reviewed journal
- practice writing science informally

Science Paper Jigsaw

A jigsaw activity starts in one group (the puzzle), then breaks up into new groups (the jigsaw pieces), and finishes in the original group (putting the pieces back together). With 12 students, we simply handed out the Aces, Twos, and Threes of a deck of cards. The first and last groupings then were done by suit (four groups of three) and the jigsaw groups were made of numbers (three groups of four).

(15 minutes) In groups by suit: Students go over the questions posed from the reading and make sure everyone understands the basics of the paper.

(35 minutes) In groups by number: Each group goes over one of the “Origin” sections (4.1-4.3). They work to understand it by breaking the ideas up and each drawing their own comic strip.

(30 minutes) Back original groups (by suit): Each student describes the section and their comic to the other students. Which theory do the authors believe is the most plausible and why?

Summary and write-up
To assess the student’s understanding, bring this writing assignment to the theme of the others, and help prepare them for their research presentations, we choose a fun write up:

Now you’ve read and understood your first peer-reviewed scientific paper! It’s time you let others join in the fun.

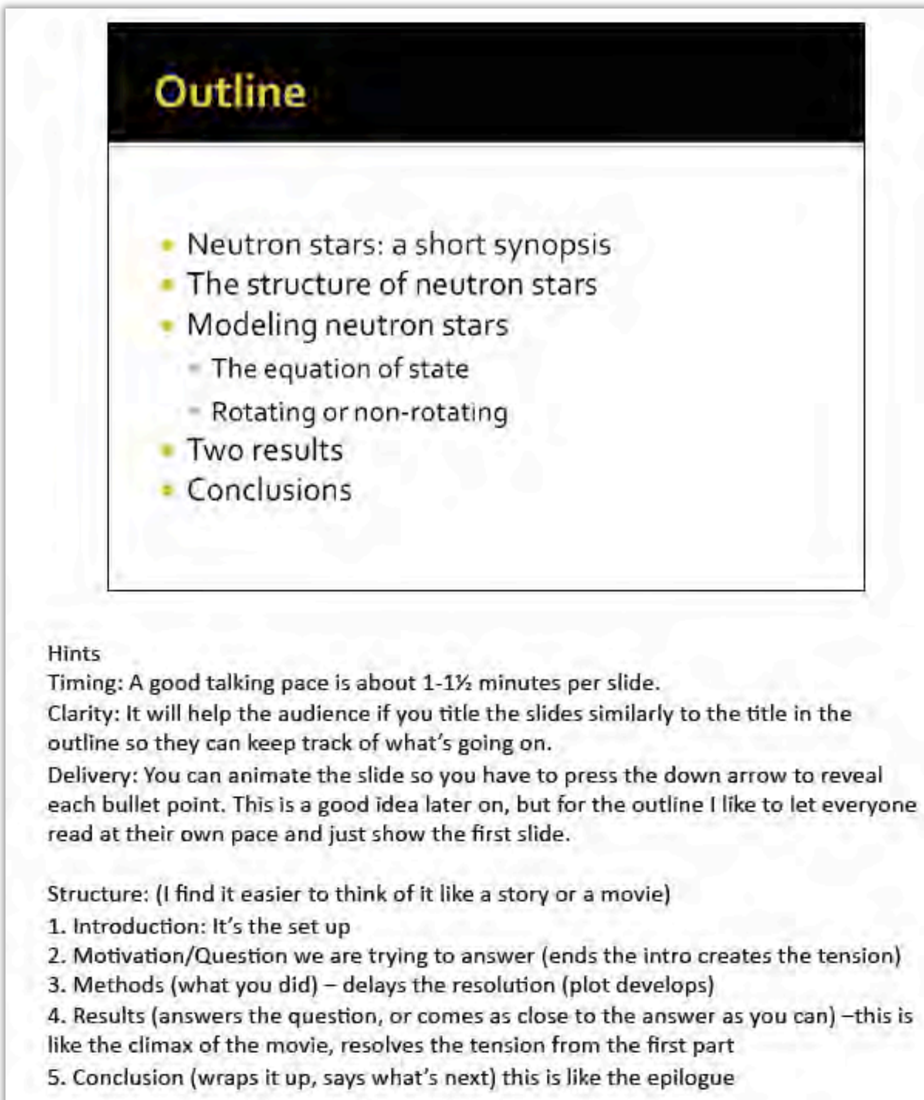
Your job is to write a summary of the discovery, its most probable origin, and why anyone should care (under 300 words!). This sort of text would appear on news websites, so make sure you use words the public will understand and you make it “pop.” You want people to be excited about this discovery (and all the discoveries you will make).

Day 20

Students will be able to:

- get an idea for what type of presentation they must do
- synthesize the research of their research projects

Take the first ten minutes of class to give a sample research presentation and then let them go back to research with their research mentors. Our 2009 instructor found an old research talk that was similar to the amount of work a Pre-MAP student would accomplish. Providing them with a PowerPoint template talk and hints for why each slide was where it was helps students write their own talks. See our online resources for templates.



Writing Assignment 5: Communicating Your Science

Purpose: This assignment nearly completes the learning goals of communicating science while helping them prepare for their presentations. It allows them to rethink their project in a few different ways, and as a bonus, will help them explain it to their family and friends over the winter break.

Two Audiences: The first two writings are for basically anyone with some general science knowledge while the third writing is for someone who doesn't know any science.

Grading Criteria: Informal grading

- 0 – no opinion or original thought presented
- 5 – satisfactory opinion or original thought presented
- 10 – well thought out, clearly some time was spent thinking the arguments over

Models: The two models are taken from Randy Olsen's book "Don't be Such a Scientist" (though it shouldn't be too hard for the students to do better).

Length: 100 words/1 sentence/as many words as it takes (average turns out to be 300)

Format: Informal typed

Time: 1 week (concurrent with preparing research presentations)

Presenting the Assignment

We present this assignment directly after the example research talk when we also describe their final research presentation.

The Elevator Pitch

How do you think our galaxy looked like a billion years ago? Astronomers attempt to do this by comparing our galaxy with distant galaxies. I've been studying the morphology of galaxies by observing them in different wavelengths. One can tell whether a galaxy is old or young, or distant or nearby by analyzing what spectra it emits. However what my partner and I have concluded is that it is not obvious to define a galaxy's attributes because some nearby galaxies seen in infrared appear identical to distant galaxies that have been severely red shifted.

Day 21

Students will be able to:

- practice their group presentations in a comforting group

Let the research mentors stay in their offices for these practice presentations.

Tension breaking icebreaker

For the first few minutes, play a theater game warm up with your students. "Zip Zap Zop" is a fun game that will help take the students minds off of what's to come.

See http://www.interplaytheatre.com/Games/ZipZapZop.html for more.

Practice Presentations

Let the students know that you will introduce them and their topic briefly and then they can go. Give them suggestions on how to start and end a talk. We had our students thank everyone for coming and introduce themselves and finish by saying "thank you."

Encourage your students to ask questions at the end of the talks. Tell them that they are not being nice by not saying anything; they are helping each other practice answering questions in front of a group.

Sit back, watch, and be very positive with your words and encouragement when they finish. It won't be too hard.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