Pre-Major in Astronomy Program Research Mentor Guide

Introduction

A Pre-MAP research mentor is a volunteer faculty member, post-doc, or advanced graduate student who creates a research project for first quarter Pre-MAP students to work on in pairs. The job begins before the classes start when you work with the seminar instructor or a Pre-MAP staff member to design and advertise a simple project. Two weeks into the seminar, you will pitch the project to the students and after the first month, will work directly with the students in each class period (and sometimes outside of class) for the remainder of the quarter. The progress will be presented by the students to the astronomy department during the last class period of the quarter.

A first-time research mentor should anticipate about 35 hours of work over the course of the quarter to follow through for their students. This includes about 10 hours of defining and preparing the project, two 80-minute class sessions a week for five weeks (15 hours), and an estimated 10 hours interspersed throughout the quarter answering emails, providing additional help, and working with students on their presentations. We suggest team mentoring (see below) to help relieve some of these time demands.

Research mentors gain valuable professional skills beyond those of mentoring. For example, our mentors have used Pre-MAP student research to meet the "Broader Impact" criteria of their NSF grants while learning better methods of training the next generation of scientists.

This guide is meant to help first time Pre-MAP research mentors. Please don't hesitate to contact us with any questions about the process, premap@astro.washington.edu.

A Brief Description of the Pre-MAP Research Seminar

For complete information, please see our document "Curriculum for Pre-MAP"

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 into three parts. For the first five weeks of a twelve-week quarter, students will learn the necessary programming and scripting languages to be able to begin research with their mentors. Weeks 6-10, students are paired with a volunteer research mentor who guides them in the completion of a research project. The final two weeks are reserved for the students to prepare and present their research to the Astronomy department. Throughout the quarter, Pre-MAP students will be learning about the communicative side of scientific research while building a support network that will last throughout their college careers.

Week	Topics Covered	Mentor's Role
Week 1	Introductions	[by Week 1] Design and advertise project
Week 2	Unix, Reading Science I	
Week 3	Projects, Emacs	10 minute project pitch
Week 4	Interpretive Language, Reading Science II	Optional: assign simple background reading on topic, meet informally
Week 5	Reading and Writing data, Plotting data	
Week 6-8	Research, Interviews, Reading Science III	Meet with students in class to conduct research
Week 9	Communicating Science, Research Presentations	Assist with talk, finish research
Week 10	Practice talks, Final Talks	Support students by attending talk

Advantages of Team Mentoring

Our projects have been mentored both by individuals and teams consisting of two or three people. There are several advantages to this approach.

Professional Development
Graduate student and post-doc mentors gain valuable mentoring experience when teamed with a faculty member.

Time commitment
First year astronomy students will need quite a bit of mentoring attention. Dividing this time by two or more mentors lowers the burden on any one person. Since many researchers have meetings and travel frequently, having more than one research mentor increases the likelihood of one being present during the seminar.

Community Building
The more departmental people that students meet, the more comfortable they will feel within the department. One of the goals of Pre-MAP is to build a sense of community for the students.

Being a Pre-MAP Research Mentor

Working with the Seminar Instructor

The seminar instructor or a Pre-MAP staff member will also ask you to report on the status of the project, the relationship between you and the students, and the relationship between the students periodically throughout the quarter. For past experience, mentors who take the lead on this are greatly appreciated by the instructors.

Designing a Research Project

A good starting point for a Pre-MAP research project could be a “back-burner” project that you have put some thought into, but isn’t the highest priority. The goals of the research project should be discussed in one of the first meetings with the students, they will be used to assess a grade for the research component of the seminar.

Goals for a Successful Research Project

1. Students complete a task that they understand and that makes them feel like they have participated in research
2. Students feel confident presenting preliminary results at the end of the course
3. Students feel they could continue their work in the following quarter for research credit
4. Continued work is presented at an undergraduate research symposium
5. Continued work is presented at a national research conference
6. Continued work results in co-authorship of a paper

For a research project to be considered a success, we believe the first three goals must be met, and the best projects are extended to meet the last three goals.

Skill Level: It should be assumed that this is the first time your students have used computer skills related to scientific research. Our past research mentors have found that introducing them to the project without the aide of a computer program or script is a good way for them to learn the topic and the importance of programming. Our examples below highlight this method.

Astronomy Background: Like the research seminar, assuming no astronomical background is a good start, though most students will be taking the introductory astronomy course for majors. A project that would interest a public audience would also be interesting to the students. To prepare them for the topic, we suggest assigning a short reading around week 4 or 5 and meeting to informally discuss their questions. Our research mentors have photocopied astronomy 101 textbooks or emailed Wikipedia links. As the project progresses and the students gain familiarity with their tasks, research mentors may introduce new details and background.

Time Constraints: The students are expected to do no more than 1-2 hours of research outside class per week in addition to in-class work. The research portion of the seminar only spans 5 weeks, which means you should expect about 35 hours of devoted research time from the students.

Sense of Accomplishment: Our evaluations have shown that students who continue in the sciences often express a sense of having accomplished something as part of their Pre-MAP research project. No matter how small, it is important that the students feel that they have contributed something to science.

Advertising the Project

Before the start of the seminar, we post projects on our website. These typically consist of a short paragraph explaining the project background and another paragraph explaining the task to be done, in addition to an image and image caption. Advertising the projects will give the students more of a sense of authenticity in the program and are useful to point to when requesting funding. Examples of our previous projects can be found at http://www.astro.washington.edu/users/premap/projects.php. Please feel free to use them as templates by viewing their source.

Presenting the Project

In the second week of class, research mentors come into the seminar and give the students a short presentation on their Pre-MAP project (See *Curriculum for Pre-MAP* Writing Assignment II). This presentation should give an overview of the science of the project and describe what the students will be doing if they work with you. Here are some points that mentors should address.

- 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?

Because the students have never done research before, your 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.

The pitch should be at a general level, so avoid talking down to the students, but don't use jargon or discuss techniques that the students won't understand. For example, avoid "as a function of redshift" in favor of "over cosmic time."

Working With Students in the Classroom

The first official task for you and your students is to clearly define expectations about student responsibilities and time-commitment. Here is a possible rubric, to be shared with the instructor and student, as an informal way of grasping their understanding from class (from Paul Teske of the University of Washington). The numbers can be scaled to fit any grading scheme.

	1	2	3	4
Research	Did some research and answered a few questions	Answered some questions, and gave short answers to some of the research questions	Answered most of the questions but did not expand much on open ended questions	Used numerous sources to find information and answered all the questions to the best of ability
Presentation	Did not give the audience facts about the topic—stated things in very general terms	Supplied the audience with a few facts	Gave the audience more than just a few facts and described the project in good detail	Supplied the audience with rich and thorough details about their subject
Science Concept Understanding	Did not mention any science concept associated with the project either in the presentation, writing, or during research	Mentioned a science concept, but did not expand on what it meant.	Mentioned a few science concepts, and made some effort to explain what they meant in relation to their subject.	Specifically mentioned, contextualized or described specific scientific concepts during the presentation, in writing, and during research

The Final Presentation

At the end of the seminar, students give a 10-minute presentation to the astronomy department. This is an opportunity for them to put their research into context and to gain a real sense of what they've accomplished in a few short weeks. It also ties the writing assignments in directly to the main events of the class. We suggest the seminar instructor take over for the beginning of class and give an example presentation, followed a week later by a full day of student practice presentations with the instructor that research mentors will not attend. This way, students will give their talks to only people they know (some students won't know other's research mentors). Meeting with the students outside of class, or taking the last day in the research seminar to go over what has been done will help the students on their final presentations.

Computing, Software, and Disk Space Considerations

Our Pre-MAP seminar takes place in our undergraduate computing lab, a bank of 30 UNIX machines that are reserved during class meeting times. We have room for about a dozen students and their research mentors, which puts a reasonable limit on class size. Disk space for Pre-MAP students could become an issue. We have no disk space specifically set aside for Pre-MAP students; our research mentors often use their own directories with shared permissions. This seems to work well.

Research Project: Supernovae or Asteroids in SDSS repeat photometry

Project Description for Students: You will detect objects that have varied in position or brightness from one night to another by subtracting one image of the sky from a later image of the same piece of sky. Some of these will be supernovae. The sky is full of other interesting variable objects, such as asteroids, variable stars, man-made satellites (some of which do not officially exist), and black holes at the centers of distant galaxies. Any new objects you find, in particular supernovae and comets, may be eligible for publication by the International Astronomical Union Circulars Central Bureau for Astronomical Telegrams.

The Project in the Classroom: The project was to identify supernovae from the repeat photometry of Stripe 82 in SDSS. The concept is straightforward: compare two images of the same galaxy, and look for bright objects that are in one, but not the other. The images were already reduced, and the color information was included. As the project progressed, the research mentor explained more details about supernovae light curves, types of supernovae, the details of the SDSS survey, etc. In this case, the research mentor had been thinking of this project for many months, but it was certainly a 'back-burner' project.

The research mentor could have provided scripts to do image registration and create difference images. In this case, the students would have gained less programming experience, and would have spent the majority of their energies on the most mundane aspects of the project, namely processing the images and repeatedly looking at the resultant differenced images.

Instead, the research mentor began by having the students look at images by hand. It immediately became obvious that automating the process was necessary. Again, the research mentor made the extra effort to assist these novice programmers in writing their own code instead of handing them one. Although this took longer, the students learned tremendously from the experience, and they fully understood how the code worked. Once the students began processing images, they started to get bored, since they weren't finding any SNe. However, they did notice they were finding hundreds of moving objects.

After some discussion, the focus of the project was switched to finding asteroids. Like the original project, this one was exciting, and conceptually straightforward. Because the students had written the code, it was easy for them to adapt it for their new purposes. Pursuing the new goal of finding asteroids was an excellent teachable moment about the process of science.

During the second year of Pre-MAP, the research mentor again submitted a related project, and the students, new and old, worked together as the project slowly evolved into classifying the asteroids, identifying orbits, and other various scientific analyses of their discoveries.

Results: The students were very successful at finding asteroids. Thousands of their asteroids were previously unidentified, so the students got to name them, and were featured in several media reports. Additionally, since the students were so captivated by the project, they continued working with their research mentor for the next several years.

Research Project: The Death and Rebirth of Circumstellar Disks around Massive Stars

Project Description for Students: In this project, you will be investigating a massive star which (for reasons not well understood) lost its old disk and recently started developing a new one. Your main tasks will be to a) analyze an existing spectropolarimetric dataset to constrain the time-scale of disk-loss and disk-renewal; and b) begin to characterize the fundamental properties of the disk, when it was present. This research could be easily extended into a longer-term project for interested Pre-MAP student(s), with the objective of publishing the results in a major astronomy journal.

The Project in the Classroom: This project was designed to be modular, with both a clear goal students could accomplish during the time-frame of the pre-MAP course, as well as objectives which could be achieved if students continued to work on the project after completing the course. The project description was written to appeal to students by creating excitement and mystery about the topic. The students were initially provided with ready-to-analyze data, which could be worked on right away. As they progressed, they learned more about the data calibration.

Results: One of the students continued working on the project throughout the academic year, and worked full-time during the summer on the project. This project has not changed focus significantly, and the student is still fully engaged. He will be presenting a poster at an upcoming AAS meeting and is a co-author of a paper submitted to ApJ for publication.

Research Project: Simulated Images from Black Hole Mergers

Project Description for Students: In this project you will be investigating the link between merging galaxies with black holes and any electromagnetic signatures from the host galaxies. You will be examining the results of high resolution computer simulations of the merger event as shown in the figure, and creating simulated optical, ultraviolet, and infrared images. By correlating these images with the time that the black holes undergo accretion events in the simulation, you will be able to distinguish the observational properties of the host galaxies at the time of the supermassive black hole feedback activity from other events in the galaxy merger scenario.

The Project in the Classroom: The exotic nature of black holes makes them of natural interest to many students just starting out in astronomy, so this project generated much interest. The Pre-MAP students were given the outputs from n-body simulations and used provided software to create simulated images (mock observations). Both the simulations and software were already completed, so the students could begin working immediately. The students learned the details of the simulation over time, as their knowledge grew. The research mentors provided one simulation with black holes and one without.

In order to build confidence of the students, and increase their interest, the students were told what the effect of the black holes was expected to be and let the students reason out which simulation was which as they progressed in their analysis. Both students continued working with the beyond the initial quarter, and the focus of the project shifted to making various profiles of galaxies (gas density, temperature, rotation curves), in sync with the students' increased programming and analysis abilities.

Results: The students presented a poster at the UW Undergraduate Research Symposium, and one student may present at a national conference in the future. The project wasn't entirely a backburner project, but was also not central to the research mentor's work plan. Since this project was successful, the Pre-MAP students were able to make enough progress to satisfy the research mentor's needs for the project.