

# The Pre-Major in Astronomy Program (Pre-MAP): The First Two Years & Plans for Expansion

## 1 Pre-MAP Vision & Goals

The Pre-Major in Astronomy Program (Pre-MAP) is designed to attract underrepresented students to the U.W. Astronomy Department, smooth their transition from high school into college, and provide them with exciting astronomy research opportunities and committed mentoring beginning in their first quarter at the University. This training enables them to succeed in astronomy and encourages them to pursue a life in science.

**Pre-MAP's long-term goal is to double the number of underrepresented students majoring in Astronomy.** This would result in a nearly 10% increase in the number of all students receiving Astronomy degrees from the University of Washington. Pre-MAP will achieve this goal by improving retention among underrepresented students intending to major in Astronomy (from  $\leq 50\%$  to  $\geq 80\%$ ), while also providing a strong recruiting tool to attract underrepresented students into the U.W. Astronomy Program in the first place.

The first Pre-MAP cohort of seven students entered the program in October 2005 (below left, pictured with Pre-MAP staff). Of these seven, five are women, one is a Filipina, one is from a low-income family, and two are first-generation college students. The second cohort of eleven students entered the program in September 2006 (below right). The group is comprised of five women, one African American, two East Asians, two South Asians and one student from a low-income family.



Figure 1: Pre-MAP Cohorts 1 & 2

## 2 Pre-MAP Description

Pre-MAP offers astronomy-specific research experiences, while creating a supportive environment in which the students can flourish. Similar programs have been shown to increase persistence within a major, student performance, and academic self-esteem.

## 2.1 Seminar & Research

Pre-MAP students register for Astronomy 102, an introductory course designed for science-interested students and offered in the Autumn quarter. They also sign up for the special Pre-MAP seminar led by a graduate student teaching assistant (TA), which meets for a total of three hours a week. (The 2005 seminar syllabus and Pre-MAP calendar are included in the Supplementary Documents.) The students start by acquiring basic computing skills required to work on astronomical research projects. For example, they learn Interactive Data Language (IDL), a programming language commonly used by astronomers and other scientists for data analysis. They also practice data manipulation and visualization, reading scientific journals and science writing, and are introduced to basic statistical analysis.

A few weeks into the quarter, faculty, post-doctoral fellows, and advanced graduate students present available research projects to the students. The students then choose projects and spend the remainder of the quarter working on them in small groups under the supervision of the seminar leader and the project scientist<sup>1</sup>.

In Autumn 2005, more than a dozen possible projects were presented, ranging from interpreting computational simulations of the Milky Way to observing variable stars with a 12-inch telescope. For the second cohort, entering Autumn Quarter 2006, eight potential projects were presented, each of which provided the students with opportunities to collect real data and to display and interpret results. All Pre-MAP projects are short-term but open-ended, meaning that the students can make significant progress in five weeks of work, but can also continue to work on their projects once the quarter is over. At the end of the quarter, the groups present their results to the department, and they are given the option of continuing with research for the remainder of the academic year (see §2.4 for details).

Pre-MAP students develop a broad set of skills that will serve them well throughout their studies. While not every Pre-MAP student will major in astronomy, Pre-MAP gives every participant experience in successfully navigating teamwork and scientific problem-solving, and thereby helps develop both collaborative learning and critical thinking skills.

## 2.2 Mentorship

Mentorship is the other key component of Pre-MAP. The graduate student teaching assistant who leads the Pre-MAP seminar serves as a mentor to the students, helping them to navigate the U.W. both academically and personally. Formally, the TA fills this role for the duration of the students' first year, but we expect that the Pre-MAP students will continue to turn to their graduate student mentor throughout their undergraduate experience. Students are mentored by the research project scientists as well, who not only teach the specifics of their particular research project but also demonstrate the abilities, knowledge, and discipline required to be a scientist.

In addition to the direct support they receive through Pre-MAP, students in our cohorts build a peer-learning community and are able to call on one another for academic and emotional support. Members of Pre-MAP's first cohort reported creating study groups that lasted into the Winter and Spring quarters and even into their sophomore year. Although it is still early in the quarter, our second cohort is showing signs of the same community-building. Students in our first cohort also became very comfortable working in our department and interacting with its members. They frequently used the undergraduate computer laboratory and sought academic support and advice from faculty, post-docs, graduate students, and

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<sup>1</sup>Note that the TA is responsible for collecting the research projects during the summer preceding the seminar, and for determining, with the project scientists, what research skills the students will need for each project.

upper-level undergraduates. We have added to this mentorship ladder by involving members of our first Pre-MAP cohort in the incoming cohort's activities, for example by inviting them to a recent movie night.

### 2.3 Beyond the first quarter

While Pre-MAP's main efforts focus on the first quarter of the participating students' first year, the program is designed so that we continue interacting with the students as they move towards declaring a major. All seven members of our first Pre-MAP cohort chose to continue with research through the Winter and Spring quarters, and six presented their results at the U.W.'s showcase for undergraduate research, the Annual Undergraduate Research Symposium, held in May 2006. We include in the Supplementary Documents a copy of a poster presented by two Pre-MAP students at this event. **Of the 505 confirmed student participants at the 2006 Undergraduate Research Symposium, only 11 were freshmen—and five of these were Pre-MAP students.**

Prospects for keeping the students engaged with the department through their sophomore years are good; one Pre-MAP student participated in a Research Experiences for Undergraduates (REU) program during the summer of 2006, while two were funded for summer research at the University of Washington. One student, now in her sophomore year, is still actively involved in astronomy research related to her Pre-MAP project. Another will be presenting her summer research at the upcoming winter meeting of American Astronomical Society in Seattle. We are currently working with the students to find further research opportunities (including through work-study) in the new academic year. In addition, several faculty members received funds for Pre-MAP student researchers as part of NSF grants they have been awarded.

Pre-MAP students have been trained to give planetarium shows and are involved in departmental outreach (a number participated in the most recent freshman orientation and recruited for Pre-MAP, for example). This level of involvement in departmental activities is unusual for students early in their undergraduate careers and is another way in which we maintain contact with them.

Finally, the graduate teaching assistant is paid (10% time) to continue mentoring and advising the students, as well as to organize a handful of social activities and a field trip, after the Autumn quarter seminar is finished. This past February, the first Pre-MAP cohort visited the Dominion Astrophysical Observatory in Victoria, B.C., where they were given tours of the various facilities and participated in observations with the Plaskett 1.8-meter telescope (pictured in §1).

### 2.4 Recruitment

Pre-MAP has developed strong relationships with programs targeting underrepresented junior high and high school students, such as the U.W.'s Women's Center *Making Connections* program and the campus chapter of the Upward Bound program. These programs can broadly be described as preparing students to attend college. Pre-MAP is an appealing partner, since one of its major advantages is that it is aimed at first-quarter freshmen and can therefore help ease the often difficult transition underrepresented students experience when they enter the University.

Over the past year we have presented an overview of Pre-MAP at many events hosted by these programs at the U.W. (e.g., the Annual Women in Science and Engineering Conference), we have co-hosted campus events (e.g., with the campus Gaining Early Awareness and Readiness for Undergraduate Programs [GEAR UP] project), and we have given numerous planetarium shows (e.g., to recipients of the Washington Education Foundation Achievers scholarships). We have also worked with the Office of Admissions and NASA Space Grant of Washington to send out tailored recruitment material targeting potential

Pre-MAP participants, and we have collaborated with U.W.'s Office of Minority Affairs counselors to identify interested students.

## 2.5 Publicity

Pre-MAP has attracted much attention, both locally and nationally, because it is an exciting attempt to address the historic underrepresentation of minorities and women. Daryl Haggard presented a poster about Pre-MAP at the American Astronomical Society (AAS) meeting in January 2006 (Washington, DC) and will be giving an invited talk about mentoring undergraduate students at the 2007 joint AAS/American Association of Physics Teachers (AAPT) meeting in Seattle. Marcel Agüeros gave a talk about the program at Vanderbilt University in February 2006 and will do so again at a NSF Fellows Symposium prior to the AAS/AAPT meeting in Seattle. Eric Agol and others presented a poster about Pre-MAP at the Teaching and Learning Symposium at the U.W. in April 2006 and Eric Hilton gave a talk about the program at the NW Astronomers Meeting in May 2006. Pre-MAP has also been featured in the Winter/Spring 2006 issue of *Perspectives*, the newsletter of the UW's College of Arts & Sciences, and will be featured in an upcoming issue of *The Daily* of the University of Washington.

The visibility of the program has proved valuable not only in recruiting Pre-MAP students, but also graduate students. As one of our new astronomy graduate students, Sarah Loebman, put it: *"I ultimately decided to attend U.W. Astronomy because of the graduate students' commitment to diversity and community — Pre-MAP was key in this decision. Pre-MAP exemplifies what an academic community should be: faculty and graduate students reaching out to undergraduates through innovative coursework, research opportunities, and most importantly, supportive mentoring for those who need it most."*

## 3 Assessing Pre-MAP

We use a number of methods to assess the effectiveness of Pre-MAP in meeting programmatic goals throughout the academic year, and suggest a number of ways of evaluating its long-term success.

### 3.1 Participant Assessment

Useful assessment requires anonymity to ensure candid responses from our (small) group of students. We worked with CIDR to develop Pre-MAP assessment tools, to collect and interpret responses to surveys, and to incorporate appropriate changes to the mentoring relationship in order to better meet the needs of our students.

We survey the recruited students at the beginning and end of the Autumn quarter to measure their expectations of Pre-MAP, their goals in participating, and their attitudes towards a career in astronomy or in the sciences. Answers to the latter questions are compared to those of all students in Astronomy 102. The survey results from our first year indicate that Pre-MAP students are more enthusiastic about majoring in astronomy and about a career in science at the end of the quarter than at its start. They also indicate that the increase in Pre-MAP students' enthusiasm was greater than for students who took Astronomy 102 but did not participate in Pre-MAP.

In addition to the attitudinal poll, we also keep track of our students' academic progress in Astronomy 102. In the Autumn 2005 course, Pre-MAP students performed better than non-Pre-MAP students, an average grade of  $3.55 \pm 0.28$  compared to  $2.82 \pm 0.89$  out of 4.00.

## 3.2 Graduate Mentor Assessment

Feedback from the graduate mentor has been crucial in refining the program. The graduate mentor keeps a weekly log of seminars, detailing not only the material covered but any problems which arise, how the various students are doing, etc<sup>2</sup>. The graduate mentor will also write an annual report detailing lessons learned, both positive and negative, and making suggestions for the graduate student leading the next year's program.

# 4 Lessons Learned

## 4.1 Seminar & Research Projects

The first-quarter seminar represents the core of the Pre-MAP experience for students. It also provides a test-bed for our research-based approach to attracting and retaining students in the sciences. As with recruitment, the Pre-MAP TA initially identified numerous resources available on the UW campus to support development of curricula and evaluation/assessment (e.g. CIDR, where Wayne Jacobson suggested one minute evaluations, a weekly log by the TA, pre- and post-surveys with Astronomy 102 students as a "control group", etc.). These suggestions, along with support from the OMA, Student Counseling Services, the College of Arts and Sciences Writing Program, and numerous other on-campus groups have proved invaluable as we work to improve and expand the program.

We have found that the students need ample time to develop computing skills (and confidence); fully half of the quarter *must* be devoted to basic research skills development. In addition, workshops (study skills, campus resources, scholarships, etc.) are beneficial, but should take place in the first half of the quarter or outside of the usual class meeting time so that the students can concentrate all of their attention on research for the second half of the quarter.

Active participation from the research project scientists is key during the second 4-5 weeks of the quarter, once students have begun doing research (weekly meetings work well). The Pre-MAP TA and project leaders are more adept at developing research teaching strategies on a week-by-week basis, instead of as a complete tutorial-based program developed in advance, due to uncertain data acquisition time lines and the wide variety of software applications used by the different projects. The human element is key! Cohort 1 students have found a home in our department and benefited from contact with upper-level undergrads, graduate students, post-docs, fellows and faculty. This exposure to the department as a whole creates a "mentoring ladder" that supports Pre-MAP students as they move toward declaring a major. In an extension of this ladder, Pre-MAP students in both cohorts have expressed an interest in public outreach, e.g. giving planetarium shows to public school groups. This is also a great way to help them develop public speaking and presentation skills and keep them involved in astronomy-related activities.

In developing Pre-MAP as a department-wide initiative, we have discovered that post-docs and graduate students can make great research supervisors, and will often jump at the opportunity to mentor undergraduates. Not only are undergraduates eager researchers, but mentoring experience is very attractive when applying for post-doctoral and faculty positions. For many graduate students, Pre-MAP presents a perfect opportunity to begin mentoring and delegating research tasks, skills most astronomers only develop much later in their careers. Even graduate students who were not technically mentoring Pre-MAP students had nothing but good things to say about working with them on their research. "*Watching a motivated student accomplish their goals in a setting that is very new to them is extremely satisfying,*"

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<sup>2</sup>A sample weekly log has been included in the supplementary materials.

says graduate student Oliver Fraser, “*and sharing their joys and accomplishments is a great part of my job!*”

Lastly, developing events that keep students involved in Pre-MAP after the fall quarter, and after the first year, is a challenge. Students are enthusiastic about attending events, but schedules are difficult to coordinate. We need to work harder at this as we move forward.

## 4.2 Recruitment

Recruitment efforts must start early. Although students may only make the final decision about whether or not to join Pre-MAP in September, the seeds must be planted in the early months of the year. Since Pre-MAP received funds late in the 2004-2005 academic year, our recruitment opportunities were limited and yielded only seven students for Cohort 1. By our second year, we had developed relationships with OMA counselors, who were responsible for guiding a large fraction of the eleven students in Cohort 2 to our program. These sorts of relationships take time to develop since counselors, understandably, are only likely to encourage students to join a program once it has proven itself.

We have also learned to simplify our recruitment by tapping into existing resources. When recruitment began, we spent much time trying to determine which Seattle-area schools were most likely to have underrepresented students, and how to get in touch with their school counselors. Fortunately, we quickly realized that there are numerous well-established organizations which do exactly this. By getting in touch with the Washington Achievers, Upward Bound, Making Connections, GEAR UP, and others, we were able to reach students in our target demographics. Although we have found our most successful recruitment tools to be OMA counselors and mass-emails through the Admissions Office, we believe that building relationships with the other organizations will pay dividends in the long-run by increasing our visibility among promising underrepresented students. Such relationships have also impacted the Pre-MAP volunteers, such as Stephanie Gogarten: “*In working part-time as the recruitment coordinator, I met with many different groups of students and educators to explain the program, and in the process gained valuable skills in networking. Pre-MAP has inspired me to continue working for diversity for the rest of my scientific career.*”

We found that coordination with the Astronomy department’s undergraduate adviser is essential. Although the ultimate goals of Pre-MAP (more numerous and diverse astronomy majors) are well-aligned with those of the U.W. Astronomy Department, we found that our undergraduate adviser occasionally turned students away from Pre-MAP due to misunderstandings about our target audience<sup>3</sup>. This situation was alleviated by keeping the astronomy undergraduate adviser abreast of our recruitment efforts and criteria.

## 4.3 Funding

The President’s Diversity Appraisal Fund provided the seed funding for Pre-MAP. The program was, however, only allocated half of the funds requested. The other half of the funding—in the form of the TA salary—was supplied by the University as a result of the advocacy of the previous and current Chairs of the Astronomy Department.

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<sup>3</sup>The adviser felt that students already committed to majoring in astronomy should not bother with Pre-MAP but should instead immediately start the math/physics sequence, in effect neglecting the disproportionately high attrition rate of underrepresented students in STEM fields and the proven ability of mentoring and research experience to increase retention of these students.

Although we have had no difficulty in finding people interested in learning about Pre-MAP, it has proved much harder to find a long-term source of funding for the program. Part of the problem is that Pre-MAP is a mid-sized program. The National Science Foundation (NSF), for example, is more interested in funding large, multi-department initiatives, yet our yearly budget of \$40,000 is too large for our small department to absorb on its own. Furthermore, the bulk of our budget goes to paying the seminar instructor, a graduate student. Many potential funding sources are reticent to fund such a program because they believe that TA salaries should be provided by the University. More generally, state funding agencies feel that insofar as the U.W. is funded by the state and is an institution of learning, the College of Arts and Sciences should be funding any education-based initiatives. Unfortunately, we have been unable to identify a process within the College or University for obtaining continuing funding for Pre-MAP.

We are responding to this challenge in two ways: First, we have developed close ties with the Biology Department, in particular with the B-Diverse group interested in increasing diversity at the undergraduate level. We have thus been able to design a broader, interdisciplinary successor to Pre-MAP, an initiative we call the Pre-Science Major (PrSM, pronounced “prism”— see next section) which may be more attractive to funding agencies interested primarily in large-scale programs. Secondly, we are investigating funding from a variety of outside sources, including the NSF, the Sloan foundation, NASA, and both the Federal and State Offices of Education, as well as private donors.

## 5 Expanding Pre-MAP to other Departments

We have recently submitted a Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) proposal to the NSF to expand Pre-MAP to other departments (ie: PrSM)<sup>4</sup>. Below is an outline of how the Pre-MAP template might be exported.

### 5.1 PrSM Partners

PrSM will take the Department of Astronomy’s Pre-MAP model and adapt and implement it in other U.W. science departments. The Department of Biology will partner with the Department of Astronomy from the outset of the PrSM project and will also be involved in facilitating the participation of other departments in future years. These departments will be the Departments of Chemistry, Environmental and Occupational Health Sciences, Physics, and Psychology, all of which see PrSM as an essential tool in recruiting and retaining students from underrepresented groups. The partner departments will help provide cohort-building activities for PrSM students by organizing field trips, research symposia, and other PrSM activities that span disciplines. PrSM will also collaborate with a number of other science departments and will work closely with several U.W. administrative units, in particular the Office of Minority Affairs. As an example, we outline below how the Pre-MAP template could be applied to a rather different STEM field.

#### 5.1.1 PrSM in the Department of Biology

The Department of Biology will focus on attracting 20 incoming freshmen from underrepresented groups into PrSM. The Biology PrSM program will center on a special seminar that the PrSM students will take in conjunction with an introductory biology course. The seminar will introduce the students to

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<sup>4</sup>The proposal has been included in the supplemental materials.

essential research skills such as hypothesis testing, experimental design, data collection and management, basic statistics, and scientific writing, with the emphasis being on preparing the students for the research projects submitted by faculty members. Several weeks into the seminar, small groups of students will move into active research laboratories. There they will interact not only with faculty, but also graduate students and postdoctoral fellows who are working at the bench and/or in the field every day.

PrSM students will have other opportunities to learn more about the Department. Faculty will give students tours of their laboratories, and will invite them to attend the weekly departmental seminars that bring biologists from around the nation and the world to the U.W. This will provide further exposure to the breadth and depth of the biological sciences. The departmental seminar series also includes a “parade” of faculty members who give short talks on their research programs. Typically, five faculty members will present each quarter, providing a rich source of ideas and opportunities for these undergraduates looking for projects that interest them.

The presence of the Howard Hughes Medical Foundation’s Biology Fellows Program (BFP) in the Department will further assist PrSM graduates in their transition into the biology major. The BFP works with first- and second-year students for two quarters (Winter and Spring), typically immediately before or as they begin the required three quarter biology sequence for majors, and has been very successful at enhancing the performance of beginning students of biology, particularly underrepresented students. PrSM and the BFP are natural partners. PrSM will serve as recruitment tool and increase the number of underrepresented students in the Department, and will begin mentoring participating students while exposing them to research opportunities. Entering the BFP will be the next step in their path towards the biology major.

## 6 Impact of Pre-MAP

The first year and half of Pre-MAP has been a resounding success. Underrepresented students are finding a calling in Astronomy, and they are finding in Pre-MAP the mentoring, support and research opportunities to keep them motivated well into their sophomore year. The Pre-MAP staff have been actively learning about diversity issues and in all cases are likely to continue being involved in advancing academic diversity issues —both through Pre-MAP and through other avenues— in the future. As our faculty director Eric Agol says: *“Before my involvement in Pre-MAP, I was not as aware of the challenges facing underrepresented students in the sciences (even though I was a low-income student when I was an undergraduate). Participation in the Pre-MAP program has inspired me to come up with projects which can be tailored for intelligent and motivated first-quarter freshmen.”*

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