Department of Astronomy Review

Focus on the Undergraduate Curriculum and Student Experience

Fall 2015

1. Analysis of Current Curriculum

1a) Curriculum Coherence and Accessibility

In astronomy we offer both a BA degree and two tracks toward a BS degree, and we have developed course sequences for these options. We do not have any recommended Gen Ed courses, and so the students are free to take whatever interests them and satisfies the university requirements. Our students must also take a number of physics courses and we ensure that we do not have conflicts with required physics courses that would make it difficult to follow our preferred sequence. Because astronomy and physics courses are sequential and because most of the courses for majors in astronomy and physics are only taught in one of the two semesters, it is important for students to plan ahead to complete our curriculum. Advising plays an important role in keeping our students on track. However, students who switch into astronomy after their first year, often times have a difficult time to catch up so they can graduate on time. This may explain why some of our students take more than 4 years to complete their degree. Transfer students often arrive here even further behind, as they often enter as Juniors, but do not have the required 1st and 2nd year courses in math, physics and astronomy. The transfer students are an advising challenge.

Accessibility of courses is generally not a problem, as the courses for our majors rarely fill to capacity. However, our students need to fill an upper level (300+) elective course, and currently with our faculty size, we are only able to offer such an elective course one semester each year. This restricts the options on what elective courses our students can take and increases the chances for course conflicts. Although we have added elective courses at the expense of Gen Ed sections, further expansion will require additional resources.

Our BS Space Science track has a concentration requirement, and currently a student would work with their advisor to develop a concentration plan. We feel it would be beneficial to compile a number of examples of concentration plans to help the students with this decision. We are currently putting these together and will post these on our website.

As part of the Five College Astronomy Department our students benefit from the courses offered at the Colleges. In fact we meet periodically and jointly plan the upper-division courses that we will offer at each campus. Consequently, our students have access to a broader range of courses offering than we would be able to offer on our own. However, the time taken for travel to other campuses is difficult, and registration through the Five College interchange is not integrated into SPIRE and requires the student to fill out forms and carry they around for signatures. This process surely can be improved. We are working on an improved departmental website that will provide information on these off-campus courses and provide assistance for students to register for these classes.

Despite a few shortcomings, we believe in astronomy we have a coherent and accessible program for our majors.

1b) Clarity of Communication

The goals and expectations for our curriculum are primarily communicated to our students through face-to-face advising meetings each semester and our website. Many students who select an astronomy major do not realize that it entails so much math and physics, although the requirements for our degrees are clearly stated. This is probably the primary reason that we have such a large number of students who drop our major after the first year or two. We are beginning to explore the use of "indicator courses" to help identify students unlikely to prosper in our major. We are also currently updating our web site to be more complete and up to date, and we intend to expand on the required skills needed to complete an astronomy BA and BS degrees.

Opportunities for non-curriculum activities are also provided through advisor meetings and emails to the students. One important area that we are just starting to address is career counseling. This semester we started a series of talks by our alumni to provide information on career opportunities. We will provide more on this in the report on advising that we will prepare in the spring. We are also considering adding a junior-year 1-credit seminar where we could help the students explore career opportunities outside of academia, offer some GRE coaching, and help students apply and plan for internships

1c) Effective Use of Faculty Time

The aspirational goal for class size is already achieved in astronomy. We currently offer small upper-division courses with considerable mentoring and advising to our students despite the large growth in the astronomy major over the last several years. Our Gen Ed classes have the largest class sizes, with lectures of 120-300 students. However, these Gen Ed classes have a lab associated with them and in these lab classes are taught in team-based-learning classrooms where the class size is typically between 25 and 65 students. These labs provide the Gen Ed students with more interactions with our instructors and other students in the team-based-learning environment.

Despite the growth in the astronomy major, we are still able to offer nearly all of our major courses in small classes with less than 25 students. The only exception is the first year course for our majors (AST 228) that has a class size of around 50 students and is growing. Besides our majors, we have a number of students majoring in other science disciplines or engineering that find AST 228 a more in-depth course to learn about astronomy than our Gen Ed options. We may need to consider offering two sections of this course or offering the course every semester to keep up with the demand. The capstone courses for all of our degrees and degree tracks have under 20 students, as do both our Junior Year Writing and IE classes.

An important aspect of astronomy studies is independent research. Although independent study is a large time commitment for our faculty, it is important for our student's education. We currently offer a number of organized research opportunities, including a summer program where are students do independent research with our faculty and our funded through the Massachusetts Space Grant Consortium and an

advanced observing course which stresses team-based research. However, for students who want to work with faculty during the semester, they must find a mentor on their own. We would like to put in place a method of placing students with faculty mentors which does not put the onus on the students.

With only a few small changes needed, we believe that we have an optimal distribution of class sizes that provide our students (both majors and students taking our Gen Ed classes) with a good student experience.

2. Goals for Student Learning and the Student Experience

In summary our student learning objectives are the following:

• Clearly describe basic astronomical facts and concepts and apply these to solve problems or form reasoned explanations of phenomena. These basic facts and concepts include: the various kinds of objects in the universe and their relative size; motions of the sky and their connection to Earth's rotation and orbital motion; basics of stellar evolution; Kepler's Laws; inverse-square laws.

• Apply physics and math to astrophysical problem solving. This includes applications of Newton's laws of mechanics and gravitation, radiation formulae, differentiation and integration, and simple differential equations.

• Write a clear and well-reasoned scientific paper about work they have done.

• An outstanding major should be able to: demonstrate excellence in an individual area related to their career plans. Examples of this might be the application of upper-level physics and computational skills to complex astronomical problems, using astronomical instrumentation and software tools to collect and analyze astronomical data, or to develop a planetarium program at a local museum for a public audience.

These learning objectives have not changed since they were compiled in 2013.

It is difficult for us to envision how to infuse diversity perspectives into our curriculum. However, we are striving to diversify our student population. We have matched the College and exceeded the University in attracting first- generation and Pell recipient students. However, Astronomy does not attract the number of women or under-represented minorities that it should, and is under-represented compared with College and University as a whole. This seems to be a problem with astronomy and physical sciences nationally, but we have several ideas and these include:

- Do more outreach to high schools, perhaps with the help of graduate and undergraduate students, highlighting whenever possible the work of under-represented minorities and women in the field.
- Recruitment efforts could be coordinated with other physical science departments that have low numbers of women and minorities.
- Advertise that our major includes courses taught at elite women's colleges Mt. Holyoke and Smith, and highlight the work of our Five College faculty colleagues.
- Reach out to first-year students who are doing well in our introductory gen-ed classes, and invite them to an open house for possible majors.

Our new IE course does address the world's most pressing and enduring issues. The topic of our IE course changes each year, and the topics for the first two offering of the course have been the hazards of climate change and asteroid impacts. The students work in groups studying the science of these topics, but in addition they explore the

impact these hazards have on both the political and social-economic scene in the US and the world. At the conclusion of the course, the students present the depth and breadth of their studies to a panel of faculty who have some expertise in the field.

3. Curriculum Revision Action Plan

3a. Without New Resources

As a Five-College department, we rely on our colleagues at the colleges to offer a number of our Sophomore and Junior level courses. The difficulty of scheduling required courses at another campus is in some cases a significant burden for our majors. We have been attempting to alleviate this problem by several methods: offering 3-hour evening courses once a week, offering a greater selection of courses at the 200 and 300 level at UMass (while reducing the number of sections of our gen-ed courses), and using video conferencing.

We have only tried the video-conferencing idea once several years ago, and it was unsuccessful. In the meantime, there have been improvements to videoconferencing rooms and technology that suggest we might try this again. To aid us in this process, it would be very helpful if registrars and IT staff at the five campuses could identify the best locations where we could offer classes this way. This wouldn't preclude occasional face-to-face sessions throughout the semester, but it would substantially reduce the amount of travel time required.

It would also be an enormous benefit for our majors if a better system than the current Five-College cross registration could be implemented. There are many problems that are discouraging for our majors when they try to register for necessary courses at the colleges: discrepant timing when cross-registration is possible, unclear and difficult-to-find listings through the existing interchange website, and nuisance paperwork. This should be fixed for all students, but it particularly impacts Astronomy majors.

3b. With New Resources

The following curricular revisions can only be addressed with additional resources, in some cases just funding and in other cases additional instructional capacity. These revisions are ordered from those needing small additional resources to those needing larger additional resources.

1. Our Gen Ed courses make extensive use of demonstrations in class. However, most of the demos we are using jointly with physics dates to the 1950's and are woefully inadequate. An infusion of only a small amount of additional funding would allow us to bring our demonstration equipment into the 21-century and provide a much improved learning experience for our students.

2. With additional resources, we could do more with technology in our various courses. For example, it is important that we fix up our computer lab, which is now used extensively for several different classes and for student’s independent study projects. This is an example of providing special facilities for our undergraduates. Currently the computer lab is barely holding up under the intense student pressure that it is now subjected to in the fall and spring and we need to identify additional resources for this lab to continue to be useful in our student's education. Lab fees now being implemented will help in replacing aging equipment, but the whole computer lab

space is outdated and requires a larger investment and IT support that go well beyond lab fee funds.

3. For our majors we would like to offer additional elective upper-division courses and we have several ideas. First, we have considered adding an observational course that would focus on radio astronomy and the Large Millimeter Telescope (LMT) in Mexico. We taught a radio astronomy techniques course in the past (last taught in 2006), however the needs to teach our IE and other elective courses required us to stop teaching this course. We have spoken with the people in the International Program Office, and they are interested in helping us develop this idea, at least for the logistical, financial, and legal aspects of such a course involving Mexico. The success of our other observations course (focus on visual wavelength observations) suggest that such a course with a focus on radio observations would be very popular. If "internationalization" is really an important priority for the University, then there is one more reason to consider such a course as well.

Another idea is an advanced computational course and this course resonates well with our idea of training technically well-versed students. We share with physics a course (Physics 281) that teaches the foundations of computation, and we believe there is a demand to have a follow-up course. We believe there will be considerable interest is such a course, given the fast rise in our majors who are double-majors with physics and other STEM fields.

We need to study all options for elective courses in more detail to decide which would provide the greatest benefit to our students. However, what ever decide will require an increase in our instructional capacity to implement.

4. Increasing our instructional capacity would also allow us to make several improvements to both our Gen Ed and majors curriculum. For Gen Ed we would like to diversify our Gen Ed offering in order to maximize our return in the existing courses and to increase the number of students we teach. Rather than offering several large sections of Astronomy 100 and 101 that are not full, motivated/interested faculty members could develop new and smaller topical Gen Ed courses that will appeal to a different group of students from those taking the survey courses. For example, we are currently developing content for Astro 339 (our IE class) that will focus on Mars Exploration. Planet and exoplanet exploration is very timely and exciting and would make for some interesting topics for our a topical Gen Ed course. In addition, subjects like dark matter and dark energy might also resonate with the interests of our students.

5. With an expansion in our instructional capacity, perhaps by hiring a lecturer, we could also offer more honors classes for undergraduates who are not majoring in astronomy. We currently teach one honors Gen-Ed course each semester, but we are not able to serve as many students with these courses as there is demand.