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UNEXPECTED ADVICE FOR BEGINNING GRADUATE STUDENTS IN ASTROPHYSICS

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Abstract. My experience is that beginning graduate students in astrophysics have unrealistic views of how to negotiate the complexities of graduate school and to prepare themselves for a professional career in astrophysics or some other field. This chapter describes my unexpected advice to students beginning with why they should not plan to write a thesis. Other advice concerns how to find and work with a research supervisor, writing and other skills needed for their research, and the need to be creative and when necessary controversial.

As a long time participant in the academic world, I have been asked by many beginning graduate students for advice in negotiating the complexities of graduate school and selecting a research topic for their thesis. Students generally expect that my advice would be to master the core courses in the astrophysics curriculum, do well in the comprehensive exam, choose a research advisor from a list of available people, and write a great thesis.

I generally surprize and often disturb them by responding that they are asking the wrong questions. The world of academia and the skills valued by the real world after graduate school are very different from their preconceived views. Since I have provided the following unexpected advice many times, I thought that it was appropriate to write down my "off the wall" suggestions for the benefit and perhaps amusement of others.

(1) Most important advice: do not write a thesis

The first question that students usually ask is what would be a good thesis topic. I generally respond by asking the student how many people will actually read their thesis. My guess is that the list consists of the author, hopefully the thesis committee members, the author's parents, and likely nobody else – perhaps a grand total of eight. Furthermore, if their Vita contains a publication list consisting of only their not yet completed unpublished thesis, no potential employer will be interested. Students often respond that after they graduate, they will become serious about writing papers for publication in the scientific journals based on their thesis research, but my experience is that after graduation, most people have other responsibilities and little time or desire to convert their thesis work into journal papers. Often, the thesis research never sees the light of day. So, why write a thesis?

Universities require that graduate students submit and defend a thesis in order to receive their PhD degree, but most universities do not require that the thesis consist only of not yet published research. I encourage students to write up their research as a series of papers on the same or similar topics and submit these papers to the refereed journals in a timely way.

When about six interesting papers have been refereed and published or at least submitted, I then suggest they write a short introductory chapter and submit a "thesis" consisting of the introductory chapter and the published papers. Since most or all of the "thesis" has been appropriately refereed, the thesis committee has little alternative to accepting it. As they say in chess, "check mate."

(2) How to select and deselect a research supervisor

Finding a research supervisor is a two-way street in which faculty members look for graduate students and graduate students look for appropriate faculty members. I advise students to take the initiative by reading recent papers published by different faculty members and deciding which topics look exciting and which faculty members are active in interesting fields.

Serious homework can avoid getting into dead-end topics that provide no excitement. When you have made your decision, go to the faculty member, mention that his or her research area is really exciting, and ask for a research assistant position. This usually works unless there is no money for such a position. Whether the potential advisor is male or female should not be a reason for selection.

Despite your best efforts, you may find that the chemistry with your advisor and/or the research topic is a failure. If so, then inform your advisor in a timely way so that he or she can find a new research assistant. Then repeat the process to find a new advisor.

(3) Don't worry – you can become a real expert

Students sometimes think that they could never master a research topic at anywhere near the level of experts in the field. I believe that this lack of self-confidence is unwarranted. For many, if not most, research topics, achieving a level of mastery approximating that of the experts should require an intelligent and industrious student to read the literature and work on the data and theory for a year or at most two years. You can do it. Furthermore, the experts have many responsibilities that occupy their time, whereas a graduate student can devote most of his time to understanding the topic. So, have no concern, you can become an expert.

(4) Develop unique tools

Whether one is an observer or a theoretician, it is critically important to develop new and more powerful tools for conducting your research. Such tools include data analysis software and semi-empirical modeling codes for observers and theoretical models and associated software for theoreticians. Often such tools may already exist, but to use them as "black boxes" does not develop your own skills. It is better to write your own software or significantly modify existing codes to understand what is real signal and what is noise. Tools that you develop can be valuable for many years in the future.

(5) Astrophysics is a literary profession

When I mention that astrophysics is a literary profession, students think that I have forgotten that astrophysicists write scientific papers, not novels. I then point out that the only way that we present our scientific results for consideration by the community is by what we publish in the journals and what we say at scientific meetings. Thus there is a premium on developing excellent writing and speaking skills. Some students are disappointed when they hear this because they have concentrated on developing their scientific and mathematical skills rather then their writing skills often because they do not think that they can ever write well.

Since writing skills must be learned, it is worthwhile to take a class in scientific writing or even creative writing and have available a textbook on writing style. However, there is no alternative to writing papers and proposals to develop and refine these skills. The more that you write, the better your writing will be. Don't be afraid to start.

The same is true of speaking skills. Presenting your research at seminars and teaching the occasional undergraduate level class can be very helpful. My experience is that developing excellent writing and speaking skills also develops better logical thinking. You do not really understand a topic unless you have written about it and taught it before a skeptical audience.

Although most papers and meetings these days are in English, it is helpful to become multilingual. Most native English speakers are deficient in this regard, thereby losing critical ability to communicate with many of their colleagues. Proficiency in two or more languages leads to better writing and speaking skills in all of the languages.

(6) Become a graphic artist

When I ask students what they should do first when writing a scientific paper, they usually respond by saying that they will first write the introduction, or an outline, or perhaps the abstract. I suggest that a far better approach is to first create the figures which contain the results of the paper in graphical form. Well-constructed figures with captions that explain the various data and assumptions tell most of the story of the paper. The text ties together the figures and explains their significance. When the figures are complete, the text can be written very easily.

Figures in journal articles contain data, fits to the data, and models both theoretical and semi-empirical. In addition to such traditional-style figures, authors should include artistic representations (i.e., cartoons) showing the physical principles underlying the models. This is a way of clearly showing the reader what is important for understanding the results described in the paper. I therefore encourage students to develop graphic artist skills. There are many software programs available for making such figures.

(7) Be creative and controversial

Most research topics use a standard set of assumptions and analysis techniques. Just because these assumptions and analysis techniques are adopted by most people working in the field does not make them right or even good approximations. It is important to look at things from a fresh perspective.

Be creative. When more and better quality data become available, the old assumptions often are no longer viable. When modeling a set of observations, it is usually better to include the physics approximately rather than including only some of the physics exactly. If you are convinced that your new approach is right, then do not be afraid of being controversial. This will attract attention to your work.

(8) Writing proposals for fun and profit

Many astronomers dread writing proposals requesting support and observing time. This is a bad habit to acquire. Instead one should view proposal writing as an opportunity to tell an exciting story. The proposal can describe a scientific journey in the quest for new insights. If you write about the science that you wish to do as an exciting journey, the reviewers of your proposal can get caught up in the excitement.

(9) Develop your teaching skills

While academic positions generally require teaching the next generation of students, graduate programs do not usually prepare students for teaching. Again, initiative on your part is essential. Volunteer to teach a laboratory or recitation section and ask your advisor for the opportunity to teach his class when he is traveling. Pay attention to how the best teachers prepare and deliver their lectures. Where there are mentoring programs to improve the teaching skills of faculty, try to participate even though you are a graduate student.

(10) Prepare for the non-academic world

Each year there is usually only one academic position for every 4.5 PhD degrees awarded to astrophysics majors and graduates in related fields who do research on astrophysics topics. While there are also positions at observatories, national facilities, and some private corporations with connections to astrophysics, many new PhDs will eventually find themselves doing something other than astrophysics. Given this reality, students should be prepared and look positively on using their skills in different areas. A graduate program is a good time to learn how to think rationally, develop a wide range of skills, learn how to present your results, and be creative.

Many employers in the business and government world value these skills. Work in the non-academic world can be very rewarding both financially and in terms of your sense of accomplishment.