Getting The Most Out Of Graduate School*

Raj Rajagopalan

Department of Chemical Engineering
University of Florida, Gainesville, FL 32611-6005

Tel.: (352) 392 0868; Fax: (352) 392 9513; EMail: Raj@eng.UFL.edu

A Foundation for the Future

What you learn in graduate school can be the foundation for a life-long learning experience and a successful career, but it takes more than a good undergraduate preparation and a desire to get an advanced degree to get the most out of graduate school. The following are some bits of advice and recommendations based on my own experience – as a student and as a faculty member – and on what I have learnt from my students. Although these comments are addressed largely to graduate students in science and engineering, many of the observations here should be of use to all graduate students regardless of the discipline. Some of the books in the list of annotated references at the end of this article have detailed guidelines on specific issues you may face during your studies and beyond. One of the books listed, by Carl Djerassi, a renowned chemist, is a fictionalized account of the competition and personal, professional and ethical issues faced by graduate students and faculty involved in day-to-day research. Another, by James Watson of the DNA fame, is a real-life story that reads almost like fiction. I have included these two books so that you have more than a list of dry, self-help books, but these two books will probably teach you more than all the other books.

Attitude Makes a Difference

The first and the foremost factor is the attitude one brings to one's life. A major part of how successful we are in what we set out to do in life often depends on our attitude. Someone who feels like a "winner" is more likely to be a winner; one who feels like a victim is likely to end up being one. Most people I have talked with recall their student years as among the best years of their lives, but how much you get out of school, professionally and otherwise, depends to a large extent on what expectations, commitment and discipline you have and how much you demand from yourself.

- First, know what to expect from graduate school and what commitments and responsibilities are expected of you.
- Do *not* postpone learning essential professional skills and basic "life skills" until you get a job or leave graduate school. For example, I have known many students who have, either consciously or subconsciously, postponed learning good communication skills, social skills needed for teamwork and building a network of peers – only to regret it later.
- As a research student, you are a junior research colleague of the faculty. This is a privilege, but one that comes with certain responsibilities and accountability. Be aware of them.

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Learn Good Work Habits

Discipline Matters

- Graduate research is about generating or implementing new concepts. It is *not* a 9-to-5 job. Most successful students I know put in at least 70 hours a week. Expect to work hard, and expect to spend long hours.
- Keep good laboratory notebooks. Divide them into sections, e.g., one for research papers you read, one for your own work, etc. When you read a research article, write down the full reference in your research notebook, cut and paste a xerox copy of the abstract into the notebook, summarize the salient points and major results, cut and paste key figures and tables (along with your own annotations), summarize major questions of interest to you and make a list of important cross-references. (You may also want to write down the dates when you do these to make the research notebook a "journal" of your thoughts and progress.) You'll appreciate the value of this habit when you are ready to write up your results for publication or when you write your thesis. If you are copying something verbatim from a publication, make a note that it is a verbatim record, to avoid using it inadvertently in your own work later without giving proper credit to the original source. (See my comment later on plagiarism.)
- Spend at least one day per week in the library. It is *your* responsibility to keep up with the literature. (It is *your* research and *your* thesis.) Do not expect your research advisor to do it for you. Take *ownership* of your project.
- Attend seminars and learn from the experts. Observe what techniques the speakers use to make their presentations engaging and understandable. Also observe what mistakes they make and avoid them in your presentations. Attend the seminars even if the talks are not on your research topic. You never know what connections you can make to your own work or how what you learned from the talks could help you later in an interview or in your career.
- Stay focused on your research, but learn about areas other than your own. The market is fluid and a typical employer often wants someone who has a broader background than the one defined by your specific work. Do not expect to work on the same problem you studied for your MA, MS or PhD when you go into the workforce. Remember that graduate school is about "learning to learn" on one's own.
- If your stipend comes from a research grant to your advisor, learn about the expectations and deadlines the funding agency places on your advisor. Understand what pressures your advisor faces in keeping the funds flowing.

Form Networks & Learn From Others

- Take the initiative and form a "journal club" or "research colloquium club" with other graduate students with similar interests. Conduct regular discussion meetings so that you can learn from each other (and can develop presentation skills). Use the journal club and similar activities to form a collegial network of your peers. You never know when you might need the help of one of your schoolmates!
- Get to know the faculty on your thesis committee and others from whom you have taken classes. In general, get to know as many faculty members as possible from within and outside your Department. Make it a point to meet with them periodically to seek their advice and to learn from their experience. Not only do you broaden your experience by

doing this, but you also create a pool of faculty members who know you well enough to write meaningful letters when you need one.

- Form a "global network". If you have questions about a paper you are reading, write to the authors. Most authors are quite pleased to respond and help. However, do not be discouraged if you do not hear from some – the world is not perfect!
- Attend a few national or international professional meetings in your discipline, even if you have to pay for the expenses. It is an investment in your future and money well spent. Use your attendance to meet and to get to know experts from outside your institution.
- Seek balance in what you do. If you are doing theoretical work, learn the relevant experimental issues. If you are an experimentalist, try to get a perspective on the theoretical issues. Remember that "theory" does not necessarily mean "dealing with equations". Mathematics is a language and a medium to achieve an end.
- Seek education beyond the classroom or your research work. Learn to *observe* and *listen*. If you have the right attitude you can learn from everyone and from every experience, positive as well as negative.
- College life offers you an opportunity unmatched by any to broaden your horizon. Break the barriers. Attend talks or seminars in disciplines very different from yours. For example, if you are in the "hard" sciences, attend some seminars in cultural anthropology, art criticism, linguistics or the like. Learn how scholars in the "soft" sciences approach their research.

Learn to Deal With Difficulties Head On & Strive to Stay Positive

- Research is a *solitary* activity. Do not always expect others to get excited about what you find exciting. You can minimize the "isolation" if you build a network of interested individuals as I suggested earlier.
- Research is full of ups and downs (more downs than ups normally), and the key to success in research is to learn to bear with or overcome the downs. Try hard to stay motivated. If you are feeling down, take a break, do something you enjoy and then *return* to your work. If you think you need someone to cheer you up or urge you on, talk to one of your friends or see your research advisor and *ask* for advice or help. Divide your work into manageable portions, and make sure that you make progress in at least one on a regular basis. Even incremental progress is better than none at all and will keep you motivated.
- Take a course on "time management". Most people can use one.
- If you feel that you are under stress constantly and have difficulty coping with stress, deal with it head on. Talk with a sympathetic friend or with your research advisor or a faculty member. Take a course on stress management. There are many self-help books available on both time management and stress management, and they can be useful. Most universities, including our own, provide professional counseling and help for students with problems and run seminars on time-management (among other things, such as public presentation, interpersonal skills, and conflict resolution), usually free of charge. Take advantage of these.
- It is not unusual to have differences of opinion with your research advisor. You may even "dislike" your advisor sometime. It is natural. It is only human. However, you'll find that in the end the overall positive experience will overcome difficulties you face along the way. It is how you respond to setbacks which determines your success and the quality of your life.

Be Aware of Your Ethical Responsibilities

- Research is a human endeavor and is not always an objective search for the truth, but do not let that discourage you or make you bend the rules. Strive for the highest standards.
- Pay attention to professional ethics. Make sure that you are aware of the rules of authorship of publications. Acknowledge in your publications those who have provided assistance in your work (be generous, but get their permission).
- If you use ideas or results of others, do not forget to cite the relevant (primary) references. If you use someone else's writing verbatim, follow the copyright requirements. Do not forget to give proper credit. When you are writing your thesis or papers, it is easy to transfer sentences you may have copied into your notebook from other sources without attribution. In our profession there is no greater sin than plagiarism, i.e., trying to get, even unintentionally, credit for someone else's ideas.

Master Communication Skills

Our profession is about generating ideas and *communicating* them to others. You fail if you are poor in either; that is, you fail even when you are good in what you do but are unable to communicate your achievements to others. I have come across many individuals in my career who have advanced rapidly in their jobs largely due to their communication skills.

- Do not underestimate the importance of writing effectively and elegantly. My personal experience is that reading only technical articles or articles in one's own profession tends to decrease one's verbal skills and vocabulary and limits one to jargon. Make it a habit to read, on a regular basis, the works of authors known for their penmanship. If you are in the sciences or engineering, read well-written popular science articles in magazines (e.g., *Discover*, *The New Scientist*, *Scientific American*, *American Scientist* or others you like) to learn how professional writers avoid jargon and communicate complicated concepts in an engaging style. Identify also some well-known authors of *non-technical* material and read their works periodically so that you keep your verbal skills honed.
- Good writing requires clear thinking. Practice writing short summaries of long articles or scholarly essays at a level accessible to a novice. The accompanying table contains a list of books and internet sites on effective writing.
- Try to be gender-neutral in your writings. It is not a matter of being fashionable or being "politically correct". It is a matter of recognizing, respecting and encouraging the participation of both sexes in our professions.
- Learn to make oral presentations effectively. This includes knowing how to organize your thoughts logically and how to prepare effective viewgraphs and knowing the proper body language. If you need help, join a public presentation group such as the *Toastmasters Club* (see http://www.toastmasters.org). Make periodic presentations to your research group and ask your friends and advisor to criticize your presentation (constructively).
- In your presentations focus on your work, but present your results in the context of the broader scope of your research group and those of others elsewhere. Doing so is much more impressive to, for example, a prospective employer, for it shows that you understand the broader context of your work and that you have the initiative to learn the broader context of whatever you are assigned.

From R. Rajagopalan, *Chemical Engineering Education*, **33**, 258 – 261 (1999).
Web sites and references updated on April 4, 2000.

- Learn to be effective in a group setting. Learn the social skills needed to be courteous and generous to others while making your own points effectively. Do not wait until you get a job to learn such skills. Your supervisors generally will not have the time to be your mentors or advisors. They will merely observe your performance and will pass you over for promotion or a choice job assignment if you do not have the necessary skills.
- If English is not your native tongue, speak only English at work. Ask an English-speaking colleague to proofread your papers and listen to your presentations. Take advantage of technical writing courses and courses on "English as second language" offered by your university.

Develop Good Social Habits

- Mingle with as many peers as possible. Get to know them. Try to make life-long friendships.
- If you are a foreign student, try to find a roommate who is not from your own country. Be a cultural ambassador of your country. If you are a native student, seek out students from other countries. Let's make the world a better place for the next generation.

Exercises

1. Write a short essay on your goals in life and in your professional career. Be honest with yourself. Make a list of your strengths and weaknesses. Identify what you can do to eliminate or minimize your weaknesses.
2. Examine and analyze the case studies on professional practice outlined in *On Being A Scientist: Responsible Conduct in Research*, National Academy Press, Washington, DC, 1995 (you can access it through the web at www.nap.edu).
3. Write a short research proposal on a topic of your choice following standard guidelines issued by your university or a funding agency of your choice and ask a friend or your graduate advisor to criticize it. (You may wish to look through the US National Science Foundation guidelines on proposals and review criteria; see www.nsf.gov.)

Some Useful References

1. *Careers in Science and Engineering: A Student Planning Guide to Grad School and Beyond*, National Academy Press, Washington, DC, 1996.
   (A planning guide for students considering entering graduate school or in graduate school. Gives real-life examples of career paths of scientists and engineers. Contains short case studies of different career paths and lists of "action points". You can read this book in the electronic reading room at www.nap.edu.)
2. *On Being A Scientist: Responsible Conduct in Research*, National Academy Press, Washington, DC, 1995.
   (Advice on professional, personal and ethical issues that a graduate student or a beginning researcher faces. Presents a number of hypothetical, open-ended scenarios designed to draw attention to ethical issues one may face in research. You can read this book in the electronic reading room at www.nap.edu.)
3. P. J. Feibelman, *PhD Is Not Enough: A Guide to Survival in Science*, Addison-Wesley, New York, NY, 1994.

From R. Rajagopalan, *Chemical Engineering Education*, **33**, 258 – 261 (1999).
Web sites and references updated on April 4, 2000.

(A concise and easy-to-read volume on what it takes to be successful, especially in an academic career.)
4. P. B. Medawar, *Advice to a Young Scientist*, Basic Books, New York, NY, 1981.
(Advice from a Nobelist to graduate students and scientists in early stages of their careers.)
5. J. D. Watson, *Double Helix: A Personal Account of the Discovery of the Structure of DNA*, G. S. Stent, Editor, W. W. Norton, New York, NY, 1980.
(An engaging record of the author's perspective of the competition, the excitement and the human side of science in action, written almost like a racy novel. This special Norton edition, edited by G. S. Stent, a well-known molecular biologist himself, has a number of critical reviews of Watson's book and additional opinions by other world-renowned biologists and chemists.)
6. A. Sayre, *Rosalind Franklin and DNA*, W. W. Norton, New York, NY, 1978.
(A discussion of the contributions of Rosalind Franklin to the discovery of the structure of DNA and an analysis of whether her contributions were acknowledged appropriately in Watson's version of the discovery.)
7. S. A. Ambrose, K. L. Dunkle, B. B. Lazarus, I. Nair, and D. A. Harkus, *Journeys of Women in Science and Engineering: No Universal Constants (Labor and Social Change)*, Temple Univ. Pr., Philadelphia, PA, 1997.
(Accounts of challenges faced by women in science and engineering.)
8. C. Djerassi, *Cantor's Dilemma*, Penguin Books, New York, NY, 1989.
(A gripping novel by Carl Djerassi, a world-renowned chemist known for his discovery of the birth-control pill, about the fierce competition driving scientific "superstars". A fictionalized version of real ethical and personal issues faced by scientists everyday. This is the first volume in a tetralogy. You may visit http://www.djerassi.com for more details on this book and its sequels.)
9. S. R. Covey, A. R. Merrill, and R. Merrill, *First Thing First*, Simon & Schuster, New York, NY, 1995.
(One of the most popular time-management books.)
10. M. Seligman, *Learned Optimism*, Pocket Books, New York, NY, 1998.
(The author, a psychologist and clinical researcher, discusses pessimism, optimism and depression and how they affect quality of life. The book also discusses the skills needed to change one's attitude from pessimism to optimism.)

Additional References (added April 2000):

1. *Advice for a Young Investigator*, Santiago Ramon y Cajal, MIT Pr., Cambridge, MA, 1999.
2. "Research as a Life Style", George Batchelor, *Appl. Mech. Rev*. **50**, R11-R20 (1997).
3. *Honor in Science* (1984) & *The Responsible Researcher* (2000), Sigma Xi, Washington, DC.

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Table 1. Some References and Web Sites on Technical Writing

Books

Alley, M., *The Craft of Scientific Writing*, 3rd Edition, Springer-Verlag, NY, 1996.

Booth, W. C., Colomb, G. G., and Williams, J. M., *The Craft of Research*, Univ. of Chicago Pr., Chicago, IL, 1995.

Brusaw, C. T., Alred, G. J., and Oliu, W. E., *Handbook of Technical Writing*, 4th Edition, St. Martin's Pr., New York, NY, 1993.

Day, R. A., *How to Write and Publish a Scientific Paper*, 4th Edn., Oryx Pr., 1994.

Dodd, J. S., Editor, *The ACS Style Guide: A Manual for Authors and Editors*, 2nd Edition, American Chemical Society, Washington, D.C., 1997.

Matthews, J. R., Bowen, J. M., and Matthews, R. W., *Successful Scientific Writing*, Cambridge Univ. Pr., Cambridge, UK, 1996.

Strunk, Jr., W. and White, E.B., *The Elements of Style*, 3rd Edition, Allyn and Bacon, Boston, MA, 1979. (See, also, http://www.bartleby.com/141/index.html; URL correct as of September 1998.)

Technical Writing Links on the Internet (As of April 2000)

- Online Writing Lab, Purdue University, West Lafayette, IN.
  http://owl.english.purdue.edu/
- Grammar Hotline Directory
  http://www.tc.cc.va.us/writcent/gh/index.htm
- Strunk & White's *Elements of Style*
  http://www.bartleby.com/141/index.html
- WWWebster Dictionary
  http://www.m-w.com/netdict.htm
- WWWebster Thesaurus
  http://www.m-w.com/thesaurus.htm