

Success in Graduate Student Research

Professor Daniel Lopresti
Department of Computer Science and Engineering
Lehigh University
Bethlehem, PA 18015
dal9@lehigh.edu • <http://www.cse.lehigh.edu/~lopresti>

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I am giving you these guidelines because you currently work with me, or have expressed an interest in doing so. Please read this document carefully and let me know if anything is unclear or if you have questions. As we go forward, I will assume that you understand this guidance and will do your best to follow it.

Performing original research is an exhilarating experience. You have an opportunity to examine basic questions facing society that can be addressed through new ideas in computer science and engineering. You will become an international expert in a particular area. Others will seek out your advice on important topics. In the process, not only will you learn a great deal, but you will also have a chance to make the world a better place. With this opportunity comes great responsibility, however. The purpose of this document is to explain my expectations if you work with me as a graduate student researcher, to offer advice that I hope is helpful, and to outline some of the things you should keep in mind to increase your chances of having a successful and rewarding experience.

While this document reflects my own personal philosophies, you will find that other professors share some of these same attitudes. If you are working with another professor and are uncertain about whether my advice applies in that case, please be sure to check with that professor.

At the end of this document, you will see that I ask you to sign it and date it. This is to show that you have read it and understood it. You will receive one copy for future reference, and I will keep another in my files. This is because I am serious about your responsibilities as a student researcher, as well as my responsibilities as an advisor. If you have any questions at any point in time, just ask me.

Keep in mind that this advice is meant to guide you, not to discourage you. Becoming a good researcher means learning many new skills as well as continuing to develop existing ones. It is important to know what to work on so that you can focus your energies effectively, and that is the purpose of this document. As with anything else you do in life, making progress takes time and effort. You must also be willing to recognize that research is not the right career path for everyone, and that it is best to be honest if you discover this is the case for you; there is no dishonor in this.

1. Motivation and Dedication

An important underlying assumption is that you are attending graduate school – and that you wish to work with me – because you are dedicated to a future career where research and scholarship will play a central role. This could be serving on the faculty at a research university (like Lehigh), or at least at a school where the quality of your scholarship is an important criterion for advancement. It could also be a career in an industrial or government research lab. If your primary reason for attending graduate

school is because you failed to get a good job out of college, or as a way to “kill time” until you can find a job with no connection to the advancement of science, then it is unlikely you will have the dedication to succeed in research. While students like this may register to take my courses, I am only interested in supervising graduate students who are devoted to a career in research. This is a choice that lies deep inside you, but know that professors can detect ulterior motives and lack of dedication.

This is also a good point to mention two overriding considerations that you should always keep in mind: scientific integrity and respect for your advisor's time. It goes without saying that I expect my students to uphold the highest standards of scientific integrity. Any violation of these generally accepted principals (e.g., falsification of data, plagiarism) will result in my refusing to serve as your advisor from that point forward. You may also lose your financial support or be expelled from Lehigh.

Not demonstrating respect for my time is also a serious issue. My primary goal is to advance science, and your role is to help me. In reading this document, you will see that there are certain things I expect a graduate student to be able to do. Professors are very busy people with many responsibilities. Successful graduate students take the initiative to learn the answers to basic questions on their own, without pulling their advisor away from more important work. Learn to tell when the help you are requesting is reasonable and when it is not – the signs will be clear if you pay attention. If you find you are making large demands on my time for non-research related issues, then you should be concerned.

2. Research is Different from Coursework

It is easy to underestimate the significance of this distinction. You may believe that, because you are a student and I am a professor, performing research under my direction must be like taking a course from me – that it is my job to spend as much time as necessary helping you understand the subject under study. This is not true. Coursework is guided step-by-step by the professor, with the student doing the assigned work and adhering to a schedule the professor sets. If you do all the work and do it well, you can expect to receive an “A” in the course.

Research requires a level of maturity and initiative that goes beyond this. You will find that I make few explicit demands of you. I will not even insist that you meet with me. This does not mean, however, that I do not have high expectations. I expect that you will take charge of your own research, that you will drive the work forward, and that you will ask to meet with me because you have discovered something interesting, encountered a problem and need some help, want some advice, or would just like to touch base and update me on your progress. If you do not hear me complain about your work, does that mean your research is progressing well? No, it does not. How will you know when I think you are doing a good job? When you hear me tell you so. This is a case where silence is not “golden.” Silence probably means that your research is in trouble.

Thinking about it another way, your coursework, while important to you personally, will not change the world. Research should aim at having an impact. It goes without saying, then, that your research deserves your undivided attention and all of the time and energy you would devote to a full time job.

Keep in mind that being an “A” student does not guarantee someone will succeed in research. Experience has taught me that some students can find a way to get good grades in courses, often by echoing back material they find on the Internet, but that they do not truly understand. If you fail to develop a deep understanding of our research topic, it will soon become obvious. Remember, you are supposed to demonstrate signs of becoming an expert in the area we are studying.

3. Claiming Ownership of Your Research

It is not sufficient for you to treat your research like a task you are doing for me, even if I give you an idea that comes from one of my projects and I provide you with funding. I expect you to claim ownership of your research topic. If you take on a task only because I tell you to do it – if you regard it as simply a “job” to be completed as quickly and with as little effort as possible – then you will never become a successful researcher. You should take on a task because you find the question interesting and the work challenging and you believe it is the right thing to do to push your research forward.

Often, I will provide you with initial “seed” – an idea that I believe can be developed into successful research. Some ideas are more promising than others. It takes years of experience to develop this intuition – this is one of the skills you should strive to learn by watching your professors. While your success or failure will depend largely on your own ingenuity and level of effort, sometimes the idea I give you is one I am particularly fond of. It may be an important piece of a project we have underway. You will sense a growing annoyance in me if you fumble an idea like this. A good researcher overcomes hurdles and will let nothing stand in the way of getting the job done. It is a particularly bad sign if I take an idea away from you because you fail to make progress and give it to another student or, even worse, if I find it necessary to go off and solve the problem myself because the project depends on it. Then you are in real trouble. Missed deadlines are not acceptable and another sign of problems. When I give you part of a project to work on, your primary goal is making sure it moves forward.

4. Interacting with Your Professor

As a simple measure, if you find that you are not regularly scheduling meetings with me to discuss your progress – something interesting to report – then your research may be in trouble. Keep in mind that “regular” can have different meanings depending on the student. A student working on an independent study that lasts one semester should probably plan on meeting with me every week or two to stay on track. This is also true for a student just starting to explore a new research area. An advanced Ph.D. student who has already published quality research results and is working on the final stages of a dissertation might be able to meet with me less frequently – say, once a month.

In general, I find that better students ask to meet with me more often. Of course, if you request a meeting, you should have something worth discussing: an important insight, some new experimental results to talk about, a relevant paper you discovered, a hurdle you would like help with, etc. Suffice to say that if you schedule a meeting with me and have nothing to say or, worse, you miss the meeting, the results will not be favorable. Do not waste my time. Keep in mind that if I am providing you with financial support, then I am paying you to help me advance research – I am not paying you to ask me basic questions that you should be able to answer on your own.

I expect all of the students who work with me to have certain background knowledge and skills. This is mostly undergraduate-level material and, if you lack it, it is your responsibility to make it up:

- You should be able to program and debug efficiently (at the level of CSE 411).
- You should be able to do high quality background research (literature searches).
- You should understand the design and analysis of computer algorithms (at the level of CSE 340).
- You should be able to use basic productivity tools like Microsoft Excel, PowerPoint, etc.
- You should be able to write a good technical paper.
- You should be able to prepare and deliver a good technical talk.

If you need too much of my help with any of these things, it may be a sign that you do not belong in graduate school. Successful graduate students learn to make up deficiencies on their own.

You will probably find that I send you email from time-to-time with information relating to your work. This could include pointers to newspaper articles, technical papers I think you should read, conference announcements in the area where we are working, etc. As a rule, if I send you an email, I expect a response; not necessarily right away, but certainly after you have had some time to think about it. Likewise, if you find something relating to our research and you believe it would be good for me to know about it, you should send me email, too. I very much appreciate receiving such messages and consider it a positive sign that you are invested in your research.

It is okay to disagree with me on a technical point – I make mistakes, too. But in such cases, be ready to support your position with strong scientific evidence. Make sure it is good: simply repeating the same unsupported claim over and over is not “strong evidence” – it is just wasting my time.

One subject never open to debate is the level of work necessary for an acceptable dissertation. Earning a Ph.D. requires making a significant contribution to the field. Graduate students do not have the perspective to know what qualifies as “significant;” this determination falls entirely within the realm of the advisor. When you receive direction from me, your best strategy is to give it serious consideration and, in nearly every case, to act on it. I pay close attention to how students respond to my feedback. I do not expect you to get everything right on the first try, but you should be getting close by the second.

5. Contributing to an International Research Community

Ultimately, an important measure of the research you do is whether it is interesting to outside experts working in the field, not just to you and other people at Lehigh. Our purpose as researchers is to broaden knowledge – to make a contribution that our most experienced, talented colleagues consider useful and important. You should be aware that at the same time we are working on a problem together, there is an international research community working on the same kinds of problems. Your goal is to gain acceptance into this community by becoming known as a researcher with original insights who does high quality work. Their evaluation of whether your work is interesting is one important measure of success. How do we determine what other researchers in the field think of your work? By their willingness to include papers you have written in their conferences and journals.

I expect graduate students working with me to produce publishable-quality research. This is an absolutely fundamental requirement – it is not negotiable and there are no exceptions. It takes some time to get going, of course, but by your second or third year working with me, you should be regularly producing research results that we can publish in well-regarded conferences and journals. If you work with me for an extended period of time and do not help generate publications, you can assume that I am not happy with your performance.

Please know that developing technical writing skills is one of the things you will learn as a graduate student researcher – again, this is a matter of “practice makes perfect.” I work with my students to help them develop this skill. The papers we write together will be a collaboration that evolves over time. At first, I may do a substantial portion of the final editing on our publications. This is most likely to happen in the early stages of your career as a student researcher. By the later stages, you should be doing most of the work described in the paper, and most of the writing, too. I strongly encourage my students to propose topics for papers and venues to publish them – this is a sign of research maturity that is critical for success in graduate school.

Becoming a member of an international research community implies other responsibilities as well. It means being aware of other research groups that do work that is similar to ours, and understanding the relationship between their work and our work. Much of this research is of high quality and deserves your respect. It is considered an insult to write a paper that ignores important related work in the field. Indeed, this reason alone may result in the paper being rejected. You should always assume there is other published research that relates to what we are doing. Finding this work and understanding its connections to our own is one of your responsibilities as a researcher. If you tell me there is no related work, my first assumption is that you did a bad job with your literature search.

On occasion, we will have an important visitor in the department – perhaps a seminar speaker, or a colleague from elsewhere who we are collaborating with. In such cases, I expect you to attend the talks and/or meetings that may take place. This is a way of building up professional contacts which will prove valuable later when you are looking for a job. It also reflects on the reputation of Lehigh – we want outside visitors to know we have good graduate students here. It is always a smart idea to do some background reading so that you can have an intelligent conversation with our visitor, who will often be a distinguished researcher in the field.

6. Developing Communication Skills

It goes without saying that I expect you to work on developing good communication skills. This means reading, writing, and speaking effectively about your research. English may not be your native language; by itself, this is not a problem. The ability to convey scientific ideas transcends knowing the finer details of the English language. As with many other skills, the secret is practice – write as much as you can, and take the time to read well-written research papers. To avoid wasting my time, do your best to eliminate as many grammatical errors as possible before you give me something to read, and always be sure to use a spelling-checker. Never give me something that is only a “rough draft” unless I ask you to do this – I am busy and do not have time to read papers that are filled with easy-to-catch errors. It may be a good idea to ask a friend to review your writing or to attend a practice talk to offer you advice before you submit your work for my evaluation.

While refining your communication skills is a natural part of becoming a researcher, muddled writing implies muddled thinking. This is a more serious problem, and one that is not always correctable. As a general rule, a good advisor can tell the difference between these two cases.

If you believe you need help in becoming a better writer or speaker, let me know – there are resources available on the Lehigh campus to help graduate students learn these important skills.

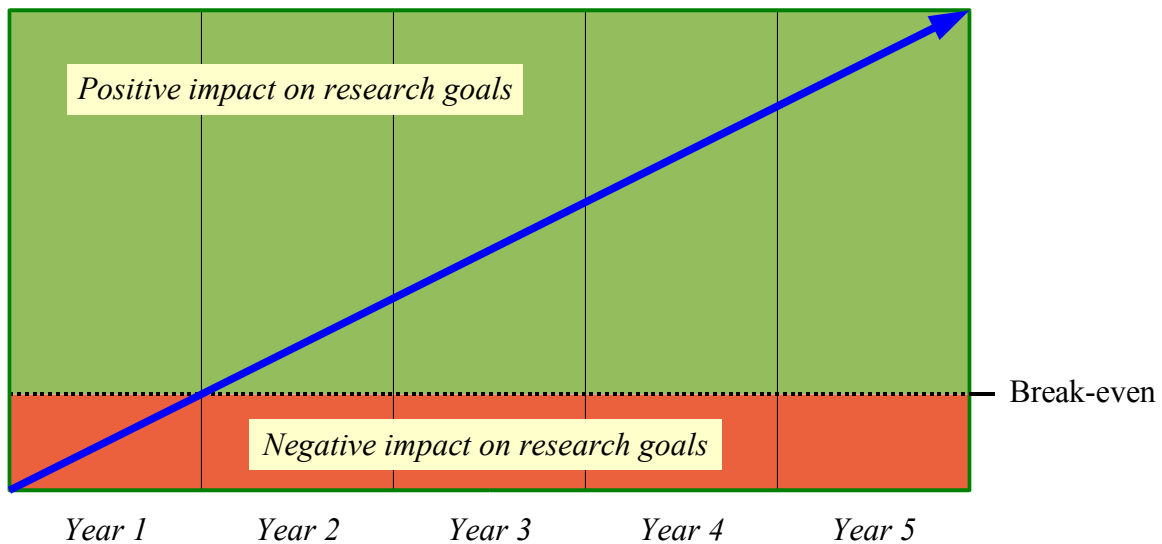
7. Productivity

I invest my time in mentoring students because I expect they will someday become productive researchers and, at that point, my investment will pay off. Productivity can be measured in research results, papers, and technical reports. Having your name on a paper by itself is not sufficient: you must have done a significant part of the work to receive full credit.

To be clear, ultimate success in graduate studies is not determined by how nice you are, whether you get good grades, or how many hours you work in the lab. The overriding consideration is whether you are making a contribution to advance the research.

It may help to think of this as a “Return on Investment” curve. In your first year, I expect that I will

invest more time in mentoring you than you will return in advancing the research. After that point, you should show signs of driving the work forward on your own. In later years, every hour of my time should yield increasingly more than an hour's worth of results. This is the natural progression in becoming a productive researcher, as depicted below. In the red-shaded region, the student produces less than one hour of results for every hour I invest. In the green-shaded region, the student produces more than one hour of results for every hour I invest. Note that the unit of measurement is the amount of work I could do in an hour, since the trade-off involves mentoring you versus doing the work myself.



This figure also indicates that five years is a reasonable length of time to earn a Ph.D. (I finished my graduate studies at Princeton in four years.) You should not expect to receive financial support after the fifth year. If your early trajectory suggests you have no chance of completing an acceptable Ph.D. in five years, I will end your funding and encourage you to look elsewhere for graduate school.

8. Deadlines and Degree Requirements

Whether you are striving to earn a Master's degree or a Ph.D., the programs at Lehigh have various requirements. There are certain courses you must take, and examinations you must pass. Knowing these rules and deadlines and making sure you satisfy them are your responsibility – do not expect me to remind you. If you fall behind, your funding may become at-risk. The Director of Graduate Studies and the department secretary who works with graduate students can provide helpful information.

9. Standards

As I have already noted, some people who are “A” students do not measure up to be “A” researchers. I demand that the work done under my direction be of very high quality. Keep in mind this means my standards are the ones that apply, not yours. It should be obvious, then, that you need to learn my standards and find a way to meet them if you want to succeed. While I do not typically give a grade for research efforts, you can still regard the following levels as guidelines:

Excellent	Well thought-out, carefully documented contributions to the project. Shows outstanding effort and creativity. Knowledgeable about related research. Work publishable in a high quality conference or journal. Meets with me often and always
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has something interesting to say. Suggests ideas that did not occur to me first.

Concern Does the minimum suggested, but nothing more. May be devoting time to the project, but work is not good enough to have a significant impact. Can quote what others have said, but does not have anything new or interesting to add. This low level of performance will lead to my dropping the advisee unless there is rapid improvement.

Unacceptable Misses deadlines and/or meetings. Makes no contributions to advancing the research. May ask frequent questions, but never ones that reflect a deep understanding of the work. Has ignored repeated warnings and suggestions for improvement. I will not continue to advise or support such students.

You will note that there is no “Average” or “Acceptable” level of performance – this is what I mean by having high standards. Either you are doing excellent work, or you are on a path that falls short of success. If you want to know your current level of performance, just ask me.

A smart way for you to start to learn my quality standards is to seek out and read some of my published papers, which you should be able to locate online.

10. Role of the Advisor

I have mostly said what you must do to be successful. What will I do? You will find that the right advisor – whether it be me or someone else – can be a valuable resource. The list of ways an advisor can help you is long and open-ended. Most importantly, of course, an advisor will help you identify research questions worth studying, start you off in the right direction, and keep you on track as the research progresses. An advisor can also assist in providing you with the professional contacts that may lead to your first job (or perhaps a later one), helping you find answers to questions you think are unanswerable, offering guidance on a variety of academic and technical issues, locating and acquiring software and equipment you need to succeed in your research, arranging for funding (in some cases) to help support you during the summer and/or academic year, and making sure your work receives the recognition it deserves within the Lehigh community as well as the outside world.

11. Student Funding

Recall my earlier comment that doing research is not like taking a regular course. In fact, a research assistant is more like an employee than a student. This means you are not paying me to teach you, as was the case when you were in college; rather, you are being paid to help me conduct research. If you do not contribute, I may be forced to turn elsewhere to get the job done and you will lose your financial support. To fully fund a graduate student costs an advisor approximately \$50,000 a year, including tuition and stipend. This funding is a privilege – it is not a right.

As a rule, I do not provide funding for Master's students. A Ph.D. student will typically receive two years of funding to demonstrate the potential to do high quality work. By your second year, you should be fully engaged in original research if you hope to receive continued funding (recall the ROI curve I provided earlier). Research grants are highly competitive and winning them takes a lot of effort. We are awarded grants because funding agencies believe we can do a first-rate job. If you are put on a project and do badly, it wastes the sponsor's money and reflects negatively on me.

It is an unfortunate fact of life that most research grants last for 2-3 years, whereas it often takes 4-5 years to earn a Ph.D. This means that there may be times when your financial support switches from

one project that is ending to a new one that is starting. The topic areas for these projects will often overlap, so the disruption should be minimal. In the worst case, there may be gaps in funding that we have to try to cover in creative ways. The effort I will devote to finding funding for a student is directly related to the quality of work that student is doing. If you are doing great research, I will do everything possible to find funding for you. I have no interest in spending time trying to find funding for students who are doing poor quality work because there is no payoff for having such students on a project.

You may begin your graduate studies at Lehigh with a university fellowship or a position as a Teaching Assistant in one of our courses. This means you are not being paid directly to help with research. It is important to realize, however, that such arrangements are usually short-term and will last for only a year or two. It would be a mistake to think that you can waste this time and ignore the need to become involved as soon as possible in research, either mine or another professor's. Before I even consider offering support to current students, I demand strong evidence that you can contribute to one of my projects. Waiting until the last minute to try to show you can make a contribution is a bad idea.

It should be noted that the very best students can sometimes obtain outside funding on their own. In a field as important to society as computer science and engineering, there are numerous opportunities for fellowships and scholarships. Making the effort to explore such options shows good initiative, and removes some of the financial pressure that graduate students sometimes experience. (I had a partial fellowship from the State of New Jersey when I attended graduate school.) But even if you find a way to fund your own graduate studies, keep in mind that my comments concerning productivity still apply. I expect all of my students to make significant contributions to the research effort, otherwise it is a waste of your time and my time for you to be in the Ph.D. program.

12. Conference Travel

One of the rewards for contributing to a successful research project is the occasional chance to attend a scientific conference in the area of our work. Because such travel can be expensive, it is not always possible to send a student to present a paper, but I will let you know when that is an option. Overseas travel is much more expensive than domestic travel and hence less likely to receive support. There are many rules and policies when traveling on official business, so make sure you know them before planning a trip, otherwise you risk not getting reimbursed. Also remember that when you travel to a conference, you are representing me as well as Lehigh. I expect you to take such travel seriously, to dress neatly, to attend the technical talks and other conference activities, and to attempt to be cost-conscious when making your travel arrangements.

13. Stress and Personal Issues

Graduate student life can be stressful. If you have been a good student in the past, you may find that this is the first time in your life there is a risk you might fail. The financial challenges of paying for graduate school also may trouble you. Sometimes family or personal issues arise which add stress. You should know that there is always help available on the Lehigh campus. The Graduate Student Life Office, housed in Christmas-Saucon Rooms #036 and #038, is an excellent resource for students.

14. A Note on Success and Failure

You are a good student, otherwise you would not have been accepted by Lehigh. Graduate school is

not right for everyone, however. It is important to realize that acceptance into our program is not a guarantee of finishing a graduate degree. Unlike undergraduate studies, where nearly everyone finishes successfully, many smart graduate students never complete their Ph.D.'s. There is no dishonor in this. Indeed, such students often go on to have successful careers, with the most obvious cases being Larry Page and Larry Brin, the two founders of google who dropped out of the Ph.D. program at Stanford.

Being a good student is a necessary pre-condition for success in graduate school, but it is not sufficient in itself. You must be creative, inquisitive, dedicated, intelligent, driven, curious, and resourceful. Either you possess these qualities or you do not – there are no miracles – they cannot be learned and I cannot teach them to you. The most I can do is give you the opportunity to demonstrate that you have these qualities, and then help you develop them if they are present.

The university, the college, and the department all prescribe various hurdles that graduate students must satisfy. In addition, you should assess your own progress on a continual basis. If things are not going well and your research is not advancing under the criteria I have just described, it is best to be honest with yourself and begin investigating other career options. There comes a time when students who are not making a significant contribution can no longer be supported financially.

15. Summary: Basic Qualities for Success

The qualities necessary to become a successful researcher are similar to those needed for success in other parts of life. They include:

- Creativity – finding solutions to hard research problems requires thinking in new ways, bringing together ideas in ways no one has tried before.
- Initiative – you must drive your own research forward. You should not depend on anyone else to outline each step and walk you through it by the hand as though you were still in college.
- Tenacity – hurdles constantly arise in the course of doing research. A good researcher is not willing to give up, always believing there must be a way around the current stumbling block.
- Maturity – strive to understand the big picture, learn what you need to do to succeed, and do it. Realize that your work is part of a larger puzzle and that other people are depending on you.
- Attention to detail – to solve a problem no one else has been able to solve, you must know it better than anyone else. If there are important points you do not understand, or related work you have not studied, the likelihood you will make a useful contribution is small.
- Confidence – an appropriate level of confidence is vital for a successful researcher. This is a quality that you will develop over time. Keep in mind that, while you have already proved yourself to be a good student, proving that you are a good researcher requires demonstrating a different set of skills.

Please keep in mind that no document like this can ever be completely comprehensive: every student research experience is unique. The most important piece of advice to keep in mind is that if you ever have questions or are unsure about something, ask me! If you do not approach me, I cannot help you.

Signature: _____

Date: _____