You are starting a graduate program, or just thinking about it, and you have lots of questions. Where do you start? What do you do? What can you expect from the course? Based on our experience and the problems our colleagues have faced, we present some ideas and practical suggestions to help new students to succeed in this incredible journey, a graduate program in computer science. We don't intend to exhaust the topic. That would be virtually impossible as there are thousands of different situations, as well as lots of articles with tips for graduate students. This article is a collection of tips and an overview of the process through which all graduate students pass during their journey.

Since we are more familiar with the database area, some of the examples are in this field. But we believe that this guide can be equally important to students of all fields in computer science and possibly to students of other graduate majors.

Getting started

Before starting a graduate program, it is important to realize that this is a long-term investment in your career. If you want to improve your knowledge, there are other options that may fulfill your personal goals. Analyze your options to make a more conscious choice. Once you are in graduate school, it is necessary to structure your personal life to fit the demands of the program. Eventually, you will have less time for family and close friends. Moreover, studying towards a graduate degree and working in a company at the same time may be very hard.

Assuming that a graduate course is your choice, what are the first steps you need to take?

A graduate program starts by the choice of your advisor during the first year. Sometimes this is done even before you are accepted into the program. The student/advisor relationship is very much like a marriage. If you
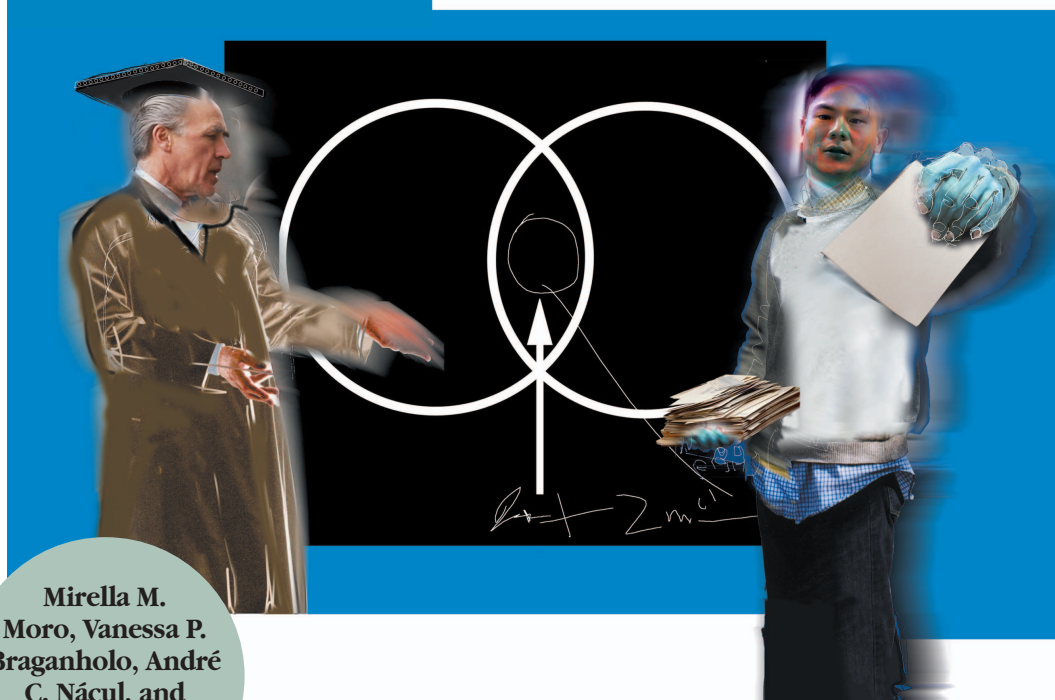
don't have a good relationship with your advisor, or if you do not share the same research interests, you are probably working with the wrong person. So try to learn about the person in advance, such as how he relates with his other students and what his scientific interests are. Read his most recent papers, and check if the topics you

The Successful Grad Student

Mirella M. Moro, Vanessa P. Braganholo, André C. Nácul, and Miguel R. Fornari

want to work with match those of your probable advisor. Write to his current students and ask how they like working with that professor. Miller has a very good paper on choosing a grad advisor, where he discusses further issues such as time availability, graduation records, the benefits of a younger or an older advisor, funding situation, and others.

During the program, try to meet and get to know your colleagues and professors. Getting to know them is essential to your program and to your life after you finish it.

Subscribe to e-mail discussion lists, which are very useful means of communication. Scientific community mailing lists are full of calls for papers (conferences, book chapters, etc.), calls for participation in events, and job offers in academia. We suggest two e-mail lists:

• DBWORLD: a mailing list of

researchers in the database area <http://www.cs.wisc.edu/dbworld>.

• SEWORLD: a mailing list of researchers in the software engineering area <http://www.cs.colorado.edu/~serl/seworld>.

Update your bookmarks. Consider storing the addresses of DBLP, IEEE *Xplore*, ACM Digital Library, CiteSeer, Science Direct, and Google Scholar. Join one or more professional societies. The IEEE and ACM are the best examples in the computer science field. Besides taking advantage of discounts on conference registration, you also receive other benefits such as their publications. Both of them have publications written for and by students: *IEEE Potentials* and *ACM Crossroads*.

No quick fixes for research

Unfortunately, there is no easy recipe for doing research. However, we can list some tips that will help you in the first steps of a well-presented work.

Read, read, read, and then read some more. Read what? Everything! Absolutely everything that you can. Start with the most recent work of your advisor. After that, select some of the bibliographical references in those papers, and read them too. Read the proceedings of the last three years of the most important

conferences in your area. In the database area, we recommend VLDB (Very Large Data Bases), SIGMOD (ACM International Conference on Management of Data), ICDE (International Conference on Data Engineering), and PODS (ACM Symposium on Principles of Database Systems), among others. If you do not know the important conferences in your area, ask your advisor. As a Ph.D. student, your goal should be to read at least one paper per day. If you do not have time to read everything, look for the accepted papers in the most recent conferences and read at least the abstracts. The important thing here is to keep yourself updated with what is going on in your area.

Reading may not be enough. Read, analyze, criticize, discuss, implement. Try to analyze the subject that is described. Try to identify weak points and possible improvements to the paper. Discuss with your advisor and colleagues. If necessary, try to implement the presented solution. Remember: a published paper is not necessarily an absolute truth. Sometimes incomplete and "wrong" work may also be accepted in big conferences.

Make notes during your reading. A good practice is to have a printed copy of the paper and annotate your thoughts and observations on it. This will help you when you need to read that paper again or reference it in your work.

Choosing the topic

Choosing the area and topic of the dissertation/thesis is the most important decision you will make in your graduate life, as it will affect all your next steps. Don't be pressured to decide the topic in your first quarter. Use your advisor's experience. He certainly has a stronger research background than you (that's why he is your advisor). He has enough experience to know which topic is going to result in an interesting dissertation/thesis.

It is necessary to know the state of the art in your field to be sure that you have not chosen an area that has already been over explored, which can greatly restrict the alternatives of your work. Worse than this, you may choose an area that is outdated, and, therefore, any work you do can be considered irrelevant (one more reason to read a lot). A good practice is to choose a topic related to one of your advisor's projects. Moreover, try to choose a theme that will have a certain impact

for a certain amount of time (two years, for instance). In summary, use the experience of your advisor to help you focus your work in an up-to-date, interesting, and solid contribution.

When choosing your research topic, remember that it must be interesting and challenging to you! You will spend a considerable amount of time working on it. If you are not motivated, you will never finish it. And speaking of motivation, do not expect that other people motivate you. You must find the motivation to finish your work. That's why enjoying your topic is fundamental.

Writing the dissertation/thesis

The focus of this section is dissertation and thesis, but the tips here can also be used to research reports, papers, and course projects.

In case you have no idea of what a dissertation/thesis looks like, select some in the library and take a look at them. Preferably, find some that were recently presented by students of your advisor. Pay attention to the structure, chapter divisions, language, and approach.

The text is the main record of your work. It is the most important contact other people will have with your research work. So don't leave everything to the last minute, and start as soon as possible. Many reviews will come before you turn in your final version to the committee.

Be aware of the format the text should have. The school's library usually has the models. Try to follow them from the beginning. Think about the chapters and the structure of the text. As a suggestion, consider the following organization of chapters: introduction, motivation, solution, experiments, related work, and final remarks. Show your initial text organization to your advisor, and discuss how to reach a final structure. Once the chapters are defined, start defining the sections in each of them.

As you define your work, write down in detail any important decision as soon as it is made. It will be very difficult to remember the specific aspects if left to the end of the process. It is also important to take note of the references of the main papers you are reading as well as to summarize them in the related work chapter. Word-for-word copying is not allowed, so try to summarize them with your own words.

Typos and grammatical mistakes are unforgivable. Use the spell checker before finishing the text. A good sug-

gestion is to ask one or more of your colleagues to review your text. A review from a professional can be helpful as well. Moreover, remember that a scientific text should be formal and that certain colloquial language must be strongly avoided.

Figures and tables are very useful. An image is worth more than a thousand words, so add all the figures you think are necessary to clarify the text. Make figures as clear and readable as possible. Trying to save space in the text by adding very small figures is not a good practice. Also, remember that figures must have their objective mentioned in the text. Tables may exempt comments because they present pure and concise information.

Be sure that the reader can understand your text as it is written. Do not assume that the reader has background knowledge equivalent to yours. In case previous knowledge is required (for instance, formal notation, automaton design), list bibliographical references so that the reader can get more information. You might also include a short subsection on the topic if the previous knowledge is a strong prerequisite in your dissertation.

Establish a schedule with deadlines and try to follow it. A good idea is to establish a plan so that your results are available in time for writing papers for the conferences in your area. Consider the following deadlines: SIGMOD November/2005, VLDB March/2006, and ICDE June/2006. A student in the database area could organize his work to have the first results in November for SIGMOD, improve the work during the winter for VLDB, and evaluate other perspectives for ICDE. Try to have a solid work near the submission deadlines of certain conferences.

Knowing when the work is finished may be difficult. Sometimes students may be too close to the work and do not have the objectivity to know when it is finished and ready to be presented. It is common to try to achieve perfection and continue to improve the work, without noticing that you already have an excellent dissertation or thesis. Once more, trust in your advisor's experience to decide at which point your work can be considered ready.

Conferences and Scientific Events

Participating in conferences and scientific events is essential. A conference is the best place to meet the community of your subject area. Everybody will be there with the same goal: to make

contact with other researchers and keep themselves well informed. Therefore, do not view a conference as a vacation. It is, in fact, a business trip. You can certainly arrive two days earlier or extend your stay after the conference to get around the city where the event is taking place.

Always have a brief presentation that summarizes the contribution of your current work. This is the well known "elevator talk." You should be able to present your research in 30 seconds in a casual conversation, for instance, in an elevator. Not a technical presentation, but the big picture and main contribution of your research.

Focus on the conference. Take advantage of the fact that several researchers will be available at the same place. So don't be shy; talk to other researchers. Have your elevator talk prepared.

Enjoy every opportunity that is offered during the event. Go to the banquet/dinner, even if you don't know anyone. Enjoy the parties. Have lunch at the same place the other participants do. These are the moments when people are more open to talk and to listen to your ideas. Use the event to get to know new people, discuss new topics, and exchange ideas with someone who usually won't be around. But be careful, don't exaggerate! You don't want to be known as the "annoying hunter of contacts" of the event. Believe us, this happens.

Don't have as your goal to attend all the technical sessions during the conference. It is possible that you won't easily understand most of the papers by only following their presentations. Therefore, try to read the paper in advance for those presentations you decide to attend. When you attend a presentation in your area of interest, try to talk to the author about his work and start a conversation. Consider going to the keynote speaker presentations, which are generally interesting.

Finally, in case you are at the event to present a paper, and rehearse your presentation. Practice in front of a mirror, talk in a loud voice, and present it to colleagues and to your family. There is nothing worse (for the audience and for yourself) than watching a presentation in which the speaker seems to be "discovering" his own slides at that time.

The life of a graduate student

The life of a graduate student is a lit-tle different from a "regular" life. There will be that day in which the only thing that matters to you is the proposal, the thesis, the defense, the journal paper. This is normal! With this in mind, we now list some ideas that can help you to manage your journey.

Homepage. It is important to have a professional Internet homepage in English. Add information about your education (degree, university, department with hyperlinks), advisor, title of the thesis/dissertation, published work, participation in research projects, scholarships, prizes, and affiliated students (if any).

Write. Write, write, write papers for conferences and journals. The best way to learn how to write papers is reading well-written papers (of journals and good conferences). Don't underestimate yourself! It is worth submitting to that huge conference that has a very small acceptance rate. Risk it! In the worst case, the reviews will be extremely helpful. Think about it: Where else would you get an expert opinion for free? You should always have the consent of your advisor before submitting any work to any event. An easier way to know where to publish is to look at the impact rates of CiteSeer <http://citeseer.ist.psu.edu/impact.html>. Conferences with high impact rates are esteemed academically, where most of the papers are of great quality.

In case your paper is not accepted, don't be disappointed. Many times, factors beyond the quality of your work may influence the results of the paper selection. Maybe you did not submit to the right conference track; maybe the committee wasn't the most appropriate to understand and evaluate your paper; maybe the topic of your work had a considerably large number of submissions that year. Sometimes, even political reasons may influence the decisions. Don't feel down. Read the comments of the reviewers. Improve the text, make it clearer, include some more experiments and results, and submit it to another conference. Don't give up after the first obstacle.

Doubts. When you are full of doubts and are not sure what to do next, make an appointment with your advisor. Organize your thoughts, and discuss with your colleagues. Discussion is an important part of your work. Sometimes, it is more productive than weeks of working alone.

Crisis. When the crisis comes, a little chat with colleagues always helps. What do we mean by crisis? There will be that morning when you wake up and think "but where am I going with this?" This is the crisis! Go to the university and talk to your advisor. If he is not there, talk to friends and more experienced colleagues; everybody has had a crisis at least once in their lifetime. If you'd like to read something, try reading R.T. Snodgrass. Believe us, the life of graduate students is very much the same, particularly the crises.

Advisor. He must be your best partner during your graduate program. Before making any important decision, talk to him and ask for his opinion. Make sure he agrees with your decision, check if there are other options, etc. Remember that your success depends on him and vice-versa. And here comes the main difference between a master's and a Ph.D. degree, the motivation for the next section.

Master's versus Ph.D: Don't mix oranges with apples

Callahan says, "The bachelor's degree proves that you can be trained; the master's degree indicates some expertise in your field, and the Ph.D. indicates your ability to become an expert in any field."

Size of the work. In general, a Ph.D. dissertation contains several master's theses, and it opens the way to other, future Ph.D. dissertations. A master's thesis is a small part of a bigger context. Its goal is well focused and limited within a bigger scene.

Advisement. The advisor has different roles. In a master's program, the advisor usually defines the topic and coordinates the work more closely; he is the script director. In the Ph.D. program, the student practically defines and develops everything: from the choice of the topic to the conclusion of the work. With the Ph.D., the advisor provides a second opinion and takes care of paperwork (scholarship, participation in conferences, hiring other scholars to help you, etc.); he is the film producer.

Number and quality of published papers. A master's student should produce at least one paper for a good conference. A Ph.D. student should have at least two papers in big conferences and one in a journal. This can be considered the minimal requirement to emphasize the importance/relevance of the thesis.

Afterward, what is the use of dedicating months and months to some work

act in concert. While individual complaints go unheard, if many students have the same complaint there is likely a legitimate issue. Second, make concerns known in writing. Write a letter outlining the issues and address it to the department head and the coordinator of the department's ABET committee. Try to open a dialogue rather than send an ultimatum. You are more likely to be listened to if you understand the constraints faculty work under, offer specific suggestions for improvement, and actively participate in your department. Include parents, another major stakeholder in education, in this dialogue. If necessary, talk to the dean, provost, or the university president, but always start at the department level. Third, question the status quo. Why is this course a necessary part of the curriculum? Is this the most effective way the course could be taught? How does this material relate to previous courses I have taken, what are the connections? Fourth, participate as an alumnus immediately following graduation. Don't wait. The voices of alumni carry more weight than that of students because they have more experience (and money) behind their opinions.

It is clear that engineering education needs to change, and this change will occur sooner if students hold the feet of faculty and university administrators to the fire. Ultimately, change will require concerted actions by all stakeholders. Currently, universities are financially rewarded for research. In the future, universities need to be financially rewarded for good teaching, and students rewarded for individual initiative and mastering new concepts. How to do this in a way that is acceptable to students and faculty will require innovative thinking. For example, some science fiction writers have discussed scenarios where an individual could finance college by selling shares of their "personal stock" (i.e. future earnings) that would increase or decrease in value with their performance in college or on the job. A more chilling, but likely, scenario is that universities will begin to sell individual assessments of a student's strengths, weaknesses, and performance to potential employers. However, since education is financed by the public, this would raise serious legal and ethical considerations.

Although many faculty decry the fact that students and parents treat a college education as a commodity item, a more fundamental problem is that students are poor consumers. Legitimate complaints are lost or muffled by the compartmentalized structure of the university. Academia complains about changing student values while remaining unwilling to try new paradigms in fear of diluting academic rigor. The will for change does not exist within the academy. It will take the voices of students to finally tell us that the emperor has no clothes.

R. Alan Cheville
Associate Professor, School of Electrical and Computer Engineering
Oklahoma State University
<kridnix@okstate.edu>

The Successful Grad Student (continued from page 13)

that will be forgotten in a library shelf? Don't let this happen to you. Promote your work by writing scientific papers.

Time. For all the above reasons, a Ph.D. requires more time than a master's degree.

Start your journey

We wish you all the luck with your work! Talking about luck, Pasteur used to say "Luck favors the prepared mind." For those crisis hours, "A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty," said Sir Winston Churchill.

Acknowledgments

Read more about it

• "How to study: Postgraduate research," http://dmoz.org/Reference/Education/How_To_Study/Postgraduate_Research

• D.W. Callahan, "The Ph.D. process—What it takes to get it done," *IEEE Potentials*, vol. 20, no. 3, 2001.

• U. Cetintemel, "On the academic interview circuit: An end-to-end discussion," *Sigmod Rec.*, vol. 30, no. 4, Dec. 2001.

• D.E. Comer, "How to write a dissertation," http://www.cs.purdue.edu/ homes/dec

• Z. Ives, "Tips on interviewing," http://www.cis.upenn.edu/~zives/tips_on_interviewing.htm.

• H.C. Lauer, "On Ph.D. thesis proposals in computer science," *Computer J.*, vol. 18, no. 3, 1975.

• S. Miksch, "Tips: How to do research," http://www.ifs.tuwien.ac.at/ ~silvia/research-tips

• E. Miller, "Choosing a grad school advisor," *IEEE Potentials*, vol. 21, no. 3, 2002.

• D.A. Patterson, "How to have a bad career in research/academia,"http://www.cs.berkeley.edu/~pattrsn/talks/nontech.html

• R.T. Snodgrass, "Why I like working in academia," *Sigmod Record*, vol. 31, no. 1, Mar. 2002.

• T. Walsh, "Ph.D. skills," http:// www-users.cs.york.ac.uk/~tw/phd

• J. Zobel, *Writing for Computer Science: The Art of Effective Com0munication*. Springer-Verlag, 1998.

About the authors

Mirella M. Moro is a Ph.D. candidate at the Department of Computer Science and Engineering at the University of California, Riverside. She received M.S. (2001) and bachelor's (1999) degrees in computer science from the Universidade Federal do Rio Grande do Sul, Brazil. Her area of study is databases.

Vanessa de Paula Braganholo is a researcher at the Universidade Federal do Rio de Janeiro. She received Ph.D. (2004) and bachelor's (1998) degrees in computer science from the Universidade Federal do Rio Grande do Sul, Brazil. Her area of interest is databases.

André C. Nácul is a Ph.D. candidate at the School of Information and Computer Science, University of California, Irvine, where he is also a member of the Center for Embedded Computer Systems. He received M.S. (2002) and bachelor's (1999) degrees in computer science from the Universidade Federal do Rio Grande do Sul, Brazil. His interests include real-time systems and embedded software.

Miguel Rodrigues Fornari is a Ph.D. student at Universidade Federal do Rio Grande do Sul, Brazil. He received M.S (1993) and bachelor's (1990) degrees in computer science from the Universidade Federal do Rio Grande do Sul, Brazil. His area of study is spatial databases.