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# A game plan for grad school success

DHADESUGOOR R. VAMAN

## GRAD SCHOOL SUCCESS

Choose research wisely. Advance two spaces.

Earn a research assistantship. Spin again.

Your advisor goes easy on students. Do not pass Go. Do not collect your Ph.D.

Earn a research assistantship. Spin again.

### Advise and consent

Each graduate student must make a judicious decision on the selection of a faculty advisor. The advisor will assist the student in the selection of courses and also the thesis/dissertation area of interest. The advisor will be a team member with the graduate student to ensure successful completion of the thesis/dissertation. Incoming students often find themselves asking enrolled students about the advisors. In any environment, there are myths and there are realities. One must understand each and make the proper decision when selecting an advisor.

The success of graduate programs (M.S. and Ph.D.) in any university is measured by the success of their graduate students working in industry and competing with peers from other universities. The lessons taught by the faculty enable engineering graduates to acquire expertise in their discipline in work, which results from poise, vigor, and hard work. Graduates should be able to maintain the same poise, vigor and hard work as they continue lifetime learning.

Education should be well rounded with good knowledge acquisition through all courses, the physical upkeep of the body and mind through extracurricular activities, and the development of the philanthropic mind through community and charitable services. In addition, the student must develop good presentation and overall communications skills. In total, these aspects contribute to the well-rounded education of a student.

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The myths:

- Select an advisor who can provide research assistantship (RA).
- Select an advisor who is very easy on students.
- Select an advisor who does not make the student work hard.

Realities:

- Select an advisor who is working in an area in which the student is interested in pursuing research.
- Select an advisor who is significantly knowledgeable in the research area of interest.
- Select an advisor who can properly assess whether the student is progressing in research. It does not mean that some faculty members may not know how to assess the progress. On the contrary, there are faculty members who may not be very active in pursuing research and therefore, they may not be in a position to provide appropriate assessment of the student's progress.

## Choose your research wisely

Understanding the research interest of an incoming graduate student is not an easy task. As long as the student identifies the core area of interest, the student will be able to pursue research in that area. Also, it is important for the student to have an understanding that the area of research must be reasonable in providing a shot at an employment opportunity. Universities offer an environment for discussion and provide an opportunity to exploit this environment through talks with faculty and their own research to see how one should choose a research area of interest.

Selecting a research area depends on many factors ranging from ease of understanding the subject matter, background knowledge derived from the coursework, passion for the subject matter, opportunities upon graduation, and how well one can maintain lifetime learning abilities. Finding a research area is not a trivial matter, and students can make a good decision through open communication with other researchers and faculty members.

Usually, when a student selects a research area, the faculty advisor is also identified. Once the association with the faculty member as an advisor materializes, the faculty member and student form a team to develop research through thesis/dissertation. Thesis/dissertation can be accomplished either theoretically or through applied research working in a laboratory or a center. Working in the center or a laboratory will provide solid experience in solving real-world problems, as the work can be supported from external grants from government agencies and industry. The faculty member is very likely to provide RA funding for the student to work in the laboratory and/or research effort. When funding is provided, there is an obligation on the part of the student to support the faculty member and there is an obligation for the faculty to provide results to his/her client (or funding agency).

It is important to understand the relationship of the student with faculty when financial support is provided. Based on the United States university system, the following guidelines are typically applied when financial support is provided through external funding:

- ❑ RA support requires each student to work 20 hours/week on the supported project.

- ❑ Thesis/dissertation efforts are to be done outside these 20 hours.

- ❑ Students can use the results of the projects for their thesis/dissertation.

- ❑ Professors will not provide RA simply to work in the laboratory/center; they expect that the student will complete their thesis/dissertation when providing RA.

- ❑ Professors expect that the students who do well in an M.S. program will continue in the Ph.D. program. Although this is not a requirement, the chances of getting an RA are high if the graduate student demonstrates an interest in pursuing doctoral studies.

- ❑ Value proposition needs to be defined to benefit the student, the professor, and the funding agency. It is an important aspect of the student-faculty team. The benefit of having an RA enhances the knowledge base by working on state-of-the-art research; developing the ability to work in a stressful environment with longer hours; the ability to solve difficult and critical problems; increased discipline in working hard to complete tasks on time; the fostering of teamwork by working with others in the group to produce quality results; and maintaining loyalty to the organization. These benefits will help students in their work environment following graduation.

The faculty benefit comes from the pleasure of developing a student to maturity in education and research; assisting the university in increasing the number of students; and bringing up the academic standing of the programs. Also, on an individual basis, the faculty is able to present research results in numerous journals and conferences, which enhances his/her status in the engineering community at large.

The department (or institution) benefits from the enhanced position with the opportunity to become a premier resource due to the expertise in research areas, which also directly benefits future student recruitment and increased monetary support of research of all faculty members. The ultimate goal, however, is to develop excellent graduate programs with state-of-the-art research capabilities in the department. This will enhance the graduate students working in industry and improved industry/university traction for hiring newly graduating students.

Since it is a team, professors play a valuable role in the growth of students, even after the completion of their education. Difficulties faced by former stu-

dents can find a sympathetic ear from the professor. A professor can become a very good friend.

## Thesis says what?

There are three factors that assist the selection of a thesis/dissertation topic:

- ❑ background research

- ❑ research topics supported in funded research

- ❑ deliverables of funded research.

The background research, when properly conducted to understand what peer researchers are doing, will assist in identifying the advantages and shortcomings of research. It can then be used to develop a research problem and allow the student to solve the problem that addresses different shortcomings. The funded research usually has a defined scope and objective that specifically targets the research for the funding agency. When working as RA, the student will be able to work on this and use the research results as part of thesis/dissertation.

The deliverables of funded research may not be usable for the thesis/dissertation, but the outcomes may provide secondary research topics that can be exploited as part of the thesis/dissertation. The student-faculty team can explore these topics to identify the research area for the thesis/dissertation.

Once the research area is selected, it is important to define the scope and objectives of the thesis/dissertation. It is very important to develop a focused scope for the research in order to ensure timely completion of the thesis/dissertation. The objectives of the research must be specific, with precise statements, so that each objective is addressed properly and solutions are developed.

Based on the scope and objectives, one should define a compelling problem statement. The student can develop a solid problem statement by working with the faculty in background research including reading published papers in journals and conferences, through the selection of proper course work in the program, and attending seminars by senior researchers who are faculty members and engineers.

With this, the student has achieved defining the scope of thesis/dissertation, defined a compelling problem statement, and generated background research material with a good set of references for the thesis/dissertation.

## Time for a strategy

Before looking at the research strategies, it is important to distinguish between a master's thesis and a doctoral dissertation. A master's thesis needs to be original in solving a research problem in the area of concentration. However, the research problem may not necessarily have to be original. The doctoral dissertation, on the other hand, needs to be an original problem not solved previously in the area of concentration.

In a master's thesis, the student tends to solve a problem that has been derived from the broader research topics that are being addressed. As long as the problem is solved in a unique way in terms of improvements, efficient methods, or good mathematical modeling and simulation, it is acceptable for the thesis. The completion of the thesis usually requires approximately nine months of effort by the student. While publication is highly encouraged, a master's thesis can be completed without publication.

The doctoral dissertation explicitly requires solving an original problem that has not yet been addressed. The solution to the problem must be demonstrated in terms of an enhancement of the knowledge base in science and engineering. A compelling argument is made by the student based on the background research conducted.

Typically, universities in the United States require the publication of at least two refereed journal papers (one published and one submitted) for the successful completion of a doctoral degree. The completion of a doctoral dissertation (and the required course work) requires a minimum of three-and-a-half years of strong efforts by the student. It is very important to complete your doctoral studies in 3.5–4 years to maintain the state-of-the-art research so it may be useful to the research community at large.

As a student works at research, it is important to know when the thesis or the dissertation is going to be completed. As stated previously, the research must have a value to the advisor and the funding agency. Working very closely with the faculty advisor helps the student to gain the knowledge of when he/she is going to complete his/her thesis/dissertation.

For timely completion of the thesis/dissertation, it is important for each student to develop both writing and presentation skills. Any subject matter must be presented to an audience at their level of understanding of

the subject matter. This skill set comes over a time with effort by each student.

Presentation skill (also synonymous with communications skill) will allow other peer members to focus on what is being discussed. A well-rounded person will have a knowledge base, writing skills, and presentation skills. Advisors often assist in the development of these skill sets by allowing students to present periodical seminars of work in progress. Universities also have courses to develop the writing and presentation skills of the students. Students should make every effort to make use of the resources available for developing these skills. If a student has difficulty in these skill sets, then he/she will find it difficult to complete the thesis/dissertation in a timely manner.

For both master's and doctoral programs, it is important to understand how the credit system works regarding research. Many students may not be aware of the credit system used in the United States. Each university offers different sets of credits to the master's thesis and doctoral dissertations.

Understanding the number of hours of effort needed to complete the thesis/dissertation using the credit-based approach is important. If a master's thesis is six credits (submitting a written thesis and defending the thesis through oral presentation), it often requires that the student put in 24 hours per week of work effort for the research. This is in addition to the 20 hours per week that a student works for the RA as well as hours for other course work in the program. If a student registers for nine credits of course work in a semester and has an RA support, he/she should expect to work a total of 15 hours plus 20 hours for RA. This comes to a total of 35 hours per week of work. Usually, the students who take the master's thesis need to spend an additional 15 hours toward developing background research and identifying the thesis problem, even when they have not yet registered for the thesis credits. Therefore, the student who is pursuing a master's degree ends up with a weekly load of 50 hours. Often it tends to be more in the range of 60 hours or more due to lack of knowledge in additional skill sets.

While the hours may be long, they are flexible, and therefore, the student learns how to manage working hours during the course of the study. Later, this skill set in managing the time will be useful in the job environment. A master's thesis is not always mandatory but is highly recom-

mended. The broad knowledge enhancement due to completing a thesis is very high. The student develops skills in writing, presentation, critical problem solving, how to validate the results, and how to work as a member of a team. Working on a thesis requires a passion in problem solving and an interest in exploring new areas of research.

For doctoral studies, the student typically registers for nine research credits every semester, with a maximum of 36 credits for research. This means the student will complete his/her essential research in two years. For nine research credits, the doctoral student should expect approximately 45 hours of work per week. This is in addition to the 20 hours per week that a student dedicates toward an RA and other course work within the program. It essentially adds up to 60–80 hours of work per week for the total program. Since the total number of credits required to complete doctoral education exceeds 50 credits, it takes about 3.5–4 years to complete the degree program. The number of hours is only a guideline to indicate the seriousness of the efforts required and is not a rigid figure.

Once the choice is made to work toward an M.S. or Ph.D., the student-professor team must succeed for mutual benefit. Disciplined efforts from the student will become the hallmark of career development, while the department and university enhance their status—it bodes well for appealing to future students. It is important to note that without the commitment to complete a master's thesis, the student should not pursue thesis work. If the commitment is lost in working on the doctoral dissertation, the student presents enormous problems to the faculty and the funding agency that supported the RA in the first place. It is extremely important that once the student starts a Ph.D. dissertation, he/she must do everything necessary to fulfill the obligation of completing that dissertation.

Whether it is a master's thesis or a doctoral dissertation, the research methodology is similar. It includes:

- conducting background research
- defining “the research problem” within the scope of research
- conducting the research successfully.

The student must be able to see that once the problem is defined and solved, and there must be an understanding of what future research problems may arise.

Conducting background research involves reading published papers in the

concentration and identifying what problems have been solved as well as the shortcomings in the published research. It will help to define the problem statement for the thesis or dissertation. The research methodology requires the student to work with the professor weekly or bimonthly. The student must seek out the professor for discussion. These discussions should assist the student in defining the problem. When students have difficulty, the professor can be helpful with ironing out the difficulties. Professors can identify situations when the student is having difficulty and when he/she is not putting forth an adequate effort. The students can get good input from professors and they must take advantage of these discussions.

The professor can evaluate whether the student has completed all the necessary research tasks and is ready to write the thesis/dissertation. The professor is valuable to the students in developing writing and presentation skills. On funded research, the professor requires students to provide results in a timely manner. Without these results, the professor cannot provide sufficient data to the funding agencies to fulfill the obligations of the research funding.

Once the research is complete, professors can assist students with employment opportunities. Professors and their universities like to see that their graduates are gainfully employed and excelling in their fields based on the knowledge gained and lifetime learning from graduate school.

Publications are important in measuring the value of research results. As discussed earlier, it is important to develop results that can be published, leading to refereed conference and journal papers. Doctoral studies often require at least one paper to be published in a refereed journal and one additional paper is submitted in order to complete the dissertation, while master's studies typically has no mandatory requirement for publications, but it is highly encouraged.

Research is a serious business in learning. Each student must demonstrate efforts in problem solving by creative thinking. By the time the student completes his/her graduate studies, experience is gained in defining and solving a problem as well as the ability to multitask. In the industrial environment multitasking is a norm, and graduate school experience will provide a resource for the student to work well in an industrial environment.

## Pump up the knowledge base

Students who want to be researchers and pursue theses/dissertations must develop an increase of the knowledge base through innovative efforts. Validation of the research can be achieved by publishing the results in refereed journals and conference papers. The presentation of research results must demonstrate accuracy, and it should not have any ambiguities. To achieve this, every effort must be made to make clear and plausible assumptions. The statements on the scope, objectives, and the research methodology must be crisp. The research and research results must be properly deduced to provide opportunities for others to critique. For example, it is not good enough to produce results using simulation tools, one must validate and verify the results. Results should be truthful and explainable. Only then can the research contribute to the increase of knowledge base in science and engineering.

Another aspect that assists in the enhancement of the knowledge base is the ability of students and faculty to discuss results at various forums. Students must make an effort to become members of professional societies (e.g. the IEEE) as student members. They should participate in meetings, network with industry members, and mingle freely with others to discuss their research and listen to other opinions of their research.

Attendance at conferences to present papers is important in getting the word out about your research. Many professors and universities provide funds for travel. Students can also gain experience by organizing seminars and inviting well known researchers to their university.

## Great expectations

It is important to remember that employers will not continue to pay the salaries of those who do not contribute to projects. Before a company presents an offer, it wants answers to many questions. An employer will request references and set up interviews during the hiring process. You should expect to answer the following questions:

- Why are you the right person for the job?
- What do you offer that cannot be achieved by other applicants?
- Are you a team player?
- Do you complete assignments on time? (This is not a 40 hours/week work environment.)

Do you thrive with independent work efforts?

Can you work independently without constant supervision? (Similar effort is done as a research student.)

Is the candidate really capable of working hard? (Many professors are asked this question about their students when contacted by employers.)

Where would you like to be in 5–10 years and beyond?

Do you have a passion for the projects required by this position?

Once the employer decides to hire the candidate, they usually expect the following from the employee:

- Be prepared to work long hours.
- Meet deadlines.
- Work as a team player.
- An ability to learn from projects that may not fall into your area of expertise.

Self-learning (books, reports) may be required since in many organizations it is difficult to get assistance in learning.

Life can be tough if one lacks the knowledge to work on projects, but learning how to work hard as a graduate student in a stressful environment while doing research is excellent experience. Professors can only guide students into productive and rewarding careers.

Universities and their departments and professors work with students as a team to attempt to present a well rounded graduate to the job market. When the graduate student gainfully moves into an industry, he/she represents the professor, the department, and the university and it is the responsibility of the candidate to maintain the spirit of discipline and become a role model for future students.

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## About the author

Dhadesugoor R. Vaman is a Texas Instruments endowed chair professor and founding director of ARO Center for Battlefield Communications (CeBCom) Research, ECE Department, Prairie View A&M University.