Notes On The PhD Degree

Last week at the department colloquium coffee hour, several students engaged the faculty in a discussion about our Ph.D. program. It became clear that many of the students did not understand the basics; they were surprised at some of the questions and confused by some of the answers.

These notes provide basic information about the purpose of a Ph.D. program in an attempt to help students decide whether to pursue a Ph.D. degree.

The Basics

A Doctor of Philosophy degree, abbreviated Ph.D., is the highest academic degree anyone can earn. Because earning a Ph.D. requires extended study and intense intellectual effort, less than one percent of the population attains the degree. Society shows respect for a person who holds a Ph.D. by addressing them with the title "Doctor".

To earn a Ph.D., one must accomplish two things. First, one must master a specific subject completely. Second, one must extend the body of knowledge about that subject.

Mastering A Subject

To master a subject, a student searches the published literature to find and read everything that has been written about the subject. In scientific disciplines, a student begins by studying general reference works such as text books. Eventually, the student must also search scholarly journals, the publications that scientists use to exchange information and record reports of their scientific investigations.

Each university establishes general guidelines that a student must follow to earn a Ph.D. degree, and each college or department within a university sets specific standards by which it measures mastery of a subject. Usually, in preparing for Ph.D. work in a given field, a student must earn both a Bachelor's and Master's degree (or their equivalent) in that field or in a closely related field. To demonstrate complete mastery of the subject, a student may be required to complete additional graduate-level courses, maintain a high grade average, or take a battery of special examinations. In many institutions, students must do all three.

Because examinations given as part of a Ph.D. curriculum assess expert knowledge, they are created and evaluated by a committee of experts, each of whom holds a Ph.D. degree.

Extending Knowledge

The essence of a Ph.D., the aspect that distinguishes Ph.D. study from other academic work, can be summarized in a single word: research. To extend knowledge, one must explore, investigate, and contemplate. The scientific community uses the term "research" to capture the idea.

In scientific disciplines, research often implies experimentation, but research is more than mere experiments -- it means interpretation and deep understanding. For Computer Scientists, research means searching to uncover the principles that underlie digital computation and communication. A researcher must discover new techniques that aid in building or using computational mechanisms. Researchers look for new abstractions, new approaches, new algorithms, new principles, or new mechanisms.

To complete a Ph.D., each student must present results from their research to the faculty in a lengthy, formal document called a dissertation (more popularly referred to as a thesis). The student must then submit their dissertation to the faculty and defend their work an oral examination.

Relationship To Products

In some cases, the results of scientific research can be used to develop new products or improve those that exist. However, scientists do not use commercial success or potential commercial profits as a measure of their work; they conduct investigations to further human understanding and the body of knowledge humans have compiled. Often, the commercial benefits of scientific research are much greater in the long-term than in the short-term.

Research Activities

Computer Science research can include such diverse activities as designing and building new computer systems, proving mathematical theorems, writing computer software, measuring the performance of a computer system, using analytical tools to assess a design, or studying the errors programmers make as they build a large software system. Because a researcher chooses the activities appropriate to answer each question that arises in a research investigation, and because new questions arise as an investigation proceeds, research activities vary from project to project and over time in a single project. A researcher must be prepared to use a variety of approaches and tools.

A Few Questions To Ask

Many of you are trying to decide whether to pursue a Ph.D. degree. Here are a few questions you might ask yourself.

1. Do you want a research career?

Before enrolling in a Ph.D. program, you should carefully consider your long-term goals. Because earning a Ph.D. is training for research, you should ask yourself whether a research position is your long-term goal. If it is, a Ph.D. degree is the standard path to your chosen career (a few people have managed to obtain a research position without a Ph.D., but they are the exception, not the rule). If, however, you want a non-research career, a Ph.D. is definitely not for you.

2. Do you want an academic position?

A Ph.D. is the de facto "union card" for an academic position. Although it is possible to obtain an academic position without a Ph.D., the chances are low. Major universities (and most colleges) require each member of their faculty to hold a Ph.D. and to engage in research activities. Why? To insure that the faculty have sufficient expertise to teach advanced courses and to force faculty to remain current in their chosen field. The U.S. State Department diplomatic protocol ranks the title "professor" higher than the title "doctor". It does so in recognition of academic requirements: most professors hold a Ph.D., but not all people who hold a Ph.D. degree are professors.

3. Do you have what it takes?

It is difficult for an individual to assess their own capabilities. The following guidelines and questions may be of help.

Intelligence:
: In your college and graduate courses, were you closer to the top of your class or the bottom? How well did you do on the GRE or other standardized tests?

Time:
: Are you prepared to tackle a project larger than any you have undertaken before? You must commit to multiple years of hard work. Are you willing to reduce or forego other activities?

Creativity:
: Research discoveries often arise when one looks at old facts in a new way. Do you shine when solving problems? Do you like "brain teasers" and similar puzzles? Are you good at solving them? In school, did you find advanced mathematics enjoyable or difficult?

Intense curiosity:
: Have you always been compelled to understand the world around you and to find out how things work? A natural curiosity makes research easier. Did you fulfill minimum requirements or explore further on your own?

Adaptability:
: Most students are unprepared for Ph.D. study. They find it unexpectedly different than course work. Suddenly thrust into a world in which no one knows the answers, students sometimes flounder. Can you adapt to new ways of thinking? Can you tolerate searching for answers even when no one knows the precise questions?

Self-motivation:
: By the time a student finishes an undergraduate education, they have become accustomed to receiving grades for each course each semester. In a Ph.D. program, work is not divided neatly into separate courses, professors do not partition tasks into little assignments, and the student does not receive a grade for each small step. Are you self-motivated enough to keep working toward a goal without day-to-day encouragement?

Competitiveness:
: If you choose to enroll in a Ph.D. program, you will compete with others at the top. More important, once you graduate, your peers will include some of the brightest people in the world. You will be measured and judged in comparison to them. Are you willing to compete at the Ph.D. level?

Maturity:
: Compared to coursework, which is carefully planned by a teacher, Ph.D. study has less structure. You will have more freedom to set your own goals, determine your daily schedule, and follow interesting ideas. Are you prepared to accept the responsibility that accompanies the additional freedoms? Your success or failure in Ph.D. research depends on it.

A few warnings:

Students sometimes enroll in a Ph.D. program for the wrong reasons. After a while, such students find that the requirements overwhelm them. Before starting one should realize that a Ph.D. is not:

Prestigious in itself

Almost everyone who has obtained a Ph.D. is proud of their efforts and the result. However, you should understand that once you graduate, you will work among a group of scientists who each hold a Ph.D. degree. (One faculty member used to chide arrogant graduate students by saying, "I don't see why you think it's such a great accomplishment -- all my friends have a Ph.D!").

A guarantee of respect for all your opinions

Many students believe that once they earn a Ph.D. people will automatically respect all their opinions. You will learn, however, that few people assume a Ph.D. in one subject automatically makes you an authority on others. It is especially true in the science communicaty; respect must be earned.

A goal in itself

A Ph.D. degree prepares you for research. If all you want is a diploma to hang on the wall, there are much easier ways to obtain one. After you graduate, you will have occasion to compare your record of accomplishment to those of other scientists. You will realize that what counts is the research work accumulated after a scientist finishes their formal education.

A job guarantee

When an economy slows, everyone can suffer. In fact, some companies reduce research before they reduce production, making Ph.D.s especially vulnerable. Furthermore, once a person earns a Ph.D., many companies will not hire that person for a non-research position. As in most professions, continued employment depends on continued performance.

A practical way to impress your family or friends

Your mother may be proud and excited when you enroll in a Ph.D. program. After all, she imagines that she will soon be able to brag about her child, "the doctor." However, a desire to impress others is insufficient motivation for the effort required.

Something you can "try" to find out how smart you are

Sorry, but it just doesn't work that way. Unless you make a total commitment, you will fail. You will need to work long hours, face many disappointments, stretch your mental capabilities, and learn to find order among apparently chaotic facts. Unless you have adopted the long-range goal of becoming a researcher, the day-to-day demands will wear you down. Standards will seem unnecessary high; rigor will seem unwarranted. If you only consider it a test, you will eventually walk away.

The only research topic you will ever pursue

Many students make the mistake of viewing their Ph.D. topic as a research area for life. They assume each researcher only works in one area, always pursues the same topic within that area, and always uses the same tools and approaches. Experienced researchers know that new questions arise constantly, and that old questions can become less interesting as time passes or new facts are discovered. The best people change topics and areas. It keeps them fresh and stimulates thinking. Plan to move on; prepare for change.

Easier than entering the work force

You will find that the path to successful completion of a Ph.D. becomes much steeper after you begin. The faculty impose constraints on your study, and do not permit unproductive students to remain in the program.

Better than the alternatives

For many students, a Ph.D. can be a curse. They must choose between being at the top among people who hold a Masters degree or being a mediocre researcher. The faculty sometimes advise students that they must choose between being "captain of the B team" or a "benchwarmer" on the A team. Everyone must decide what they want, and which profession will stimulate them most. But students should be realistic about their capabilities. If you really cannot determine where you stand, ask faculty members.

A way to make more money

While we haven't heard any statistics for the past couple of years, graduate students used to estimate the "payoff" using the starting salaries of Ph.D. and M.S. positions, the average time required to obtain a Ph.D., the value of stock options, and current return on investments. For a period of at least five years that we know, the payoff was clearly negative. Suffice it to say that one must choose research because one loves it; a Ph.D. is not the optimum road to wealth.

The good news:

Despite all our warnings, we are proud that we earned Ph.D. degrees and proud of our research accomplishments. If you have the capability and interest, a research career can bring rewards unequaled in any other profession. You will meet and work with some of the brightest people on the planet. You will reach for ideas beyond your grasp, and in so doing extend your intellectual capabilities. You will solve problems that have not been solved before. You will explore concepts that have not been explored. You will uncover principles that change the way people use computers.

The joy of research:

A colleague summed up the way many researchers feel about their profession. When asked why he spent so many hours in the lab, he noted that the alternatives were to go home, where he would do the same things that millions of others were doing, or to work in his lab, where he could discover things that no other human had ever discovered. The smile on his face told the story: for him, working on research was sheer joy.