AC 2008-1418: ISSUES EFFECTING DOCTORAL STUDENTS RETURNING TO ENGINEERING EDUCATION FOLLOWING EXTENSIVE INDUSTRIAL EXPERIENCE

Walter Schilling,

Walter Schilling is an assistant professor in the Software Engineering program at the Milwaukee School of Engineering in Milwaukee, WI. He received his BSEE from Ohio Northern University in 1997 and his MSES and PhD. from the University of Toledo in 1998 and 2007 respectively. He worked in the automotive industry as an embedded software engineer for several years prior to returning for doctoral work. He has spent time at NASA Glenn Research Center in Cleveland, OH. In addition to one US Patent, Schilling has numerous publications in refereed international conferences and other journals. Schilling is the recipient of the Ohio Space Grant Consortium Doctoral Fellowship, and is a member of IEEE, IEEE Computer Society, IEEE Reliability Society, ACM, and ASEE.

Issues Affecting Doctoral Students Returning to Engineering Education Following Extensive Industrial Experience

Abstract

It can be said that the best time for an engineer who desires to enter academia to earn their Doctoral Degree is after a four to five year period working in industry. During this time period, a practicing engineering can be extensively exposed to the practical aspect of the engineering discipline. This exposure can aid to a more effective mentorship with students, better professional relationships with other practicing engineers, and a better understanding of the real problems faced by engineers solving real world problems.

However, a practicing engineer who wishes to return for doctoral studies faces numerous hurdles not necessarily encountered by a traditional student. This article puts forth some of the challenges facing a practicing engineer who attempts to return to graduate school for Doctoral Study. Areas to be addressed include difficulties obtaining graduate admission, the lack of fellowships and grants for returning professionals, other financial aspects of graduate studies impacting practicing professionals, project management issues, and job search issues.

1. Introduction

It can be said that, from many aspects, the best time for an engineering student to obtain their Ph.D. is after a period of working in industry. By the time one completes five to seven years of higher education, students can be "burned out" and otherwise not ready for the rigor of a Doctoral Degree. By breaking at this point and working in industry for a few years, students can obtain a better understanding of the practice of engineering than can be obtained from the classroom and co-operative (co-op) or internship experience. Furthermore, they can better understand exactly what area of engineering they wish to pursue in their studies.

While this approach is very logical, few students actually take this path. Rather, the majority of Doctoral Degrees granted are given to students who have not broken their academic studies nor worked significantly in an industrial setting. Many factors contribute to this, both intuitive and non-intuitive. This article attempts to address the issues facing a non-traditional doctoral student with significant work experience as have been observed from personal experience. Many of these issues are faced by traditional graduate students, but the issues are made more difficult by the age factor for non-traditional graduate students.

2. The Admissions Process

Difficulties for returning students begin with the admissions process into doctoral degree programs. Most students, upon contemplating entry into graduate school for their Master's Degree, take the GRE or other qualifying examination, typically during the Junior or Senior year. As such, students are best equipped for success on the examination, for test taking is part of a students routine life.

GRE test scores, one of the most critical decision factors in admission, however, expire after 5 years. So, if a student desires to enter the workforce following a Master's degree, just about the time they would be considering returning to graduate school for a Doctoral Degree, their GRE scores expire. In order to obtain admission, Doctoral students must retake the GRE exam, an expense both in terms of time as well as money.

However, even once a student has overcome the difficulty with GRE scores, there is the difficulty with the admissions process. Many graduate schools, in their admissions process, routinely do not accept graduate students whose bachelors degree is more then 3 to 4 years old. Thus, finding graduate schools with the appropriate field of study who will accept older students can be challenging.

The lack of part time enrollment also affects the ability of professionals to return to graduate school for a terminal degree. While a few corporations will pay for doctoral work, those that will often stipulate that any degree earned be done on a part time basis. Yet, most Doctoral Programs will not accept students on a part time basis. This lack of part time enrollment also affects the ability of students who might be considering a Ph.D. yet are concerned that they may not be academically capable to continue the studies. Returning part time may provide the assurance that they are capable of learning in an academic setting yet still allow the safety net of employment should a problem develop. Vesting in retirement plans, leave of absence policies, and other corporate policies may make it prudent for a doctoral student to want to start studies on a part time basis.

3. Funding Issues

There is ample evidence that from a financial standpoint, returning to graduate school does not necessarily increase one's earnings potential, and in fact, may result in decreased job availability and reduced income, especially if one enters academia as opposed to working in industry[1,2,3]. This is a major issue, but generally is beyond the scope of this paper. However, there are other funding issues which affect industrially experienced students differently from traditional students.

While it can generally be argued that the number of fellowship opportunities and funding sources for graduate students is less than optimum, nowhere is this truer than the fellowship opportunities available to non-traditional graduate students. Fellowship opportunities, such as the National Science Foundation Graduate Research Fellowship, are limited to "students who are in the early stages of their graduate study."[4] Since these experienced professionals already have their Master's degree, they are ineligible for these

programs. Local university programs suffer from similar problems, in that in order for a graduate student to apply for the program they must be enrolled full time in the university. Yet, it is impossible for one in industry to be enrolled full time while still working, and from a financial standpoint, it is not feasible to leave a secure industrial position to return to graduate school if some funding source is not guaranteed for the requisite period of study.

The ever rising cost of graduate school attendance affects returning students as well. While fellowships and other assistanceships cover the cost of tuition, these programs generally do not cover other associated campus fees assessed upon graduate students, which in many cases are rising at rates higher than the rate of increase for overall graduate tuition [6]. These fees, like books and housing, must be covered out of the student's income.

4. Other Financial Issues

While tuition and other expenses have grown, this pales in comparison to the impact of medical expenses. At most graduate schools, enrollment in a campus insurance program is required of all full time students. These programs, while well intentioned, operate on the academic calendar. This poses significant changes when dealing with life changing events, such as marriage, spousal job changes, or births, which do not correspond with the academic calendar. Because of this, students may have periods of double coverage or no coverage at all if life changing events occur during the academic year. These problems become even more paramount if the person has a family with one or more young children, in which case the only feasible mechanism for covering insurance may be a spouse's medical plan or COBRA.

Children also complicate the funding situation from a savings standpoint. With the ever growing cost of education, it is imperative that parents begin saving for college as soon as a child is born through a 529 or similar plan. Yet, saving for a child's college expenses seems to be the wrong approach if one is amassing student loans to pay for graduate school enrollment.

Leaving the industrial setting poses other issues to graduate students. As a working engineer, it is most likely that a person is contributing to a pension savings plan through a 401K or other defined benefits plan. At a minimum, assuming one is not working for a government agency, employees are paying into Social Security. This stops when one returns to graduate school, as retirement plans are not readily available to students. Making matters worse, if one attends a state institution, it is very likely that instead of paying into Social security, a graduate student will be paying into a state retirement fund. Because students typically are not employed long enough to obtain full vesting, returns from the plan are diminished accordingly. Worse yet, however, because payments were not made into Social Security, the retirement benefit from Social Security can be significantly diminished.

Student loan policies also impact non-traditional graduate students. If a student enters graduate school directly after their undergraduate degree, loans can be deferred. But, once a student enters the workforce, repayment must start. If a person consolidates their loans using a private lender program, It is very possible that a non-traditional graduate student may end up being forced to pay off loans from their undergraduate degree at the same time as incurring new loans for their Doctoral Degree. If the students themselves are not paying off student loans, then it may be that one's spouse is dealing with student loans.

Conference attendance also presents a significant challenge to Doctoral students. As more Doctoral Programs require a satisfactory record of publication prior to defense, attendance at technical conferences has become paramount. However, at the very same time, the costs of conference attendance are increasing and support for conference attendance is decreasing. In some cases, departments may support student attendance at conferences, but this is by no means universal. Campus Graduate Student organizations may also help with conference attendance, but the funding available is often significantly less than the cost of attendance at a conference. While reduced rates for students to attend conferences are available, and some conferences offer student travel grants to attend, many conferences require students to register at full rates if they are presenting a paper at the conference. This circumvents any student rate for the conference. Certain fellowships may include a travel stipend, but this stipend typically will only cover one conference, leaving the graduate student to pay for conference attendance.

Membership in professional societies also poses an issue to graduate students. While many societies offer significant discounts to students during their undergraduate and graduate years, a practicing engineer returning to graduate school may be unable to obtain student rates within the society because they have previously become a "full member". This also applies to offices and leadership positions held; many Professional Societies prevent student members from holding offices within the organization, so a person with industrial experience is unable to continue to hold an elected office if they convert to student membership. Yet, on a graduate student income, full membership in a technical society may be impractical.

5. Educational Enrichment

While nearly all graduate schools have a graduate student association or similar campus organization present to support graduate students, these organizations can be ill-equipped to support older, more mature non-traditional graduate students. This can lead to those who return to graduate school felling isolated and without a support network.

One major reason an engineer with industrial experience would desire to return to graduate school is to be able to teach in an academic setting. While graduate schools offer significant opportunities for research, the majority of graduate programs offer little or no guidance for a student who desires to teach at a teaching oriented school. Aside from a few seminars on effective teaching, which are typically targeted at international students overcoming language barriers, few graduate programs require Doctoral students

to enroll in a teaching methods course. And, because many such courses are outside of the engineering domain and may not be offered at the Doctoral Level, fellowships and assistanceships often do not cover the tuition for these courses.

6. Project Management

The lack of discipline exhibited on many research projects also hampers non-traditional graduate students. In an industrial setting, every project is initiated by defining the scope and objectives for the project. In the academic setting, if the scope and objectives are defined, it is rare for them to be current and accurate. Even rarer yet is the concept of project management and project planning. These steps are paramount to the success of any project. Yet, rarely is the discipline applied to graduate projects, and attempts to apply this form of discipline can be actively discouraged. This results in success only being obtained through heroic efforts as opposed to measured and disciplined progress.

Even when a graduate student attempts to use project management and risk management skills from industry, it can be difficult to obtain consensus on milestones and deliverables. This often needlessly leads to schedule slips, resulting in delays in graduation. In certain cases, when funding expires, graduate students must make the tough decision leaving with an uncompleted degree or spending one or more semesters / quarters unfunded in order to fulfill final graduation requirements.

Tied in with this is the steadily increasing time required to complete a Ph.D. Degree, which has increased on average by more than 6 months since 1987[5]. While this extension in completion time has resulted in a greater non-completion rate for Doctoral students, it also discourages the best and the brightest and most entrepreneurially minded engineers from ever starting the process.

Misunderstandings of the patent process also routinely occur. In a rush to publish articles, many graduate research projects have forfeited the ability to patent intellectual property. The zealous guarding of intellectual property, and the care which must be taken to secure laboratories from outside intrusion in order to protect intellectual property is a skill engrained in practicing engineers. Yet the openness of the academic work can easily circumvent this care. For a non-traditional student researching in their field, the ability to share their work if initiated in a corporate setting may be bound by an existing Non-Disclosure Agreement (NDA) with their prior employer and may also result in legal difficulties if a new NDA is signed for a research project.

Confusion over patents has also led to graduate students being unable to defend their dissertation or graduate on schedule as miscommunications between advisors and research offices over patent issues have occurred. These issues typically appear in the days before a defense is scheduled or after a dissertation has been successfully defended but before a dissertation is formally accepted by the graduate school.

7. Job Placement Issues

Assuming that one is successful at completing a Ph.D. program, finding a position in academia is often extremely difficult. In stark contrast to articles which have appeared indicating a shortage of faculty members with industrial experience[7,8], the interview process for academic positions can be problematic. Even in a good market, landing interviews can be difficult at best, and answering questions can prove difficult.

In the interview cycle, great emphasis is placed upon engineering sciences as opposed to engineering design. As has been stated by Griffin, this leaves even the most widely recognized industrial engineers unemployable within academia[9]. This leads to the problem of an effective demotion. In an industrial setting, an engineer with 5 or more years of experience is often poised for or has recently received a significant promotion. Starting over in academics, however, this experience is rarely considered. Job postings for faculty often designate that those with industrial experience will be placed on a non-tenure track appointment as a full time instructor or lecturer.

Practicing engineers also face the problem of specialization. As a practicing engineer, one gains prominence by having a broad expanse of interdisciplinary knowledge. This often contrasts starkly with academic positions which request a very narrow and sharp focus, and discourage breadth.

One of the hallmarks of industrial practice is the importance placed upon Intellectual Property and Non-Disclosure Agreements. In the interview process, even for industrial positions, it is not uncommon for an engineer to be unable to answer a question due to their NDA. However, whereas this is viewed as a normal part of interviewing for industrial positions, the inability to answer a question due to an NDA often reflects unfavorably upon a candidate for an academic position.

Working in industry, it is also extremely rare for an engineer to publish. Corporations have a vested interest in their intellectual property. Because of this, it is very rare for an employee to be able to publish outside of internal, confidential publications. This puts an engineer with industrial experience at a distinct disadvantage, for the measures of achievement in academic circles are based almost solely on a publication record and a grant writing record[10,11].

The one exception to publications which corporations routinely grant is patent applications. Corporations are able to license patents to other companies and stand the chance of profiting from patents, and thus, practicing engineers are encouraged to patent when they can. But, in the academic realm, patents are viewed with significantly less emphasis than journal publications. This difference in focus can make it nearly impossible for an engineer with experience to compete in the interview cycle against a Ph.D. student who has published extensively in the academic arena yet has not actively worked in engineering.

But another problem exists. If a practicing engineer is unsuccessful at obtaining academic job placement, the opportunities in industry are limited as well. Because the

engineer has been in academics for 4 to 5 years, technology has changed. Returning even to the same caliber position that an engineer left may be impossible, for few companies are likely to hire an engineer with a Ph.D. for non-research or supervisory positions. When corporations face rough times, the advanced research organizations which employ PhDs are often the first areas to be cut, resulting in unemployment. Thus, many graduating Ph.D.s face the prospect of underemployment[12].

8. Conclusions

The issues effecting professionals returning to graduate school are numerous and complex, and in many cases, unique to each person's situation. However, while the complexities of graduate school can be difficult for a traditional graduate student, the increased age of returning students with industrial experience compounds these difficulties.

The admissions process represents one area in which the policies created by graduate schools directly affect the ability of non-traditional students to succeed. If one is unable to obtain admissions to a graduate program due to artificial barriers, then it is impossible for one to complete a degree.

All students experience financial issues in graduate school. The very nature of funding and the ever growing expense of graduate school makes this unavoidable. But, for a non-traditional student, these funding issues impact them in different manners than a traditional student. Most students in the engineering field rely on financial support to justify the completion of their degree. Yet, by their very nature, many of these opportunities exclude non-traditional students.

Again, while timing and organizational issues affect traditional graduate students, the greater age and maturity of a non-traditional student causes these issues to impact a non-traditional student in a greater fashion.

And finally, there is the job placement issues. By returning to graduate school, a practicing engineer gives up the ability to continue along their existing career path, however stable or unstable it may be, to enter into a career path in which they are distinctly disadvantaged versus more traditional students.

Resolving these issues in the present academic environment cannot be expected to occur instantaneously, and there is not necessarily a "silver bullet" which will resolve these issues easily. Admissions policies, which are directly under the control of individual programs, can be adjusted in a manner that is more conducive to non-traditional students, or it may be possible to create special programs targeting these students. Funding, a problem for all graduate students, can be improved for non-traditional graduate students by removing restrictions on existing programs which prevent non-traditional graduate students from applying. Parallel programs can also be created which specifically target these students. Resolving the job placement issue is a more significant problem, for it

involves focusing on the skill sets desired in new faculty members as well creating a market for these engineers.

By understanding the issues and considering them when revamping policies and procedures, it may be possible to mitigate these problems for non-traditional students, and improve the experience for those few non-traditional doctoral students.

Bibliography

1. D. Comer. "Notes On The PhD Degree", Purdue University. http://www.cs.purdue.edu/homes/dec/essay.Ph.D.html.
2. R. Wilson. "For Love, Not Money". The Chronicle of Higher Education. September 14, 2007.
3. R. Freeman. "Does Globalization of the Scientific/Engineering Workforce Threaten US Economic Leadership?" NBER Innovation Policy and the Economy. 2005.
4. Program Solicitation NSF 07-576, Graduate Research Fellowship Program (GRFP). National Science Foundation Directorate for Education & Human Resources Division of Graduate Education. November, 2006.
5. R. Monastersky "The Real Science Crisis: Bleak Prospects for Young Researchers". The Chronicle of Higher Education. September 21, 2007.
6. 2005 – 2006 Tuition and Fees at Virginia's State-Supported Colleges & Universities. State Council of Higher Education for Virginia, July, 2005.
7. A. Rugarcia, R. Felder, D. Woods, and J. Stice, "The Future of Engineering Education: A Vision for a New Century". Chemical Engineering Education 34(1), 2000.
8. I. Harrison. Strategy: Pursuing Large Scale Proposals. A Case Study from the University of Virginia. October, 1999.
9. M. Griffin System Engineering and the "Two Cultures" of Engineering. Boeing Lecture, Purdue University. March 28,, 2007.
10. T. Allen "Universities encourage industrialists to come back to their roots" Nature **404**, 793-794 (13 April 2000).
11. C. Baile. "A Program for Georgia's Universities That Means Business" University of Georgia Research Magazine. Spring, 2007.
12. PhD Career Paths, University of Washington, Graduate School, May 1998. http://www.grad.washington.edu/stats/phd_survey/1996/index.htm