A Model for Successful Engineering Internship: Growing Our Own Future Engineers

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Abstract. UCLA's *Higher Education Research Institute* reported there has been a 60% drop in science and engineering majors among incoming college freshmen since the year 2000. Competition for the dwindling number of graduating entry-level engineers is fierce. At the same time, the academic experience of engineering rarely emulates what students can expect in the real world. Students need relevant work opportunities to validate their career plans while keeping them engaged in their engineering degree programs. Two years ago, we established an Internship Program to respond to both sides of this challenge. Internship expands the concept of training beyond enhancing the skills of existing staff, to include a company making a training investment in student engineers they might like to hire full-time someday. In this paper, we provide a template for our successful Internship Program as a model for other employers who would like to "grow their own" entry-level engineers.

Introduction

The "scholarly world" cannot always provide students with experiences that approximate the "real world." Consequently, recent college graduates seeking their first post-graduate professional position may lack realistic expectations and experiences relevant to the kinds of challenges and responsibilities they will encounter on the job. Particularly relevant to us in the information technology (IT) professions, the number of qualified *engineering* graduates is shrinking. UCLA's *Higher Education Research Institute* reported there has been a **60% drop** in the popularity of science and engineering majors among incoming college freshmen since the year 2000. Companies like Microsoft lament "…while [they] find many suitable engineering candidates for employment in India and China, [they] have a harder time recruiting qualified individuals in the U.S." (Montalbano 2005) With fewer graduates, the competition for entry-level engineers is fierce.

We first became aware of the extent of this problem while engaged in an Industry Outreach initiative for forging research relationships with local universities. Our university partners opened our eyes to the problems they face in the classroom. University engineering programs are under pressure to fulfill chartering and funding requirements, many tied to enrollment, retention and graduation metrics. They very much want to provide students real-world insights in the classroom and to graduate employable entry-level engineers, but they have a difficult time getting the students to stick-it-out past the first two years of the curriculum.

For their part, engineering students sometimes fail to appreciate the value of [what seems to them] irrelevant courses in English composition, mathematics and other cross-discipline studies. They don't seem to understand the need to have some theoretical foundations before interesting

application-oriented projects will be possible, and quite simply lose interest in becoming engineers. We also informally attribute declining enrollment in engineering majors to what we refer to as the "LA Law effect." The hypothesis is that many students may not be pursuing engineering because they don't view it as exciting a career as law or medicine or other jobs that are glamorized in the movies and on television!

Our university partners were eager to have industry involvement with their institutions, particularly to provide credible, realistic engineering role models to the students. They were especially seeking ways to help engineering students understand the levels of communications skills, performance and self-management that will be expected of them in the "real world." Because The MITRE Corporation has a strong public interest mission, we were able to garner management support to stand up an array of University Outreach initiatives to help our academic colleagues. One of these initiatives is an engineering Internship Program. In this paper we describe what we have found to be key elements of a successful Internship Program as a model for other employers who might try, like us, to provide meaningful work experiences to engineering students and to "grow their own" entry-level engineers.

The Internship Approach

Internship Meets Needs. Dwindling retention in the science and engineering curricula is having impacts in the IT workplace. Senior engineers are nearing retirement age, or mid-career engineers may be transitioning to management roles to leverage their years of hands-on experience. Entry-level engineers are needed to backfill the labor and talent pool. Another concern is companies wishing to refresh their technology resource pool with younger talent who have grown up in the internet age and hopefully come readily equipped with cutting-edge web-oriented skills.

As we ourselves have screened resumes and interviewed entry-level candidates with some of these thoughts in mind, we have encountered a number of shortfalls that validated our academic partners' concerns. Often the academic preparation of the candidates we saw reflected dated programming language courses and lacked balance between theory and practice. Their writing and speaking skills are sometimes lacking, as evidenced in haphazardly assembled resumes and lackluster face-to-face interviews. Even fewer candidates had relevant [summer] job experiences. Perhaps owing to the fact our offices are located near a resort area, many of the students' previous work histories were limited to non-technical pursuits such as life guarding and service industry jobs.

Rather than sit back and complain that the potential labor pool could not meet our needs, we decided to proactively take the bull by the horns. For students and recent graduates to have meaningful work experiences to list on resumes, at a minimum we as a company must be willing to provide them these opportunities. We designed our Internship Program in part to fulfill this purpose. Granted, at our location we could only support one or two interns per year, but we were able to convince our management that this is an investment in our future. By reaching out to our academic partners, and providing promising engineering students meaningful work opportunities, we hoped to groom future members of our engineering staff one-by-one.

Internship Principles. We started by defining "internship" as a special working relationship whereby a student from a local college or university who has completed at least two years of an appropriate technical degree works for us part-time, ideally for a period of at least one fiscal year, while still attending school. We had in mind that through strategically selected activities

integrated with meaningful tasking – whose successful completion advances the projects to which they are assigned – interns could be exposed to the breadth of engineering work supported by our company. We believed this would help keep them engaged in their studies and clarify their future career goals in conjunction with their academic program choices.

We realized that internship could provide an "extended job interview" to observe a student's skills and performance at low-risk and low-cost to us, and to determine how they might fit into our work culture in the future. But, it is important to note – given the above definition of internship – we made a conscious decision that internship should be more than just a part-time work arrangement for the student and "cheap labor" for us as the employer. But rather, the Internship Program should mutually benefit both the employer and the interns.

This notion of "mutually beneficial" is a guiding principle for our Internship Program. We spoke to several students and even some colleagues who had worked in unsatisfactory "internship programs" in the recent past. While during the interview process they were promised an opportunity for growth and "real engineering" work, too frequently quite the opposite came to pass. The students received all the worst non-technical tasks, or were left to languish with no explicit objectives to fulfill during their tenure. We wanted to make sure we avoided these pitfalls in our program.

In addition, we recognized that, to be successful, internship must be viewed as a living process. While structure is needed, the internship yet must remain open to tailoring, both to leverage the strengths and to shore up the weaknesses of individual participants. The program and those who implement it must also be adaptable to evolutionary changes that will grow and improve the program during its successive executions.

We designed our Internship Program as a flexible framework within which talent, innovation and growth would be nurtured rather than constrained by a rigid one-size-fits-all solution. We imagined there would be opportunities to keep promising engineering interns on track academically, such as "curriculum adjustment" to increase their general employability upon graduation. We included elements in our plan to increase the likelihood of a good match to our full-time technical staff once the intern graduates. We were also humble enough to realize we probably wouldn't "get everything right" on the first iteration, so we needed to be prepared to eliminate aspects of the internship framework that didn't work well and to proactively respond to unanticipated wrinkles in the program.

Internship Team. To ensure a successful internship experience, we believe it is necessary to involve a small team to support its multiple aspects. This provides checks, balances, and a rich complex of relevant experiences to benefit the intern. A team approach also distributes responsibility for the "care-and-feeding" of the intern across multiple staff, minimizing the impact of sustaining the program on any single individual.

Our internship teams consist of the following seven players. We briefly describe each role.

- **Resource Manager**: Provides funding source and a short, specific work plan to be impacted by the intern's work.
- **Task Leader**: Assigns and oversees successful completion of tasks. Identifies additional resources needed and ensures these needs are met.
- **Engineer Advisor**: Ensures intern's work experience is exposing him/her to the breadth of engineering activities our company supports. This role is often called "Mentor." Evolves the relationship to one in which the intern can independently take the initiative.

- **Faculty Advisor**: Ensures balance is maintained between the intern's academic obligations and workplace responsibilities, with each reinforcing rather than negatively impacting the other.
- **Business Specialist**: Facilitates hiring process. Provides financial and resource guidance to the team.
- **Outreach Specialist**: Engages entire team to ensure the internship mutually benefits the company and the intern. Facilitates a "mini-P&D" (performance review – discussed below), communicates the company's expectations for the internship, and conducts an "exit interview" to collect feedback about the program.
- **Intern**: Communicates his/her expectations for the internship. Performs tasks and related activities to the best of his/her ability

Internship Package. All team members receive a copy of an internship package that is drawn up for the student, which becomes a focal point for documenting the team's activities supporting the intern and the intern's progress. Each team member signs a Participation Agreement to acknowledge they understand their active roles in the success of the internship. We provide an outline for our internship package in Figure 1.

Internship Description
Internship Team Participation Agreement: ***Names and signatures of the team members.***
Resource Manager: ***Role description, funding source, work plan, dated list of any modifications.***
Task Leader: ***Role description, initial tasks, additional tasks, list of resources required and when satisfied.***
Engineer Advisor: ***Role description, strategic event checklist, additional relevant.***
Faculty Advisor: ***Role description, feedback dates and comments***
HR/Business Specialist: ***Role description, dated list of financial, business, hiring, separation support provided.***
Outreach Specialist: ***Role description, dated list of intake, goal-setting and exit, process improvement activities facilitated.***
Intern: ***Role description, expectations, mini P&D schedule.***

Figure 1. The Internship Package Outline.

Finding Suitable Interns

Advertising the Position. Even with the supporting infrastructure in place, a real challenge to implementing a successful internship program is finding suitable student candidates. Maximizing the chance of finding suitable intern candidates can hinge on creating a clear, realistic job description. A job description that specifies the need for doctoral level competence in esoteric topics will not bring in the kinds of students you are seeking for internships. Keep in mind that our internship concept presumes that students are mid-stream in their bachelor's degree programs, so that they are still growing and learning; there we scope tasks and expectations accordingly.

We recommend working with project and resource managers who have funding to identify a few significant, impactful tasks as the basis for internships. Then, develop one or more job descriptions that clearly distinguish between technical skills that are *essential* to accomplishing the work versus skills *highly desirable* in a likely candidate. Be sure to keep that vision separate from the "wish list" of skills and qualities you think would exist in a *perfect* [though probably non-existent] candidate. Figure 2 shows an example internship description we've successfully used in the past.

Once agreed by the funding managers, we post the internship description in our company's job search database, which is publicly accessible to anyone with an internet connection. We also have established working relationships with Career and Counseling Services at several local colleges and universities with strong engineering programs. This is critical for "plugging into" their student placement databases. There we can post our available internship description, as well as receive resumes from students looking for jobs. In addition, we have found it helpful to establish solid working relationships with key faculty in the engineering, mathematics and computer science departments at these same schools. We email them the internship postings directly, encourage them to advertise the postings in appropriate places on campus, and ask them to recommend promising students to pursue an internship with us.

INTERNSHIP OPPORTUNITY

Purpose: Perform engineering support and web services development for the XXX project. This work is being supported through the MITRE Hampton, Virginia office.

Key functions: Support multiple efforts at MITRE that require the creation and maintenance of web services and their related infrastructure. Service development activities include: design, creation, configuration management (CM) of web services of various complexity levels; investigations into existing and emerging standards to determine their relation to the work program; and selection, installation, and management of infrastructure tools and services required to support a service-oriented architecture.

Preferred education/experience: Minimum requirement is completion of one year in Computer Science, Systems Engineering or Computer Engineering.

Desired Skills: XML, SOAP, WSDL, JAVA, Web Service Development

Figure 2. Example Internship Job Description.

The Interview Process. Next, the team should work together to develop a list of questions to ask all the candidates for each internship position available. This ensures that the interviews are comparable and non-discriminatory. If you are lucky enough to have a strong Human Resources (HR) department in your company, they may offer interview training that can benefit members of your team who will be involved in this process; or your corporate policies may require that all interviews be conducted by HR. These are waters your team will need to navigate as part of

standing up your Internship Program.

If you do conduct your own interviews, we've found the following tips to be helpful:

- When setting up interviews, ask candidates to bring along some samples of their work (e.g., code, written projects)
- Be friendly and professional; establish rapport with the student.
- Budget interview time effectively. We normally allow 45 minutes for each interviewer.
- Be sure to reserve some time (5 to 10 minutes) at the end of the interview to answer the candidate's questions about the job, internship and your company. The best potential interns will have questions for you, so be prepared for them.
- Have at least three team members separately interview the candidate; each will bring a unique perspective to the process.
- Ask one legal, non-offensive, job-related question at a time. Use silence effectively and listen carefully. The less talking you do, the more the candidate will talk.
- Look over the candidate's work samples and ask leading questions to ferret out specific examples of qualities such as innate curiosity, self-motivated learning, initiative.
- Take notes of what the candidate actually says.
- Remain neutral and avoid making promises. Explain there are other candidates in the process and a timeline to follow for making a hiring decision.
- Follow-up with a formal interview report if your company requires one. Even if they do not, review and supplement your notes immediately after the interview, especially if you anticipate talking to several candidates. Don't rely on your memory.

Once a successful candidate has been identified, again you will need to follow your company's policy regarding how to make an offer of employment. For example, in our company an HR representative follows through with a standard corporate process to send an offer letter on our behalf.

A Day in the Life of the Intern

Intern's Schedule. Once hired into our program, the intern's schedule is fairly flexible. This is necessary to ensure that schoolwork is not negatively impacted. A notional schedule is negotiated in conjunction with the Task Leader and Faculty Mentor to ensure balance is maintained between school and workplace responsibilities. This will change from semester to semester with the student's course load.

As with full-time members of our technical staff, each intern is provided a laptop equipped for telecommuting so that work from home is possible to the extent practicable given his/her tasking. In this way, the intern is treated as an ethical professional and is expected to meet his/her work commitments without any micro-management. Typically an intern works fewer than 20 hours per week, although during holiday breaks and the summer this may increase up to full-time based on intern availability and funding.

Some companies place an annual cap on the number of hours regular part-time employees such as interns can work. Be sure to clarify this with your HR department and pace the intern's schedule to stay within any such limits.

Strategic Events. As part of the internship, we believe a student should be exposed during their tenure to every aspect of a typical engineer's day. This helps familiarize students with the

breadth of engineering work possible in their future careers. We strategically target specific opportunities for the intern to participate in events that are integrated with the overall tasking, but also complement the lessons of the college classroom with practical work life experiences typical of the professional engineer. Some examples of these "checklist" activities are:

- ☐ Attend Overview / Orientation briefings on the site and its projects.
- ☐ Attend a Technology Symposium.
- ☐ Participate in one or more local training activities (e.g., seminar, tutorial).
- ☐ Prepare / present a substantive technical briefing.
- ☐ Support a University Outreach event (mentoring activity with a partner school).
- ☐ Participate in a working group and/or technical exchange meeting as appropriate to tasking.
- ☐ Give / receive constructive criticism on work products.
- ☐ Write meaningful activity report / bullets.
- ☐ Write a substantive technical note.
- ☐ Observe meeting / briefing at O-6+ level.

The checklist is reviewed by the Engineer Advisor periodically to ensure that the intern is on-track for accomplishing these strategic workplace experiences. Satisfying events are documented in the student's internship plan.

The importance of engaging the intern in interactive situations cannot be over-emphasized. We feel strongly that the intern needs to observe our best technical staff engaged in doing their work so they appreciate how interesting engineering jobs really are. It is equally important to break down the perception that anyone can guarantee a long and enjoyable career by designing solutions or writing code in isolation. Especially on efforts that involve a high component of solitary activity, we move the intern around to observe and support different aspects of projects, particularly interacting with customers, doing briefings, and marketing ideas. This empowers interns with the realization that people management and dynamics under certain circumstances are as important – maybe more important – than certain technical or engineering skills. Such knowledge may benefit them someday down the road if they want to move into engineering management or strike out as independent contractors. Plus, overall, it helps the students become strong team players.

The "Mini-P&D". To help the intern internalize the values and develop the skills for goal-setting and career self-direction, in our Internship Program the Outreach Specialist conducts several performance reviews with the student. This process is referred to as the "P&D" (**P**roject & **D**evelopment] in our company. We refer to the intern's review as a "mini P&D" because, due to the part-time nature of the workload, the number of goals and actions that can realistically be set and met by an intern is on a smaller scale than what we would expect of a full-time employee.

The Outreach Specialist meets with the intern within the first two weeks of his/her tenure and works with the intern to set goals for the internship cycle. The intern learns how to start with high level goals related to their assigned tasks, then to break goals down into specific actions with measurable incremental outcomes and estimated completion dates. The intern also has a chance to articulate his/her goals for the internship and to incorporate those in the internship package. Some of the expectations we've heard include:

- To know what the employer expects of him/her.
- To understand the concepts and goals of the projects he/she supports.
- To be assigned specific, challenging tasks appropriate for his/her part-time work schedule.
- To learn and apply technical skills while successfully completing assigned tasks.
- To experience the activities and responsibilities expected of a professional engineer.
- To learn the social skills of the technical working environment.
- To identify a research project topic that builds on his/her internship experience as needed to satisfy academic requirements.

We make sure the intern includes appropriate academic development goals, such as completing several core courses or a major degree-required project, as part of their P&D proposal. These are given equal emphasis as the specific project-oriented goals that fulfill the general tasks he/she was hired to support for us. The goals and supporting data are logged into the same corporate P&D system that all our other employees use.

A "vector-check" is done at the mid-point of the internship cycle, to ensure goals and expectations are on track. Adjustments are made accordingly – flagging a goal as satisfied, introducing a new goal, modifying those that need redirection – and again logged into the P&D system.

Finally, overall performance is assessed at the end of the internship cycle, and the intern experiences an "end-of-year" review with the Resource or Task Manager he/she primarily supported. The manager emulates the kind of review a full-time member of the technical staff would receive and provides written feedback in the P&D online system. If the internship continues into a second cycle, the entire process is repeated.

The mini-P&D is a unique and valuable aspect to our Internship Program. We believe any successful professional engineer makes setting both project-related and professional development goals an integral part of their work style, whether required by the employer or not. The student intern will be able to apply the goal-setting skills he/she acquires during the internship throughout his/her future career, whether or not working for our company. The process also provides a comparable, quantifiable basis to measure the success of the Internship Program for the managers who support and invest their project resources to finance it.

Internship Length. People often ask us: *How long should an internship last?* Initially, we make a fixed commitment to the intern. For example, the plan may call for a cycle lasting one fiscal year; or if the internship is a mid-fiscal-year event, the first internship cycle may be just 3 to 6 months long. The timeframe should provide sufficient time for the internship goals to be met with minimal failure risk; concurrently, appropriate goals should be set in accordance with the available time frame.

How things proceed after the first internship cycle depends on individual circumstances. We've found that successful interns will begin generating their own work and may continue interning with us until graduation, if mutually agreed and funded. On the other hand, it may be clear by the end of the initial internship cycle that the match is unsuitable. In that case, the intern will gracefully separate from the company at the end of the cycle, yet still take away some valuable, relevant engineering experience.

Additional Internship Concerns

Process Improvement. Intern feedback is collected at the end of each internship cycle. We do this through a brief survey, shown in Figure 3. We use the results of this survey as one source of ideas for enriching and improving our program.

- Did the internship experience fall short of, meet, or exceed your expectations? Explain how.
- Did the internship complement or compete with your classroom experiences and responsibilities? In what ways?
- Was having a mentor useful during your internship? Why or why not?
- What was the best part of your internship?
- What was the worst part of your internship?
- Suggest at least one thing that would have improved your internship.
- List at least one skill you acquired or improved during your internship that you believe will help you in the future.
- Do you feel you now have a better understanding of the work life of a professional engineer?
- Has your internship changed your professional and/or educational goals? If so, explain how.
- Would you recommend a MITRE internship experience to other students? Why or why not?
- Please feel free to provide any other comments or feedback here.

Figure 3. Internship Feedback Survey.

Funding Internship. How to fund an internship will vary with the specifics of individual organizations. In our company, we have been successful in getting buy-in from project and resource managers regarding the mutual benefits of internship, and they have been able to earmark funds out of their annual budgets to support interns. Roughly, in our organization the average student working fewer than 20 hours per week costs a project less than $15K per year.

For us, timing intern hiring efforts to match the budgeting process has been the real challenge. We have two windows of opportunity: the first and third quarters of the fiscal year. At the beginning of the fiscal year, the manager may agree to earmark money to support an intern. However, if the slot is not resourced during the first quarter (i.e., we have not been able to find a suitable student to hire), the funds typically are re-purposed elsewhere and we lose a hiring opportunity. Similarly, around the third quarter of the fiscal year, some projects find they are "under running" their budgets and have money they could commit to an intern. Once again, if we are not able to resource the slot, the funds will be spent elsewhere.

So, the process of identifying suitable intern candidates must be an ongoing one to sustain the program and to take advantage of the budget cycle. Anyone who wishes to stand up an Internship Program must understand enough about the inner financial workings of their organization to strategically finance each internship "in sync" with the programmatic budget ebb and flow. Some companies already have co-op and summer hire programs in place, with their own funding cycles. These work arrangements can be enriched by incorporating components of our internship model.

One additional observation we will reiterate is that – in our experience – a successful intern

will soon begin generating his/her own work. We found that once an intern successfully completes a significant task, it is key to provide the student the opportunity to brief the work to others in the company. In this way, more often than not, the intern is soon contacted by other projects with requests for funded support. This affords the additional opportunity for the intern to learn – with some mentoring at first – how to define tasks, estimate level of effort, budget time, etc. The highly desirable side-effect is this makes the internship position easier to fund by sharing the financial commitment across multiple contributing projects.

Internship Program Lessons-Learned

Internships help fill a gap that exists between engineering in the classroom and engineering in the real world. As one of our interns said so pointedly:

> "They don't teach you the important corporate stuff in school such as staffing your hours for work and developing goals, and you have helped me through these details."

In the future, we would like to more proactively engage with the leadership of local colleges and universities to help evolve their engineering curricula so that graduates better meet 21st century employer expectations. Our commitment to internship lends credibility to our inputs in these matters.

Our biggest challenge, surprisingly enough, has NOT been getting management support and offers of funded internship slots. But rather, it continues to be finding qualified student interns who stand a good chance of thriving in our work environment. We need to do a better job of leveraging university partnerships to get our academic colleagues to "funnel" the strongest student candidates our way.

From a corporate perspective, the growth and promulgation of the Internship Program beyond our site is impeded by the resource commitment: not the money resource, mind you, but rather the time commitment involved on the part of internship team members. All their "care-and-feeding" activities for the intern are what we call "hide" work (in other words, done in their "spare time"). For day-to-day tasking, this is not too great a burden. But the interview process is time-consuming, and to really sustain internship it must proceed throughout the entire year. We highly recommend leveraging whatever HR assets might be available in your company to off-load the first stages of resume inspection and phone screening to limit the number of internship candidates who progress to face-to-face interviews with the team.

Conclusions

We hope that, by providing the outline, details and practical experience insights of our successful Internship Program, other companies will be encouraged to join us in providing meaningful work experiences to engineering students. Our staff sincerely enjoy working with college students and contributing meaningfully to their growth as young engineers. The students' enthusiasm energizes us, and we have observed many occasions where our co-workers spontaneously develop informal mentoring relationships with interns outside the formal team structure we have provided in our program.

Internship expands the concept of training beyond simply educating the staff we already have on board, to include reaching out to train student candidates we'd like to have on board full-time someday. Given the competition for an ever-dwindling number of qualified entry-level

engineers, it's an innovative investment worth considering. We also are happy to report that we are finding the "grow our own" approach successful. We just hired our first intern, who has now graduated, as a full-time member of our engineering staff.

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BIOGRAPHY

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