On the Development of a Student Integrated Intern Research Experience as a Pathway to Graduate Studies

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Abstract

A national need exists for increasing the number of United States citizens who complete engineering degrees. The Student Integrated Intern Research Experience (SIIRE) program at the University of Arkansas provides financial support to students from all engineering departments within the College of Engineering. Through scholarships and integrated industry supported work experiences with on-campus research activities, SIIRE provides a pathway to a graduate engineering degree. This paper describes this innovative approach using company sponsored work experiences that aims to improve the way that students and faculty interact with industry. The experiences also intend to increase the likelihood that industry will better value engineers with M.S. degrees. The SIIRE program advances the knowledge of how to integrate co-operative education with graduate research via the following elements: leveraged scholarship support, a student cohort focused on engineering research initiatives, integrated one-on-one faculty and industry joint mentoring, industry driven research topics, and course work options enabling completion of B.S. and M.S. degrees in 5.5 total years. This program advances the discovery and dissemination of research that bridges undergraduate experiences with the attainment of graduate engineering degrees. Furthermore, it strengthens industry partnerships and develops highly trained workforces, by systematically creating a pipeline of diverse engineering professionals. This program developed can be readily adapted and implemented at other programs across the nation.

Introduction

The Student Integrated Intern Research Experience (SIIRE) program at the University of Arkansas is funded via the NSF S-STEM program. The NSF S-STEM program provides student scholarship funds to encourage and enable academically talented but financially needy students to complete STEM degrees and enter the workforce. The SIIRE project addresses NSF's programmatic goal by integrating external (industry supported) intern or co-op experiences of students with ongoing on-campus engineering research activities to provide a guided pathway to a graduate engineering degree. The requested scholarship funds defray student educational costs during their sophomore, junior, and senior years of undergraduate study and during 1.5 years of their graduate studies.

We first describe the background and motivation for the need for programs to increase the number of students who complete B.S. and M.S. degrees in engineering. Then, we describe the structure of the SIIRE program and how it operates. Finally, we will conclude with some thoughts for future efforts within the program.

Background and Motivation

According to the report on the Economic Impact of the University of Arkansas [1], workers within the state with a bachelor's degree can expect to earn $25,430 more annually over those with a high school diploma, with a graduate degree increasing that amount by $13,036. The report noted that in areas where more workers have obtained higher education levels, there is a

spill over effect, which improves the salaries of workers with lower education levels[1]. The report also indicated that the dynamic rate of return for higher educational attainment is between 11 and 12%. The societal benefits of higher learning have been well established[2-6]. Engineering education improves significantly on this benefit. The economic value of an engineering degree is ranked highest in Georgetown University's Center on Education and the Workforce recent publication[7], "What's it worth? The Economic Value of College Majors". In addition, the value of a graduate engineering degree is 32% more than the undergraduate degree.

According to the US Census Bureau's 2005-2009 American Community Survey (ACS) 5-Year estimates, the national mean percentage of full-time employed workers (age > 16) working within the Architecture and Engineering (A&E) sector is 2.37%. For this same statistic, Arkansas is last in the nation (52nd, including D.C. and Puerto Rico), with an estimate of 1.44%! The next closest state is South Dakota at 1.51%. Other states rank as follows: Mississippi (1.65%, 49th), Missouri (1.88%, 41st), Tennessee (2.01%, 36th), Oklahoma (2.03%, 35th), and Texas (2.6%, 19th). The ACS indicates that an A&E degree holder in Arkansas has a median salary $53,432, which happens to be the highest median salary category in the state. Arkansas has less highly educated people overall and even less in A&E. According to the US Census Bureau, the percentage of Arkansas 25 and older that hold a bachelors degree is only 18%, with the US average being 27.5%. The University of Arkansas, and specifically the College of Engineering (COE), has averaged 84.7 engineering master degrees awarded per year during the last 10 years (2002-11). Of this amount, only 35.7% went to Arkansans. The remaining degrees were to citizens of other states and foreign nationals. These rates are not uncommon[8]; however, because of immigration and hiring policies foreign students in engineering are unable to make a significant impact within the state. The College of Engineering's contribution to engineering based Master degrees within our state represents approximately 1.1% of the awarded degrees, of which only 35.7% went to citizens of our state. These facts indicate that there is a critical need to increase the number of graduating engineers within the State of Arkansas in order for the state to gain the benefits associated with a highly educated workforce. Increasing this number can have a significant multiplier effect within the state, since people born and educated in the state tend to stay within the state.

The lack of US citizens graduating with M.S. degrees is not just a problem within the State of Arkansas. The National Academy of Engineering's *Educating the Engineer of 2020*[9] recommends that "U.S. engineering schools must develop programs to encourage/reward domestic engineering students to aspire to the M.S. and/or Ph.D. degree"[9]. SIIRE addresses this recommendation by providing scholarship support and professional development activities that will increase the number of engineering degrees (undergraduate and graduate) completed and increase the likelihood that the students will stay within the state as practicing engineers. The SIIRE program enhances the available financial aide. Alon[10] found that the funds most likely to affect the graduation rate of underrepresented students was scholarship funds and that for every additional $1,000 awarded increased the likelihood of minority student graduation by 0.02.

SIIRE is based on leading talented students to the realization that graduate education is within their reach. Not only will it mitigate financial barriers to obtaining a graduate degree but also emphasizes that engineering research is predicated on problems faced by industry through

integrated work experiences. In the following section, we discuss how the SIIRE program is structured and how it operates.

Structure of the SIIRE Program

The SIIRE program address the following objectives:

1. To provide underrepresented and financially needy undergraduate students with information on the benefits and opportunities associated with graduate education,
2. To provide underrepresented and financially needy undergraduate students with enhanced financial support and career experiences to improve the likelihood of completing both a BS and a MS in engineering,
3. To provide personalized integrated industry and academic mentoring and professional development that results in increased enrollment and completion of graduate engineering degrees involving industry beneficial research,
4. To increase the number of highly skilled employees in engineering fields ready to directly apply engineering research,
5. To develop an innovative program that integrates industry based student experiences with on campus research experiences that result in benefits to industry, faculty, and students.

These objectives are achieved via the following features 1) leveraged scholarship support for a cohort of students with financial need, 2) a cohort of students focused upon engineering strategic research initiatives, 3) integrated one-on-one faculty and industry joint mentoring, 4) industry motivated graduate research topics, 5) course work options enabling completion of B.S. and M.S. degrees in 5.5 total years, and 6) the seeding of highly trained practicing engineers within the workforce.

How the SIIRE Program Works

The SIIRE program begins by recruiting on-campus freshman engineering students from within the College of Engineering's Freshman Engineering Program (FEP). The FEP is designed to establish the foundation for academic and professional success of freshman entering the COE. In this program, all students take a common set of courses for one year and then choose a discipline-specific undergraduate program. The FEP also includes a student services program that provides orientation, peer mentoring, tutoring, academic and career advising, academic success and diversity training, and personal counseling. During the second semester of the freshman year FEP students are recruited to apply for a SIIRE scholarship. This and subsequent key milestones for the SIIRE program are illustrated in Figure 1.

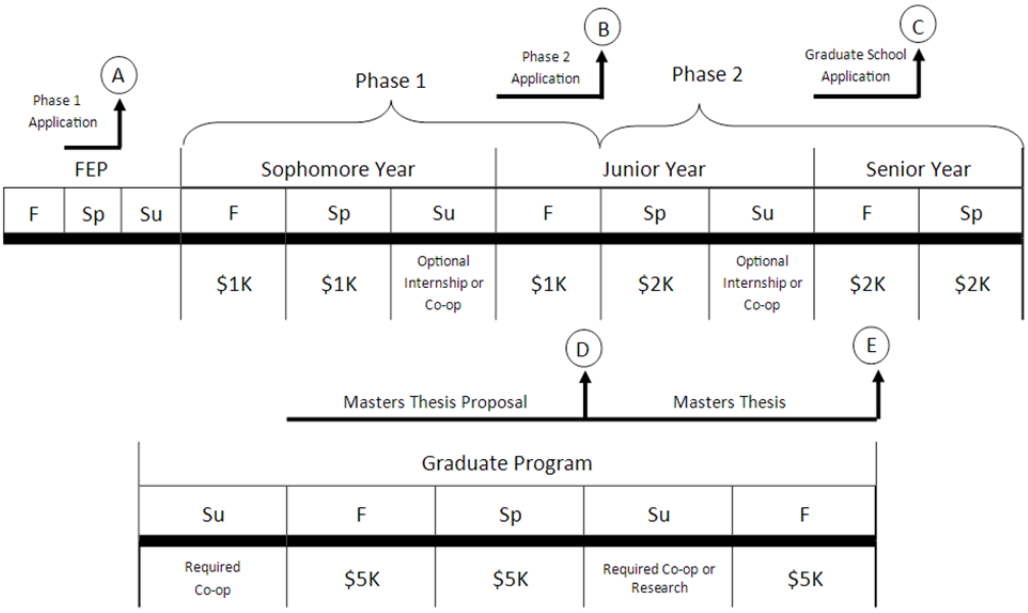

Figure 1 SIIRE Program

1) ***Freshman Year:*** Starting in their freshman year, eligible students are identified and informed of the scholarship opportunity within the Freshman Engineering Program (FEP). Candidates will be assisted in applying for a phase 1 scholarship as part of FEP student services. This is illustrated as Milestone A in Figure 1. Students receive an initial scholarship based on academic performance, economic need, and diversity criteria by a SIIRE review committee. The review process involves an interview with the student to understand how prepared and committed the student is to SIIRE goals. The student will use the phase 1 scholarship during their sophomore year and the fall of the junior year. This will be a $1K per semester scholarship starting their sophomore year, as illustrated in Figure 1. They will then develop a phase 2 SIIRE Scholarship Application.

2) ***Sophomore Year:*** Phase 1 scholarship recipients are matched up with participating faculty within the College of Engineering (COE). Initial scholarship recipients are expected to work with their COE Faculty Mentor to identify areas of interest and company internship or co-op opportunities. Peppas[12] found that undergraduate students who participated in research experiences working directly with a faculty mentor were more likely to choose graduate school when compared with other students. The students also participate in professional development enrichment activities and are assisted in finding an optional co-op or internship for the summer between their sophomore and junior years. If the student participates in a co-op or internship during the summer, the student's faculty mentor is involved with reviewing the work experience, visiting the student "on the job", developing a relationship with the company, and assessing the potential for the student to develop research based on experience with the company.

3) ***Junior Year:*** During the student's junior year, the student receives the scholarship and participates in professional development and enrichment programs. The faculty mentors assist the students in preparing for the phase 2 SIIRE Scholarship Application. This is illustrated as Milestone B in Figure 1. The focus of the full application is on ensuring that

the student is a candidate for graduate studies. The scholarship application includes reflective statements from the students based on their experiences in the enrichment activities and previous summer co-op experience. This reflective statement is a key component in assessing the student's eligibility for continued support through graduate studies. The SIIRE application acts as a "draft" graduate school application, which is finalized during the fall of the senior year. Students are accepted based on academic performance, economic need, and diversity criteria based on input from faculty mentors, a SIIRE review committee, and an industry liaison committee. During the summer before their senior year, students are encouraged to participate in an optional paid internship or co-op with a company sponsor. The company sponsor funds the internship. The primary purpose of this work experience is to provide the student with industrial experience within an engineering setting and to identify topics that can serve as potential graduate thesis research areas. Alternatively, the student may perform a research experience for undergraduates.

4) ***Senior Year:*** During the student's senior year, the student is funded by up to $4K of scholarship funds as illustrated in Figure 1. Their COE faculty mentor guides them as they develop a research topic that may build on work related to their industry-based experience. They also work with their mentor to apply for and be accepted for graduate studies during the fall of their senior year. This is denoted Milestone C in Figure 1. If they are accepted into the graduate school (based on each COE department's existing graduate admissions criteria), they continue with the SIIRE program. Students who opt to attend another university for graduate studies or decide to directly apply for a PhD program are also tracked as program successes, but will not receive SIIRE funding.

5) ***Year 1 Graduate Studies:*** After their senior year, the student performs a required internship or co-op with a company sponsor. The student works collaboratively with the company and with their COE faculty mentor on their graduate thesis research topic, *in situ*. The COE mentor is involved in guiding the work effort, collaboratively with the company. During the student's first year in graduate studies, the student's graduate tuition and stipend is funded through their SIIRE Scholarship, supplemental departmental support, and a graduate tuition waiver from the graduate school. Besides taking graduate courses, the student is expected to finalize and present their MS thesis proposal. This is denoted Milestone D in Figure 1.

6) ***Year 2 Graduate Studies:*** After successfully completing their 1st year of graduate studies, the student completes their final required intern/co-op experience during the summer with their company sponsor. The primary purpose of this intern experience is for the student to work on their MS thesis within an industrial setting with access to the data and expertise of their company sponsor. The company sponsor funds the internship. The student then returns for their final semester of graduate studies where they complete and defend their research thesis work as well as any courses necessary to complete their degree requirements. This is denoted Milestone E in Figure 1. The student's graduate tuition and stipend is funded through their SIIRE Scholarship, supplemental department support, and a graduate tuition waiver.

An important aspect of the SIIRE program is the integrated nature of the co-op and graduate research experiences. This relationship is predicated on a mentoring team from both industry

and academia. A faculty mentor will work with students to develop their research interests, guide their academic progress, and assist with forming relationships outside the university. The industry mentor will assist in guiding the student during co-op experiences and in formulating an engineering career path. Both mentors will work together with the student. In addition, the research that the student will propose during graduate studies is to be derived from their work-experience. This will force faculty and students to interact with industry to develop meaningful research and illustrate to industry the value of graduate degrees in engineering.

An important challenge facing this program is the fact that the NSF S-STEM program policies forbid projects to require work (e.g. co-op) for receiving scholarships when a student is an undergraduate. For graduate students, the scholarship can form the basis of their graduate stipend. Thus, we are working on methods to recruit highly motivated students and to counsel them on the value of co-op/intern experiences during their undergraduate studies. In addition, because the program has two phases, complete with a second application process, the selection committee will choose students who show promise for graduate studies and who are successfully showing involvement in career development activities (as well as work experiences).

Potential Students Impacted by SIIRE Program

SIIRE undergraduate students must meet the following criteria: 1) must be a US citizen, permanent resident, national or refugee eligible to receive NSF funds; 2) must receive a University of Arkansas renewable scholarship (minimum criteria 24+ ACT and 3.5+ HSGPA); 3) must have financial need and receive grants, as determined by the federal government through Free Application for Federal Student Aid FAFSA submission; 3) must pursue a bachelor of science degree in engineering and be a full-time engineering student; 5) must demonstrate a work ethic, time management skills, communication skills and professionalism; and 6) must agree to participate in all parts of the program.

SIIRE graduate students must meet the following criteria: 1) must be a US citizen, permanent resident, national or refugee eligible to receive NSF funds; and 2) must apply for and be admitted into a COE department's MS program of study as a full-time graduate student. The participating engineering department must then recommend the student for a SIIRE Scholarship. Applicants are evaluated based on their graduate studies application materials, which should include a statement of interest, discussion of previous research and work experience, three letters of recommendation, GRE scores, and a letter of recommendation from the Department Head of the involved engineering department. The Department Head's letter must address why a SIIRE scholarship is applicable to the student and, if applicable, how the department will supplement the SIIRE scholarship through other sources of graduate funding, if necessary. Students who meet the above criteria and who have not been undergraduates within the SIIRE program are still eligible to apply for graduate funding. Students who have been SIIRE undergraduate students and/or developed relationships with industry and faculty mentors are given priority during the review process. Applicants must also 1) demonstrate a work ethic, time management skills, communication skills and professionalism; and 2) agree to participate in all parts of the program.

To better understand the number of students that can be affected by SIIRE, we analyzed engineering enrollments and financial aide eligibility. Table 1 reports first-time freshmen

enrollment figures for 2006-2011 and retention figures (after freshmen year) for all but 2011. The data from Table 1 indicates significant enrollment growth since 2006.

Table 1 - Undergraduate Engineering Students

	2006	2007	2008	2009	2010
# first-time freshmen	396	376	441	404	532
% retained after year 1	59.8%	62.5%	68.1%	69.6%	75.0%
% completing FAFSA	58.3%	62.8%	66.4%	66.1%	85.3%
% with EFC < COA	71.9%	70.3%	70.6%	68.5%	63.4%

According to our financial aide office, the cost of attendance (COA) for 2011-2012 is approximately $20,337 (includes tuition, fees, room/board, books/supplies, and typical personal expenses). Using data on expected family contribution (EFC), the average funding amount for which engineering students are eligible (i.e., COA-EFC) can be computed as well as the percentage of engineering students with EFC < COA. Based on 2010 enrollment and given the % of students returning as sophomores, % completing the FAFSA, and the % with EFC< COA, over 200 students should be eligible for the program, based on financial need. The historic percentage of freshman engineering students that achieve a 3.0 or higher GPA is approximately 14%. Thus, assuming that the financial need and academic characteristics for future classes will be similar to the current classes then approximately 28 students should be eligible each year for funding through the SIIRE program.

How the Scholarships Work in SIIRE

A key concept used in SIIRE is to stack scholarships to attempt to cover the cost of attendance for merit and economically needy students. This attempts to mitigate cost as a barrier to obtaining an engineering degree. As indicated in Figure 1, undergraduate students either receive a scholarship of $2K per year or $4K per year. The set of students targeted includes those students who have received merit scholarship. Our university has many renewable scholarships for students that typically range from $4,000/year to $17,500/year. SIIRE maintains the number of students low enough to keep the scholarship amount significant enough to mitigate financial barriers and make a maximal impact for eligible students.

Graduate students receive the full $10K per student per year permitted by the NSF STEM program. The cost of graduate education is higher and student financial aid eligibility is based on the student's ability to pay (not based on their parents). The full $10K per year will be used as a graduate stipend as part of their graduate degree program. Typical COE MS student stipends vary by department from $1000-1200 per month. Participating COE departments make up any differential and the Graduate School is providing 7 graduate tuition waivers per semester for both fall and spring. In addition, the students can earn funds through the integrated work experience. Thus, the cost of attendance for graduate studies should be almost completely mitigated. The attainment of graduate degrees should raise the expectations of future generations, since parents educational level is an important predictor of educational and occupational success[11].

A total of $520K is allocated to scholarships over the 5-year program, yielding on average $104K per year. Based on the amount of funds available and student costs, we expect that on

average 15 students (8 undergraduates, 7 graduate students) per year can be covered by program. However, we expect these numbers to vary over time as students matriculate through the program. As an example, in year 1, we anticipate awarding 16 $2K scholarships, 8 $4K scholarships, and 4 $10K scholarships. This totals to $104K. The number of $2K scholarships will be reduced each year as the number of $4K and $10K scholarships increase. Thus, students may enter the program at milestones A, B, or C as depicted in Figure 1.

SIIRE undergraduate students can apply for phase 1 funding at the end of their freshman year. Given the applications and once the eligibility of the students is determined, scholarship offers are made. Funding within the student's sophomore year is limited to $2K per year. After the fall of the junior year students are evaluated for scholarship renewals. The funding for the junior year is limited to $4K. To receive continued funding for the senior year, the student must be eligible for renewal and submit a statement of interest, discussion of previous research or work experience and one letter of recommendation from their faculty mentor or industry mentor. The funding for the senior year is limited to $4K.

For a student to qualify for scholarship renewal, he/she must: 1) successfully complete the required number of credit hours during the year; 2) meet the GPA requirements for renewal; 3) apply for all scholarships and aid available to them; and 4) submit the FAFSA form yearly. University of Arkansas scholarships require students to complete 27 to 30 hours in the freshman year and 30 hours each year thereafter to remain eligible for scholarship renewal. Recipients must also have a minimum GPA of 3.0 at the end of each academic year. Students who go on academic probation lose their university scholarship immediately; otherwise the review takes place at the end of the academic year. SIIRE renewable scholarships are intended to supplement university scholarships and grants, therefore the SIIRE renewal criteria is the same as the university scholarship criteria.

If a SIIRE student loses their university scholarship due to the hours or GPA criteria not being met, he/she can apply for a SIIRE probationary scholarship. This scholarship will fill the gap in funding created by the loss of the university scholarship, provided: 1) the student applies for this probationary funding; 2) the student can successfully restore their GPA to the eligibility level within one year; 3) progress is sufficient to stay on track for GPA eligibility restoration. After one semester, probationary scholarship eligibility will be evaluated for a second semester, if required. If a student is unable to increase their GPA to the required level within the probationary position, he/she will permanently lose their SIIRE funding, and another student will be selected to fill the vacated position. SIIRE scholarships being vacated by students changing majors or losing their SIIRE funding are filled by other qualified students.

Cohort and Experience Building Activities

SIIRE students have a number of specifically designed activities to enhance their professional development as illustrated in Table 2.

Table 2 – Enrichment Activities

	Sophomore	Junior	Senior	MS Year 1	MS Year 2
Work Experience (summer)	Optional Co-Op or Internship	Optional Co-Op or internship	Required Co-Op or internship	Required Co-op/internship on graduate research	
Research Experience	Optional	Optional	Required	Prepare MS thesis proposal	Defend MS thesis
Professional Development Activities	• How to be an effective mentee • Time management • Exploring your options • Resume writing & job search skills	• Effective oral/written communications • Developing research skills • Ethics in research and professionalism	• Applying for graduate schools • 7 Habits of Highly Effective People • Resume writing & job search skills	• Writing and presenting a business case • Presenting and communicating research	• Transition from student to employee
Faculty Mentoring	Monthly meeting	Meeting at least twice a month	Meeting at least twice a month	Meeting at least once per week	Meeting at least once per week
Peer Mentoring	As needed, at least once per semester	As needed, at least once per semester	As needed, at least once per semester	As needed, at least once per semester	As needed, at least once per semester

Students have specific training on time management, resume writing, job searching, and transitioning from student life to employee life. In addition, since graduate research requires strong written and oral communication skills the students have specific skill development workshops/seminars on oral communications, writing, presenting engineering work as a business case, as well as presenting engineering work in scholarly forums.

As students move through the educational process, they interact with many support services and people. It is important that they receive the "continuity of care" that is required. Thus, the SIIRE program takes a team-based approach to monitoring student progress, led by their faculty mentor. Mentors and meaningful engagement with faculty advisors have been shown to be important factors in student retention[13]. The mentoring process will follow the guidelines and procedures described in Brainard et al.[14] A support team monitors each student within the SIIRE program. The team consists of the student's faculty advisor, an industry mentor (when the student participates in industry experiences), and an upper-level student mentor. Each semester the team reviews the student's progress and then the student meets in a one-on-one session with their faculty mentor. After that, the faculty mentors associated with the students meet with the program director and discuss any issues, review the student's progress, and map out any responses. The faculty mentor is critical to this process.

Summary and Future Work

This paper describes the motivation, structure, and activities associated with a new NSF-STEM funded scholarship program called SIIRE. SIIRE addresses the national need for increasing the number of U.S. citizens who complete engineering degrees. SIIRE addresses this need through an innovative use of company sponsored work experiences that may improve the way that students and faculty interact with industry. The experiences may also increase the likelihood that industry will better value engineers with M.S. degrees. The program will advance the knowledge of how to integrate co-operative education with graduate research. The program advances the

discovery and dissemination of research that bridges undergraduate experiences with the attainment of graduate engineering degrees and strengthens industry partnerships for developing highly trained workforces.

The SIIRE program is in its initial phases: recruiting students and developing program activities. Future papers will present results from the program including assessment results involving a mixture of evaluation techniques, using implementation, progress and summative evaluative techniques. The evaluation will consist of both assessment of the various outcomes associated with the program goals as well as an overall evaluation of the students who participate in the program. Evaluation activities will be guided by evaluation questions that encompass the overarching vision of SIIRE, its content goals and objectives. The evaluation will be based on the assumption that the faculty who participate in SIIRE activities are willing to change their practices to achieve the intended vision. Finally, the evaluation will examine whether S-STEM students ultimately affected by the various activities will become more interested in engineering; and be more attuned to engineering research.

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