SURE Program for a Conjunction between Engineering Education and Research

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Abstract

The importance of engineering education and research was often discussed, but the practical transferring from education to research has been seldom performed in engineering education. To make a smooth transition of the engineering education from the classroom to the laboratory or research environment, the Department of Electronic Engineering has developed a 10 weeks research internship program for undergraduates, namely summer undergraduate research experience (SURE). SURE program is intended to provide a conjunction between engineering education and research to junior/senior students who have interest in either a graduate study or career in research field. Each participant is assigned to a research laboratory under the guidance of the professor, and one graduate student plays a mentor-role for the participants. SURE Program is designed to enhance the interaction between the participating undergraduate students, graduate students and professors in the Department of Electronic Engineering by providing one-on-one research guidance to participating undergraduate students. Pairing one or a group of undergraduate students with a graduate student helps to alleviate any discomfort that the students may have as they acclimate themselves to the university research environment. In 2008, we have initiated SURE program with eight undergraduate students (two seniors and six juniors) in four research labs, and two seniors continued their graduate study in 2009 and at least four juniors have determined to do so in 2010. We have convinced that SURE program not only enhanced students' motivation from the classroom to the research environment, but also alleviate concerns of avoiding engineering graduate study in the Department of Electronic Engineering at Myongji University.

Introduction

Recalling three decades back from now, international calling or even domestic long distance calling, nominally DDD in Korea, was just a surprising technology that we utilized in our daily life. Personal computer systems are just anywhere nowadays and even most of first grade students use them for their homework, but they were only for business machine in a specific purpose. People would not imagine having one on their desk as we do now. It was just a non-sense carrying a computer while they are traveling. Just ten years ago, we would not believe someone was calling while he/she was walking along the street. The words, such as on-line, mobile, get-connected, anytime, anywhere, and information, are prevail in our daily life. No information access from the web, no-email, and immobility due to the wiring is simply just another non-sense in our daily life. Technology development during the past three decades changed our life style as well as our way of thinking, and it is no doubt that the development has been securely founded in engineering education. Scientific theory in the classroom was expanded to find a better solution for assisting our convenient life, and industries transformed the immature research outcome derived from the theory to the very useful tools for us. The development of technology based on engineering education for the last 30 years provided countless lists of unimaginable changes around us.

However, looking into any arbitrarily chosen engineering classroom in a university, we often can observe very similar scenes that we might have seen a few decades ago. The professor stands at the front of the classroom copying his/her lecture notes down on the board, and students sit in passive are creating another copy of the lecture notes. Some of them may be reading other books, working on homework for another class, playing with his/her mobile phone or PDA, or even enjoying a daydreaming. To get an attention for the class, professors sometimes asks a simple question to the students, but no one answers the question - just waiting for the answer from the professor. Perhaps, some students in the first few rows who feel compelled to answer tend to answer the questions. As the technology develops,

the professors use presentation slides rather than board-writing, and the students do not even practice the contents in the classroom. At the end of the class, the professor gives students a homework to repeat the formulas what the professor just derived with a simple modification of a couple of variables or constants. This scene may repeats in the classes.

Some engineering professors, however, try to change the classical lecturing with visual aids, such as digital pictures, movie clips, and even personally recorded video interviewing contents with domain experts. Other professors assign lab hours in the lecture hours so that the students can take part in the lab or design topics along the theoretical study. All these efforts are, in some extent, cumbersome to the professors since they have not educated in a similar fashion; it is somewhat true that the professors are educated to become professors, but most of the students in the classroom are not (Feynman, 2000).

Since 1999, the accreditation board for engineering education of Korea (ABEEK) initiated issues on engineering education in Korea, and a good deal of interest on engineering education that suits for its criterion is increased by a number of engineering schools in Korea. ABEEK has indicated a suitable guideline for university engineering programs in order to fostering engineering education and promoting qualified engineers though accreditation and consultation (www.abeek.or.kr).

For electronic engineering program, ABEEK suggests the following criteria to fulfill; the number and responsibility of professors, qualification for professors, and curriculum. The curriculum should provide professional knowledge of engineering and the program graduates should demonstrate the knowledge of basic science and engineering to analyze and design adequate hardware and software for the purpose of the program. It might be not so difficult the curriculum to satisfy required hardware and software skills, but students are not easily exposed to a circumstances that connects classes what they have learn and what they will be learning in the next semester. Students are fairly busy in preparing what outside the academic area requires for their career. In other words, even though they struggle with their major to increase their engineering study during the semesters, they will have to spend their vacation for English study.

Likewise other university students, many senior students of the Department of Electronic Engineering at Myongji University are repeating the very similar sinusoidal (or seasoning) cycle every year. Some students take part in an internship program in industry during their summer vacation, but the position that they are seeking is very limited or their duty is sometimes trivial to attract students' interests. As a matter of fact, many students, in most cases, are not ready for having an internship in industry since they are not qualified for the seeking position yet. The requirement from current IT and Microelectronics engineering industries are becoming diverse and practical.

Recently Microelectronics program in the Department of Electronic Engineering at Myongji University had focused the presented issues along how to demonstrate students' ability to analyze and design adequate hardware and software about the basic science and engineering, and we found an intermediate solution for the issues via connecting engineering education with undergraduate research. While students perform a small research project with graduate student mentor, they experience how to solve practical engineering problem based on what they had learn from the classes. When they encounter a huddle to overcome, they always can ask helps from the mentor group. By transferring engineering education from the classroom to the laboratory, we could achieve smooth transition of knowledge pursuing enthusiasm from the book to hands-on-experience, and this eventually ignited students' self-motivation for extensive learning as well as vision for their higher education. In this paper, we introduce the 10 weeks undergraduate research internship program, namely summer undergraduate research experience (SURE). In the followings, we describe undergraduate research program in the US universities, and summer undergraduate research in Engineering/Science at Georgia Tech is closely benchmarked. The evaluation of the program and students are provided, and finally, forecasting in 2009 will be briefly presented in summary.

Undergraduate research program

Until the institute for gifted students (IGS) at Korea Advanced Institute of Science and Technology (KAIST) officially introduced university research program (URP) in 2008, no significant practice on research program for undergraduate students has been observed in Korea. Through the URP suggested by IGS, undergraduate students may have an opportunity to performing research with professors and/or doctoral researcher, but this opportunity is very limited to the student who has been qualified for a certain level of research capability. The URP aims higher education for the gifted students can expand their domain knowledge and be advanced in their professionalism. Only 15 students were selected in 2008, and it is planned to be expanded in 2009, but the selection process is fairly competitive for those who are not either talented or qualified.

On the other hands, MIT established university research program in 1969, which is named Undergraduate Research Opportunity Program (UROP), founded by Dean Margaret MacVicar and President Paul Gray (http://web.mit.edu/urop/index.html). The participated students became recognized professors at Caltech, and Fred Shair founded Caltech's summer undergraduate research fellowships (SURF) program. In the early '80s, national science foundation (NSF) also created its research experiences for undergraduate (REU) program to provide support for students to participate in research with faculty, and IGS's URP resembles with NSF's REU. REU started to supports participating students (8-10 or more) to work on projects within NSF's area of interest. University originated UROP/SURF and government founded REU were serving as models for undergraduate research program in other US universities through '70s and '80s.

Founded by the top ranked university and supporting by government organization, diverse university research program has been developed in state universities as well as private universities in the US, including Rutgers University, University of Washington, University of Illinois, Emory University, and Georgia Institute of Technology. Table 1 provides university research programs running the corresponding universities.

Table 1 Snapshot of undergraduate research program in the US

University	**Name of Program**	**Motivation**
Rutgers University	RISE (Research in Science and Engineering)	To improve undergraduate education and research opportunities and to promotes a vitality in undergraduate education and undergraduate research (http://rise.rutgers.edu/)
University of Washington	URP (University Research Program)	To support students seeking opportunities to do undergraduate research and to assist faculty wishing to explore ways of including undergraduates in their work (http://www.washington.edu/research/urp/)
University of Illinois (Urbana-Champaign)	SROP (Summer Research Opportunity Program)	To increase minority recruitment for graduate school and improve retention (http://www.grad.illinois.edu/eep/srop/)
Emory University	SURE (Summer Undergraduate Research program in Emory)	To support requirement strained resources in the biology department due to a large grant awarded from Howard Hughes Medical Institute (HHMI), alleviate overworked, understaffed, and overwhelmed department due to the required research, and support student research and internship opportunity (http://www.cse.emory.edu/sciencenet/undergrad/SURE)

Among many undergraduate research programs, our benchmarking was summer undergraduate research in Engineering/Science (SURE) of the school of electrical and computer engineering at Georgia Institute of Technology. Georgia Tech is one of the leading research universities in the US, providing a focused, technologically based education to more than 18,000 undergraduate and graduate students. As a leading technological university, Georgia Tech has more than 100 interdisciplinary research centers that consistently contribute vital research and innovation to government, industry, and business in the US. Although the US universities enjoyed a leadership role in the development of leading edge research and technology, the representation of minorities in engineering and science was not

satisfactory. In 1999, 16% of students who earned B.S. degrees in science and engineering came from underrepresented populations, but the underrepresented minority representation drops significantly for advanced engineering degrees, as only 11.5% of Master's and 8.7% of the Ph.D. degrees awarded in that same year were earned by these students. This has led to a low number of tenure-track minority professors in engineering and science (6.8%) in the US. According to James McCullough, a former Director of Program Evaluation for the National Science Foundation, undergraduate research programs are "highly effective in helping students who are uncertain about going to graduate school to clarify their intent to pursue those goals and in bolstering the certainty of those students who have already decided to pursue those goals."

Gary S. May, Professor and Steve W. Chaddick School Chair, a founder of SURE program, realized that many minority students fit exactly into these categories; although some are not considering a higher education at all, others who are not absolutely certain about the other variables involved in their graduate studies. In addition, the decision of the minority student to attend graduate school is also affected by the amount of faculty involvement in their undergraduate career. Quality interactions with engineering faculty can have a significant impact on a student's decision to pursue graduate education, since such interaction provides the student with effective role models. He also believed that a key factor for motivating students to pursue advanced degrees and research careers in science and engineering is a fruitful research experience as an undergraduate. Such experiences can be highly effective in helping students who exhibit uncertainty or a lack of confidence regarding attending graduate school. The overall goal of Georgia Tech's SURE program is to expose minority students to electrical and computer engineering and electronics packaging research, and as a direct consequence, interest the in opportunities available through graduate study (www.sure.gatech.edu).

Key elements of the program include:

- Ten weeks of meaningful research in engineering (electrical, aerospace, chemical, civil, computer, environmental, industrial, mechanical, or materials), applied science (physics, chemistry, biology, or mathematics), and electronics packaging - Pairing each student with both a faculty advisor and a graduate student mentor
- A weekly seminar on emerging research in engineering/science fields
- A monthly stipend competitive with what the students might receive from a summer internship in industry
- Lodging, meals and a travel allowance for participants
- Opportunities to visit local industrial research sites
- Oral and written research project summaries prepared by the student participants
- Social interaction between the student participants and their graduate mentors
- Program evaluation by the student participants

The SURE program at Myongji University

Definition of the undergraduate research described in this paper should not be misleading by the terminology itself. The term "University research" is used in various meaning, such as faculty directed undergraduate student-assisting research for an ongoing project, students-students collaboration for research-based courses, student collaborations for a class project, a capstone- design by undergraduate students, and etc. The word 'research' is now used so commonly, has been so vulgarized, that any answer must be carefully defined (Rosovsky, 1990). Likewise, "Undergraduate research" described in this paper limits its scope within the scope of "directing by faculty, mentoring by graduate students, and conducting by three or less undergraduate students."

The department of electronic engineering at Myongji University encounters, in some sense, similar situation to the minority ethnic group in the US. The number of graduate students started swung for a few of years and rapidly decreased, and undergraduate junior and senior students were so unsure whether they would continue their graduate

study or getting a job. As a result, in Feb. 2008, the number of incoming students in Master's course dropped to only two, and only 11 graduate students were enrolled in the Master's course. It might be a nation-wide phenomenon in Korean private engineering graduate school, but it was required that a remedy for helping students who were having uncertainly regarding attending graduate school, especially for whom pursuing research position in their job. The remedy for helping students decision for their graduate study as well as education through a small research project, we have launched a research internship program in graduate research laboratory in the department of electronic engineering. This program has been given the acronym SURE *("Summer Undergraduate Research Experience."*

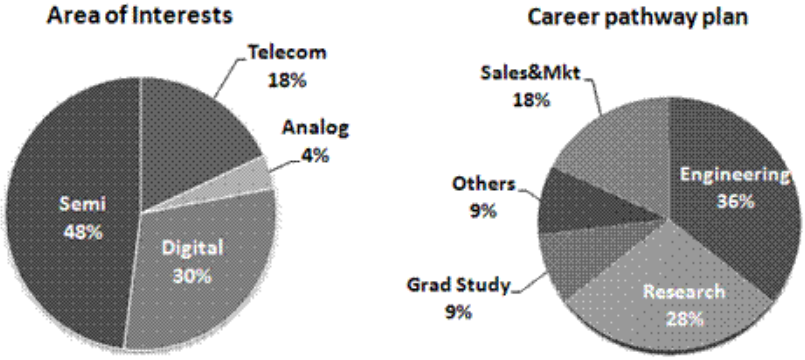

Figure 1 Student survey considered in SURE design (As of Mar. '08)

Learning from similar undergraduate research programs and undergraduate internship programs in the US, the ultimate goal of our SURE program is to conjunct engineering education and research via three methodologies. One is to make sure the decision for their graduate study is valuable by performing an engineering research project in a team of professor-mentor-student, another is helping their decision for their graduate study by assisting an ongoing research project, and the other is providing a research opportunity by having an internship in a graduate laboratory.

While the SURE was prepared for a proposal, we struggled to decide suitable objectives for students in our department. Program design only by department faculty can be a misleading the necessity of students. Even it can be a well organized or prepared bogus program for students without students' participation. To avoid such a misleading, student survey from the juniors and seniors was analyzed. Three groups of questions were: 1) Degree of satisfaction for their education; 2) Desired career pathway either getting a job or continuing study at a higher level; and 3) Area of interests among Telecommunication (Telecom), Analog circuits and systems (Analog), Digital circuits and systems (Digital), and Semiconductor/packaging (Semi). Among the four area of interest that the department offers semiconductor and packaging was about 48%, but less than 10% were planned to enter upon studies.

Survey result on area of interest was not surprising because the department is currently giving more emphasis on the area of microelectronics via Nurturing Excellent Engineers in information Technology (NEXT) funded by Korean Ministry of Knowledge and Economy. However, career pathway plan seemed not quite reasonably answered. Students pursuing R&D career pathway is fairly high, but only 9% of students were answered for graduate study. High in research, but low in graduate study stands for either the students' uncertainty for graduate study or misleading for R&D position. Recently, industry requires higher degree or multi-years experience for R&D position, but students may not realize what the current hiring trends are. To help what students desire in their career pathway, it is beneficial to encourage them pursue a higher degree. However, we prefer to provide research opportunity to student whom are pursuing R&D position rather than directly persuade them. Providing a vision to achieve is important, but the self-motivation for pursuing a higher degree should come first than others to actively achieve their goals.

Provided research opportunity is not only a good starting point to drag them from the textbook, but also a challenge to apply what they have learned from the textbook. No research topic is well documented and kindly explained with examples and exercises. This is a certainly a big challenge for students to gather necessary information to solve the

real problems. For students who decided their graduate study, SURE will be a good opportunity to get trained in advance. Professor suggests a simple research topic with required background information in graduate study, graduate level mentor guides how to utilize background knowledge in research, and the performing student navigates in another way of education. SURE is beneficial for students whose decision is in between. By assisting an ongoing research project as a team member, they will experience how to pick-up necessary information from the textbook or others' work and how to apply for solving research problem. Of course, not much role in a research team may be given to undergraduate students, but it is certainly a good opportunity to learn a responsibility. For students who are participating as an internship in a graduate laboratory, they will learn why they need to pay attention to their classes. Even though student's responsibility in research will be much smaller in other cases mentioned above, they still are able to realize what they have learned from the class is used for practical problem solving or even further development of newer technology.

As the first year of our SURE program in 2008, we rather focused on the second and third suggested purpose than performing meaningful research by students themselves. Five participating professors with five volunteering graduate students steered the program, and each graduate mentors recruited undergraduate students who would like to participate the SURE program. Some topics were given by faculty members, and some topics were brought to student by graduate mentors. In our SURE program, the mentor-student relationship is significantly emphasized in establishing research experience within two months period. The mentor-student relationship process is also acknowledged as an important factor for academic success in higher education (Cusanovich, 1991). Student advising by faculty is desired for a good research outcome, but mentoring by graduate student will provide much closer relationship and understanding student's thinking. Peer mentoring or mentoring is definitely helpful for our students who hesitate to consider their graduate study.

Table 2 Suggested research topic for SURE program

Area of Interest	**Topic**
Microelectronics	Process optimization of SF6/O2 Plasma Etching of BT material
Semiconductor	Semiconductor processing technology and tool training
Microwave Engineering	Design of Balum for 2.45 GHz WiMax Design of Balum for 5.5GHz WiMax Design of 3.3-3.7GHz WiMax filter using LTCC
Bio Engineering	Bio-signal acquisition system
Image Processing	Higher dimensional representation with 3-D surface plots

Goal & Grade		Goal Index	Grading Method	S1	S2	S3	S4	S5	S6	S7	S8	S9	Sum	AVG
	SURE program	1. Research topic	Midterm survey of constituent members											
			Final survey of constituent members											
		2. Schedule	Midterm check											
			Final check											
		3. Outcome	Data											
			Midterm outcome											
			Final outcome											
		4. Presence	Time limit											
			Attitude of listener											
			Contents of Present											
		5. Others	Cooperation with another											
			Cost of Materials											
			Effect of another											
		Evaluation of Program Manager												
	Participating Students	Goal Index	Grading Method	S1	S2	S3	S4	S5	S6	S7	S8	S9	Sum	AVG
		1. Outcome	Arrangement of Data											
			Midterm check											
			Final check											
		2. Cooperation	Inside of Group											
			Outside of Group											
		3. The way ahead	Survey											
		4. Feedback	About SURE Program											
		Evaluation of participate Student												
	total sum of Grade													

Program management and evaluation in 2008

Chronologically, we have announced SURE program in the beginning of April to prepare students' participation with suggest research topics from five research labs. Once the applications were submitted by the end of May, faculty members selected applicants' research proposal and study of purpose, and finally announced 9 selected participating students in individual. During 10 weeks of period, first 4 weeks were mostly dedicated to theoretical study and literature survey, and the rest 6 weeks were spent on basic research guided by mentors including final presentation. Four research topics suggested in listed in Table 2. During and after the SURE program period, program itself as well as participating students were continuously monitored and evaluated, and the final evaluation is presented in Table 3.

Analyzing the evaluation, satisfactory result was achieved, but four resolutions are still remained for the next year.

1) When the individual research plan is changed in the middle of program, it is very hard to catch up the schedule. Research plan should be in concrete, and the feedback should be more frequent.
2) The program is desired to be announced in numerous methods to get more participation from students.
3) To improve the quality of the program, rubric for the program evaluation should be further developed.
4) It is desired to collaborate with professors in other department and even in other university if it is necessary.

Projection in 2009 and Summary

Summer Undergraduate Research Experience (SURE) is proposed for a conjunction of engineering education and research by Department of Electronic Engineering at Myongji University. Benchmarking undergraduate research program in some US university, we have successfully implemented a suitable undergraduate research program combining education and research. SURE has three objectives to pursue, and we, as the first year, have focused on the

followings; 1) providing an research experience in a desired area of interest for students who are hesitating to decide their graduate study: and 2) introducing research experience for those of whom just wants to expand their knowledge of interests. As a result, two students continued their graduate study from 2009, three students have confirmed their decision for graduate study, and the rest four are significantly positive to do so. Not only for increased number of graduate students, but also participants' feedback regarding their precious 10 week period was more valuable. We are continuously going to have the second year's project in the next few months, and hopefully it can be requested during the winter break.

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