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Summer Industrial Projects Program (SiPP) Drives Engineering Technology Student Retention

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Abstract

Engineering Technology education is experiential learning. It serves the hands-on engineering profession that combines knowledge of mathematics and science with the practical application of technology. Typical Engineering Technology (ET) programs prepare graduates to implement technology; evidenced by the nearly 60% of classes that include laboratory content. These laboratory exercises are constructed to simulate manufacturing process and product design problems. While labs are critical to gaining technology experience, they are not engineering projects. The first comprehensive engineering project a student attempts is the program's capstone course; the Senior Design. The under-served component of Engineering Technology education is engineering projects.

This paper describes a three-year NSF-funded summer program designed to improve student retention in Engineering Technology by exposing students to an industrial setting to gain practical engineering experience. Sophomore and Junior-level students were organized into teams and assigned to small or medium-sized manufacturing firms close to the university. Each team conceived and/or implemented a two-month manufacturing project that solved a design or process problem.

Introduction

The Summer Industrial Projects Program (S*i*PP) promoted student retention and persistence in Engineering Technology in four important ways.

- The emotional experience of a meaningful engineering project re-kindled the student's desire to become an engineer.
- Successful projects improved the relationship of the University and Industry Partner.
- Students significantly interacted with an engineering or manufacturing staff; became known and evaluated by a potential future employer. Several were hired.
- The students received ET credit hours for the project experience while NSF-funded scholarships and Industry Partner donations paid the course tuition.

Engineering Technology Student Retention

A recent decade-long study[1] tracked the progress of 2,909 Engineering Technology students that attended IUPUI between September, 2000 and May, 2010. These data showed that twenty-three percent of those students persisted to earn BS degrees in their initially declared programs of Biomedical (BMET), Computer (CpET), Construction (CEMT), Electrical (EET) and Mechanical Engineering Technologies (MET). Nearly half (48%) of the ET students switched programs one or more times; 3% into other Engineering Technology programs and 24% to Engineering majors. The remaining students moved to other programs and Colleges within the

University. Overall, 50% of those students declaring for an Engineering Technology program earned their degrees; far exceeding the 37% overall graduation rate of the university.

Engineering Technology Programs	Number of Students Declaring an ET Major	Graduation Rate in this declared Major	Number of ET Students	Graduation Rate in Another Major Within this College	Number of ET Students	Graduation Rate in Another Major outside of this College	Number of ET Students	Total Graduation Rate for this Population	Number of ET Students That Graduated	Institution-Wide Graduation Rate for this Population	Difference from Institution (Graduation Gap)
Biomedical ET	141	27%	38	3%	4	13%	18	43%	60		
Computer ET	140	29%	41	12%	17	8%	11	49%	69		
Construction ET	622	39%	240	4%	22	7%	45	49%	307		
Electrical ET	810	18%	148	26%	207	8%	65	52%	420		
Mechanical ET	1,196	17%	198	25%	297	9%	111	51%	606		
	2,909	23%	665	19%	547	9%	250	50%	1,462	37%	13%

Figure 1: Persistence in Engineering Technology Programs

Data from the study[1] showed that the greatest program retention losses were those declaring for Electrical (82%) and Mechanical Engineering Technologies (83%). However, a closer inspection revealed that 31% of the EET transfers moved into Electrical Engineering and three percent to other ET programs. METs had similar transfers with 32% to Mechanical Engineering and two percent into other ETs. The balance of transfers went to other programs and Colleges within the university. Overall, those initially declaring for EET and MET programs had the highest graduation rates (52% and 51% resp.) of the entire Engineering Technology program section.

Summer Industrial Projects Program (S*i*PP)

S*i*PP was created in December, 2011 as a small segment of the Central Indiana STEM Talent Expansion Program (CI-STEP); funded by a National Science Foundation grant. CI-STEP was charted to "set a target of increasing the number of STEM graduates at University by 10% per year".[2] S*i*PP focused on retaining second and third-year EET and MET students in the School of Engineering and Technology and reinforcing persistence to graduate in their chosen programs.

The S*i*PP program was designed to reinforce a student's ET program choice through the application of Experiential Learning Theory (ELT). Experiential learning was introduced by John Dewey in 1938, and later refined by Kurt Lewin and David Kolb. Dewey described learning as a process of participating in an activity, reflecting on that experience and later using the conclusions when doing other activities.[3] Lewin, a social psychologist, believed that the challenge of modern education was how to implement "concrete experience" based on Dewey's process.[4] Kolb unified the process in 1984 as the "Experiential Learning Cycle", which connects the four actions of learning.[4] Kolb's cycle depicts experience explained by reflection, reflection creating new concepts, and new concepts used to plan new experiences. He refers to the cycle as concrete experience (CE), reflective observation (RO), abstract conceptualization (AC) and active experimentation (AE).[4]

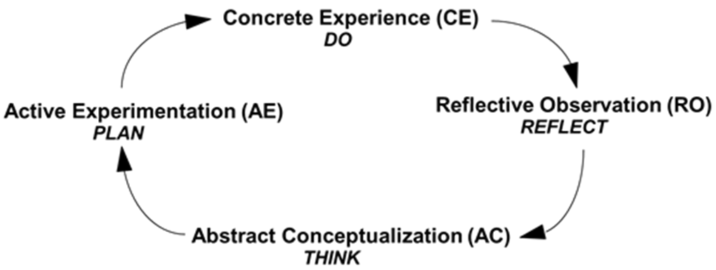

Figure 2: Klob's Experiential Learning Cycle[4]

Students begin a learning cycle at any stage and all subsequent stages follow in sequence. Successive stages of the Learning Cycle provide feedback needed for evaluation of the action and planning for new action.[4] Since the Experiential Learning Cycle is an unending process it assumes the nature of continuous improvement.

S*i*PP projects were planned to begin with abstract conceptualization after a discussion with the Industrial Partner. A problem statement was generated and multiple solutions were evaluated through active experimentation of FEA or software simulations and simple fixtures. Construction began once a plausible design was completed and the design was completely or partially implemented to obtain the concrete experience. The results of the design were observed and reflected upon and its strengths and weaknesses identified. The learning cycle was repeated until a satisfactory solution was created by the team. Reflection and planning were done in weekly meetings among the student team members, and progress reviews were conducted with the Industry Partners.

The working relationship of the student team and its Industry Partner was structured as a consulting entity and its client. The consulting entity concept was chosen to mirror research into experiential learning with teams by Klob and others in 2005. Klob and his fellow researchers identified three critical aspects of experiential learning in team settings[5];

- Teams need a "conversational space" where members are free to reflect and discuss their shared experience.
- Team members learn through shared experience and reflection. They collectively form new concepts and create plans for a new experience.
- As a team develops into an effective learning system, members must assume the functional roles necessary for team effectiveness. A leader emerges and bonds form.

They surmised; "Team development is thus a process in which a team creates itself by learning from its experience."[5]

The S*i*PP teams occupied University office space from May to July; 2012 until 2014. Since the program was offered in the summer session, they had nearly-unlimited use of ET Department resources, including computers, software, labs, machine and fabrication shops, test equipment and sensors. The Industry Partner supplied most of the raw materials and purchased items needed for experiments and prototypes. Team leadership and roles were self-selected; the faculty mentor and Industry Partner staff were guides - not members.

Depending on the type of project, student teams were comprised of all METs, all EETs or a mixture of both. MET projects included mechanisms to fixture products for testing, dispensing systems, gasket design, and tooling for stampings. EET projects focused on data acquisition, Bluetooth connectivity, and PLC control systems design. Mixed teams of MET and EET students worked together on product defect and unauthorized intrusion detection, production layouts, and inventory tracking systems.

Teams began the process with a project schedule, researched applicable standards, brainstormed concepts, used decision matrices for design direction, and attended weekly team meetings and scheduled design reviews with the client. They spent significant time on the factory floors and laboratories of their clients, and worked side-by-side with engineers, production and maintenance personnel, and the firm's managers. They designed solid-models and detail drawings and schematics. They performed simulations using Finite Element Analysis and other software. They designed tests and constructed prototypes or design component simulations. They submitted a comprehensive design package to the client, and wrote an essay on their S*i*PP experience.

In the three years of S*i*PP, thirty-two students, two staff and three faculty members worked with nine local firms on sixteen projects. Four Industry Partners sourced two or more projects. Two firms participated two summers. One student repeated S*i*PP in the sophomore and junior years. All of the projects resulted in completely detailed designs and bills of material. Eight projects included simulation and/or testing of design concepts. Four prototypes were built. Two designs were constructed and placed into the firm's production system.

Year	Industry Partner	Project	Team	Design	Simulation/Test	Prototype	Implemented
2012	AMG Engineering and Machining	Production Area Layout	MET & EET	X			X
2012	AMG Engineering and Machining	Pressure and Leak Test Fixture	MET	X			
2012	AMG Engineering and Machining	O-Ring Insertion Tool	MET	X			
2013	Raytheon	Vibration Test Fixture	MET	X			
2013	Praxair Surface Technlogies	Crack Detection - Data Acquisition System	EET	X	X		
2013	N. K. Hurst	Flavor Packet Detection	MET & EET	X	X		X
2013	Stanley Security Systems	Coverplate Intrusion Detection	MET & EET	X	X	X	
2013	Stanley Security Systems	Coverplate Gasket	MET	X	X		
2013	Top Gard	Bollard Cap Manufacturing System	MET	X			
2013	Top Gard	Bollard Cap Filling Design	MET	X	X		
2014	IUPUI Aquaponics	Fixture and Piping Design	MET	X			
2014	IUPUI Aquaponics	Control Systems Design	EET	X			
2014	Aerodyn Engineering	Strip Feed and Stamping Fixture	MET & EET	X	X	X	
2014	Stanley Security Systems	Bluetooth Communication Dongle	EET	X	X	X	
2014	Top Gard	Bollard Cap Filling Fixture	MET	X		X	
2014	Connecta	Inventory Tracking System	MET & EET	X	X		

Figure 3: SiPP Projects

The Student Experience - In their own Words

A review of the thirty- two student essays regarding the S*i*PP experience found that thirty enjoyed the program and felt it reaffirmed their commitment to the EET or MET program they declared for in their freshman year. One student stated that the experience convinced him to continue in his MET program instead of the change he was considering before S*i*PP. Two students felt their project was not very interesting and didn't add much to their commitment toward an Engineering Technology degree. Excerpts from a sampling of student essay conclusions[6] include;

“I am very happy that this experience and course brought me new visions about Mechanical Engineering Technology degree. Before this course I was thinking about switching majors, I was frustrated, and thought that the real world and working in the field is just like the classroom. Just like learning and memorizing a bunch of different material, and then throwing all of them on a paper and getting a score. I was sad, and depressed. But now I feel good about my degree. I think if I work harder, I will earn the job I deserve, I know everything depends on how hard we work, and we actually earn it.”

“This experience has made my desire to be an engineer even greater. This is truly my calling.”

“In all, this was a great experience. It’s fun to design a system and see it work the way you intended it to, and as a student it’s invaluable to be able to work with a real engineering team and get feedback from them on how to solve a problem like this”

“I also felt that the project we were given was more of a “busy work” project than an engineering project. I will continue to pursue my MET degree, because hopefully when I graduate I will be trusted with a higher profile project.”

“This class will be a memorable class for me through my whole career life of engineer as the one that made a difference in my education.”

“The SIPP enforced my choice of engineering as a profession. It felt great to be able to use my imagination and skills to help solve a problem for a company that really appreciated the help.”

Students, Retention, and Persistence to Graduation

All of the students who applied to S*i*PP were accepted. The only requirement of acceptance to the program was that the student had earned enough credits to have sophomore or junior status. Grade point average was not considered for admittance. The mean GPA of participants was 3.14, including a minimum of 2.10 and a 3.98 maximum. Twenty-seven percent had GPAs under 3.00, 18% above 3.50, and 55% between 3.00 and 3.50. GPAs and student strength and weakness surveys were used to assign members and balance the strength of the teams. Fifty-five percent of the S*i*PP students held part or full-time jobs while contributing 10-15 hours per week to their team’s projects, and 18% had some factory maintenance or production experience.

All of the students who participated in S*i*PP are still enrolled, or have graduated with a BS, in their declared ET program. All nine of the 2012 participates, and six of the ten 2013 participants, have graduated in their declared programs. The remainder of S*i*PP 2013, and all thirteen of the 2014 participants are still enrolled in their declared ET program and progressing toward graduation.

While the student sample size is small, and seventeen of the thirty-two students are still working toward graduation, it is clear that the S*i*PP experience has a positive impact on student retention and persistence in Engineering Technology.

The program has also succeeded in introducing the Industry Partners to our students and faculty for the purpose of further engagement. Firms have hired four (full and part-time) of the S*i*PP participants they worked with. All of the firms have later participated in subsequent fall and/or spring semesters of EET and MET Senior Design projects. In all, another 17 Industry Partner-collaboration projects were created with 46 participating ET students. From a project success perspective, two S*i*PP projects (assembly area plant layout and missing flavor packet detection system) were built and placed into production in the sponsor's facility.

	December 31, 2014			
	Graduated	**Not Attending**	**Attending**	***SiPP***
ECET student	X			2012
ECET student	X			2012
MET student	X			2012
MET student	X			2012
MET student	X			2012
ECET student	X			2012
MET student	X			2012
ECET student	X			2012
MET student	X			2012
MET student	X			2013
ECET student	X			2013
ECET student	X			2012&13
MET student			X	2013
MET student	X			2013
MET student	X			2013
MET student			X	2013
MET student	X			2013
MET student			X	2013
ECET student			X	2013
ECET student			X	2014
ECET student			X	2014
MET student			X	2014
MET student			X	2014
MET student			X	2014
ECET student			X	2014
MET student			X	2014
MET student			X	2014
MET student			X	2014
ECET student			X	2014
ECET student			X	2014
ECET student			X	2014
ECET student			X	2014

Figure 4: Student SiPP-experience Outcomes

Conclusions

There was a strong, positive and emotional impact with students and S*i*PP. Students were reenergized in their conviction that they had made the right career choice in Engineering Technology. They found this method of learning interesting, challenging, and rewarding. Their team structure created peer pressure and they reacted positively to the motivation it provided. After completing this program they became confident that they could be successful when assigned engineering work in an industrial environment. Overall, students prospered from and enjoyed the S*i*PP projects.

I hear and I forget, I see and I remember, I do and I understand. ~ Confucius, 450 BC

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