



Increasing Student and Faculty Participation and Student Learning in an Undergraduate STEM Summer Research Program in a Government Institution through a Higher Education Partnership

Dr. Mary Yvonne Lanzerotti, Augsburg College

Dr. Lanzerotti received her A.B. from Harvard College, M. Phil. from University of Cambridge (U.K.), and her Ph.D. from Cornell University, all in physics. She is an Assistant Professor of Physics at Augsburg College, in Minneapolis, Minnesota. Previously she was a faculty member in the Department of Electrical and Computer Engineering at the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

Dr. Sean Joseph Creighton, SOCHE

BIO

Sean Joseph Creighton, Ph.D., is the President of SOCHE, a regional association of colleges and universities dedicated to educating, employing, and engaging citizens. SOCHE coordinates programs for over 20 diverse members of higher learning with an annual economic impact of \$3.3 billion, serving over 120,000 student and more than 36,000 employees. In 2012, SOCHE received the Dayton Business Journal Non-Profit Business of the Year Award and in 2007 the Governor of Ohio recognized SOCHE as a model for collaboration in higher education.

Sean is currently in his second term as an elected member of the Board of Education for the Yellow Springs Public Schools, where he has been president, chaired the 2020 Strategic Plan, and served as the district's legislative liaison. He also serves on advisory committees and boards for several local and national organizations, including Dayton Literary Peace Prize, Midwestern Higher Education Compact, TEDxDayton (license holder and co-chair), ThinkTV Public Broadcasting, and Wright-Patterson Air Force Base Community Partnership Leadership Council.

Sean has published and presented extensively on the impact of higher education, collaboration, civic engagement, and talent retention, and has also conducted research for the Kettering Foundation on the economic and civic missions of regionally based colleges and universities. He is a voice for collaboration and posts regularly at www.creightoncollaborative.com. Sean holds degrees from Marist College and New York University, and earned his PhD from Antioch University. He lives in the charming village of Yellow Springs with his wife, Leslee, and his five fun children, Liam, Maya, Quinn, Audrey, and Juliette.

Ms. Maggie Varga, SOCHE

Maggie Varga, Director, Southwestern Ohio Council for Higher Education (SOCHE)

Maggie Varga is a Director for the Southwestern Ohio Council for Higher Education (SOCHE). In her capacity as Director, Maggie leads the SOCHEIntern Program, which employs nearly 300 students annually in cooperation with local government and small businesses, as well as the Air Force Institute of Technology (AFIT) and Air Force Research Laboratory (AFRL) at Wright-Patterson Air Force Base. The program provides high impact experiential learning opportunities for students while generating economic benefit and enhancing community sustainability. Her work improves the efficiency of programs that support member institutions and increase the success of more than 120,000 students in southwest Ohio. Maggie has also provided guidance and leadership in the creation and evolution of regional initiatives such as the Dayton Water Roundtable, Ohio's Great Corridor Association, and the University of Dayton Rivers Institute.

Prior to her position at SOCHE, Maggie worked for the Fitz Center for Leadership in Community at the University of Dayton.

Maggie has a Master of Business Administration and a Bachelor of Science in Economics and Finance from the University of Dayton and was a member of the first cohort of the University's Rivers Steward Program.



Dr. Richard Martin, The Air Force Institute of Technology

Richard K. Martin received dual B.S. degrees (summa cum laude) in physics and electrical engineering from the University of Maryland, College Park, in 1999 and the M.S. and Ph.D. degrees in electrical engineering from Cornell University, Ithaca, NY, in 2001 and 2004, respectively. Since August 2004, he has been with the Department of Electrical and Computer Engineering, Air Force Institute of Technology (AFIT), Dayton, OH, where he is an Associate Professor. He is the author of 33 journal papers and 62 conference papers, and he holds five patents. His research interests include radio tomographic imaging; navigation and source localization; cognitive radio; and laser radar. Dr. Martin has been elected Electrical and Computer Engineering Instructor of the Quarter three times and HKN Instructor of the Year twice by the AFIT students. He is currently serving as a Senior Area Editor for IEEE Signal Processing Letters and has served as a Guest Editor for The IEEE Journal of Selected Topics in Signal Processing and an Associate Editor for IEEE Signal Processing Letters.

Dr. Derrick Langley, Air Force Institute of Technology

Derrick Langley is an Assistant Professor of Electrical Engineering at the Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base (AFB), Ohio. He received his B.S. in electrical engineering from the University of Central Florida in 2003, his M.S. in electrical engineering from Wright State University in 2007, and his Ph.D. in electrical engineering from AFIT, Wright-Patterson AFB in 2012. His current research interests are metamaterials, microelectronics, microelectromechanical systems and nanotechnology.

Mrs. Diana Lynn Cahill, SOCHE

Diana Cahill, M.Ed., is currently Program Manager for Southwestern Ohio Council for Higher Education, SOCHE. Previously, Cahill was the Civilian Student Coordinator at the Air Force Institute of Technology, AFIT. She earned an M.Ed. in Curriculum and Instruction from Wright State University and a BA in English from Youngstown State University.

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Abstract

This paper describes steps taken to increase participation and student learning in an undergraduate STEM Summer Research Program at the Air Force Institute of Technology (AFIT), a government institution. The paper also describes outcomes related to how the program is helping the students prepare for their futures. These steps are taken during the third year of an ongoing process to transform the undergraduate program. A partnership among AFIT, the LEADER (Launching Equity in the Academy across the Dayton Entrepreneurial Region) Consortium, and the Southwestern Ohio Consortium for Higher Education (SOCHE) was established to assess the students' experiences and to inform future experiences based upon the results of surveys conducted annually since 2012. SOCHE has employed nearly 1,000 STEM students in the past 25 years.

In 2012, a formal assessment tool was distributed to the students for the first time to measure the impact of the research experience. Also in 2012, a formal assessment tool was distributed to the Faculty Advisors of the students for the first time to measure the research experience of the students from their advisors' perspective. Following the student survey results in the 2012 Program, we identified the following four broad needs expressed by the students: (1) A desire for mentors with increased organization and communication among SOCHE, AFIT, and the students; (2) A desire for increased interactions with other students; (3) A desire to improve their CV or resume at the beginning of the program; (4) A desire to gain engineering experience, skills, and confidence in research.

In the 2013 Program, we introduced and implemented four new voluntary components in response to the student needs. Because of government restrictions, the participation of students in the components is voluntary, and students were encouraged to participate by SOCHE. These transformational components are: (A) A joint orientation process with SOCHE and AFIT Project Leaders; (B) Student cohorts through social activities and STEM-based games; (C) A weekly seminar meeting with outside presentations of general interest; and (D) A Poster Session so that students can present the engineering experiences they have gained. Selected students were awarded "Posters of Excellence" Certificates in a poster competition.

Student response rates in the 2013 Program were low to both a pre-survey administered by SOCHE when the program was in session and to a post-survey following the program (pre-survey response rate: 33%; post-survey response rate: 16%). While participation in the Joint Orientation was nearly 100%, student participation in the other 11 one-hour weekly events was low (13%).

This paper describes increased student and faculty participation in the 2014 Program. The 2014 Program comprised 49 students and 14 Faculty Advisors. The 49 participating students is the

largest number of students since the start of our assessment effort (The 2013 Program comprised 43 students, and the 2012 Program comprised 48 students). SOCHE continues to advertise the research internships conducted at the Federal Government Institution throughout southwestern Ohio.

In the 2014 Program, we introduced and implemented a fifth component. This component is: (E) Counseling. This component provides personal interaction among the students and SOCHE at the Government Institution (where the students are pursuing their research projects). In this component, the Director of SOCHE drove to the Government Institution for one day (Wednesday) each week and spent four hours meeting informally with students and answering student questions regarding the Program. Approximately 20 students met the Director each day.

In addition to introducing Component (E), we also standardized the location and time of each event in the four components (A)-(D). Each event was held at the same time (noon-1pm) each week in the same location. The consistency of the programming helped the students remember each weekly event and contributed to increased participation.

This paper will describe the new component (E) and additional steps taken to increase student participation and student learning in the five components in the 2014 Program. This paper will also describe outcomes related to how the program is helping the students prepare for their futures and steps taken to increase faculty participation in the Faculty Advisor survey.

In the 2014 Program, student participation increased in each component. Nearly 100% of the students participated in the Joint Orientation. Thirteen of the 49 students (26.5%) participated in the Kayak trip; 18 students (36.7%) participated in the resume workshop; and 21 students (42.9%) participated in the Poster Preparation Session. Seventeen students (34.7%) prepared 12 posters for the Poster Session, compared with the participation of 9 out of 43 students (21%) who together prepared 7 posters in the 2013 Poster Session (a Poster Session was not held in the 2012 Program). Faculty participation in the 2014 Faculty Advisor survey is 11 out of 13 on-campus faculty (85%) (One faculty transferred out of the country prior to the administration of the Faculty Advisor Survey and was not able to be surveyed). The increased faculty participation rate in the 2014 Program compares favorably to the Faculty Advisor response rates of 56% in the 2013 Program and 61% in the 2012 Program, respectively.

Our capability to strengthen the program focuses on incorporating feedback from the students, who are government contractors, and incorporating feedback from the Faculty Advisors in order to inform best practices in workforce development. Additional results and findings of the assessment of the 2014 Summer Research Program will be discussed, and the results and findings will be compared with results from the 2012 Program and 2013 Program.

Introduction

A series of reports published by the National Academy during the past decade entitled *The Engineer of 2020: Visions of Engineering in the New Century*, *Rising Above the Gathering Storm* and *Examination of the U.S. Air Force's Science, Technology, Engineering, and Mathematics*

Workforce Needs in the Future and Its Strategy to Meet Those Needs, describe a vision for engineering and workforce needs in the U.S. in the STEM fields in the 21st century. According to the National Academy of Sciences in the groundbreaking 2004 report entitled *The Engineer of 2020: Visions of Engineering in the New Century*, successful engineers in the 21st century should exhibit *key attributes* to ensure their success and the success of the engineering profession. The list of key attributes are: **strong analytical skills, practical ingenuity, creativity, communication, business and management, leadership, high ethical standards, professionalism; dynamism, agility, resilience, and flexibility**, and the ability to become **lifelong learners** [1].

The project described in this paper is motivated by the results and findings of these reports. Our project exposes a pool of STEM undergraduate students to research opportunities and future educational opportunities at a DOD institution of the federal government. One desired outcome is to motivate the students to graduate with STEM degrees and thereby increase the number of students in the STEM workforce. As described in prior work, the exposure gained by the students to STEM research in a DOD institution increases the number of civilian students with unique capabilities and current skills that are aligned with the workforce needs of the Air Force.

In addition to the Summer Research Program offered at the DOD institution of the federal government described in this paper [2], the DOD and DOE offer additional opportunities to undergraduates and summer undergraduate interns in engineering careers. These opportunities are reviewed here:

- SMART Scholarship Program, a DOD program in which participants receive tuition and other educational expenses, a generous cash award, health insurance allowance, and summer internships at AFCS facilities” [3];
- National Defense Science and Engineering Graduate (NDSEG) Fellowship program, a DOD program in which participants receive an award during their pursuit of a doctoral degree [4];
- Year-round Internship Program [5] a DOD program that is also held at this DOD institution during the school year for students in STEM fields;
- Pathways Internship Program, a DOD program that “provides students with paid opportunities to work and explore Federal careers” [6];
- PALACE Acquire, which is a DOD program that “offers [students] the opportunity to occupy a permanent full-time position during a 2-4 year, formal training plan design” [7];
- Air Force Office of Scientific Research (AFOSR) Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE), which is a DOD program similar to the NSF Research Experiences for Undergraduates (REU) program [8];

- NSF Federal Cyber Service: Scholarship for Service (SFS) Program (DOD) provides scholarships to undergraduates at participating institutions [9];
- Oak Ridge Institute for Science and Education (ORISE in the DOE), which matches students which research opportunities at research facilities at national laboratories located around the United States [10].

This paper describes the next set of steps in a transformation of all internships in the undergraduate STEM Summer Research Program in the federal government at the Air Force Institute of Technology (AFIT) to prepare students for engineering careers in the 21st century. In these steps, we introduce a fifth additional component to an existing summer research program specifically (1) to increase participation of the students in the optional, voluntary program components and (2) to increase faculty participation in the faculty advisor survey. The overall goal of this effort is to develop the *key attributes* of **strong analytical skills, communication, high ethical standards, and professionalism** that are desired in 21st century engineers. This paper also describes student responses to the program's effectiveness, and we provide a description of student learning through the program. Student observations are also presented, and we present outcomes describing how the program is helping students prepare for their futures.

Motivation

As described previously, many challenges existed at a government institution to introduce standard STEM program components to a long-standing summer research program. In our prior work, the partners AFIT, SOCHE, and the LEADER Consortium presented a unique campus-community partnership that successfully introduced a new paradigm to the AFIT Summer Research Program [11, 12]. With this paradigm, the three partners found a way forward together to upgrade the AFIT Summer Research Program based on student recommendations. Student participation is completely voluntary. Prior research presented at 2013 ASEE and 2014 ASEE describe this new paradigm that upgraded the summer program with the inclusion of four components to improve better student research experiences.

As described previously, the partners are motivated to improve the summer research experiences of the students with the goal to motivate the undergraduates to complete their STEM degrees. This paper describes our efforts to increase student improve the research experiences through the incorporation of five STEM components intended to improve the students' professional skills.

As a federal government institution located on an operating military base, the incorporation of these five components offers the opportunity to the partners to bring unique opportunities to the participating students.

Partners

The LEADER Consortium is funded by an ADVANCE Institutional Transformation Award from the NSF Award #0810989 since 2008 and is a partnership of four institutions of higher education in the Dayton region: the Air Force Institute of Technology, Central State University, University of Dayton, and Wright State University [13].

The Air Force Institute of Technology (AFIT) is a purely graduate-level institution, and as such, it is one of the few institutions offering graduate-level ABET-accredited degrees [14]. Out of roughly 800 students, 74% are MS, 16% are PhD, and 10% are certificate or non-degree-seeking students. The enrollment is 73% Air Force, 4% sister services, 3% international officers, and 20% civilian. AFIT's faculty members are approximately composed of 50% military faculty and 50% civilian faculty, and they are expected to conduct research programs in the same manner as civilian schools. AFIT's mission is to advance air, space, and cyberspace power for the Nation, its partners, and our armed forces by providing relevant defense-focused technical graduate and continuing education, research, and consultation. In 2011, the Carnegie Foundation identified AFIT as a doctoral/research institution for the first time in recognition of the doctoral education productivity with strong research activity in Science, Technology, Engineering, and Mathematics disciplines. Students participating in the AFIT Summer Research Program work with faculty in six departments: Aeronautics and Astronautics, Electrical and Computer Engineering, Engineering Physics, Mathematics and Statistics, Operational Sciences, and Systems and Engineering Management. These departments contain five centers: the Center for Cyberspace Research, Center for Directed Energy, Center for Operational Analysis, Center for Technical Intelligence Studies and Research, and Advanced Navigation Technology Center.

The Southwestern Ohio Council for Higher Education, or SOCHE, is a 501c3 non-profit organization [15]. Formed in 1967, SOCHE is a regional consortium of 20 colleges and universities in southwest Ohio. SOCHE's mission is to be "the collaborative infrastructure for higher education, helping colleges and universities transform their communities and economies through the education, employment, and engagement of more than 120,000 students in southwest Ohio." In addition to providing internships [5], the organization manages a comprehensive portfolio of programs and initiatives to support higher education in the region.

Background and overview of prior work

Over 40 students participate annually and perform research in all six engineering departments at the AFIT Graduate School of Engineering and Management. First, starting in summer 2012, a formal assessment tool is now distributed to students to measure the impact of the research experience. Second, starting in summer 2013, students are now provided with four career broadening programs that are informed by student survey results in 2012. These programs are made possible through a partnership among AFIT, the LEADER (Launching Equity in the Academy across the Dayton Entrepreneurial Region) Consortium, and the Southwestern Ohio Consortium for Higher Education (SOCHE). The partnership assesses the students' experiences and informs future experiences based upon the results of student surveys.

In 2012, feedback was sought from the 48 participating students to improve all internships in the Summer Research Program in order to help prepare engineering student interns for work in the 21st century. In response to the feedback, four new voluntary program components were made available to all students in the 2013 Program. Because of government restrictions, student participation is voluntary. The components are: (A) A joint orientation process with SOCHE and AFIT Project Leaders; (B) Student cohorts through social activities and STEM-based games; (C) A weekly seminar meeting with outside presentations of general interest, such as job-hunting, resume-writing, information about scholarships and fellowships, and the process to apply to graduate school; and (D) A Poster Session so that students present the engineering experiences they have gained. These four components are designed to provide students with the opportunity to develop and exhibit **strong analytical skills, communication, high ethical standards, and professionalism** through written and oral presentations and discussions with fellow students, industry experts, and faculty.

In 2013, SOCHE again implemented an assessment tool in an effort to better understand the needs of the 43 participating students. Of these students, 10 students had also participated in the 2012 program (repeat participation rate of nearly 25%). SOCHE asked all 43 students to complete a pre survey when the program was in session (response rate: 33%) and a post survey following the program (response rate: 16%). Post survey responses are favorable to the career broadening programs. Student participation in the 12 one-hour weekly events was nearly 100% in the joint orientation and 13% in the other events.

In this paper, we describe the importance of the fifth new career-broadening component in addition to the four components added in 2013 and 2014 that are transforming the internships at AFIT to prepare students for engineering careers in the 21st century. We seek to increase participation of the students and faculty in each of the components. Each component provides students with the opportunity to develop and exhibit the key attributes of **strong analytical skills, communication, high ethical standards, and professionalism**.

We first review the transformation of the AFIT Summer Research Program in Year 1 (2012) and Year 2 (2013). In the 2012 Summer Research Program, we identified four broad needs expressed by the students based on the pre-survey and post-survey administered by SOCHE (www.soche.org):

- (1) A desire expressed by students for mentors with increased organization and communication among SOCHE, AFIT, and the students;
- (2) A desire expressed by students for increased interactions with other students;
- (3) A desire expressed by students to improve their CV/resume at the beginning of the program and interest expressed by students in applying for the SMART Scholarship;
- (4) A desire expressed by students to gain engineering experience, skills, and confidence in research.

In the 2014 Summer Research Program, we planned and implemented five additional components to address these four needs. First, to increase communication among SOCHE, AFIT, and the summer interns, we *planned a joint orientation process with SOCHE and AFIT Project*

Leaders/Mentors. Second, to increase interactions among the students, our team *developed student cohorts*. Third, we *developed a regular seminar* with three outside presentations of general interest, such as on job-hunting, resume-writing, information about scholarships and fellowships, and a poster creation workshop. Fourth, since one of the more valuable skills that students can learn from open-ended projects is the opportunity to *develop presentation and communication skills*, we *organized a small conference to present the students' work to the AFIT community so that students can present the engineering experiences they have gained*. Fifth, in 2014, we introduced a fifth component entitled Counseling.

Here is the announcement of the programming elements at the beginning of summer 2014 by the SOCHE Director to all of the students in the 2014 AFIT Summer Research Program:

Over the past couple years, SOCHE has expanded its internship programs and has begun examining the role internship can play in addressing the workforce challenges of this region. Our SOCHEIntern program has a vision that graduates of SOCHE-member institutions will chose to live, work, and play in southwest Ohio. To accomplish this vision, we hope to deliver a holistic internship program that provides a high-impact, exceptional quality, experiential learning engagement that grows the workplace competencies and technical skills of the student while creating value for AFIT, enhancing the impact of higher education, and promoting the community.

We hope to provide additional support to students through weekly Lunch gatherings on Wednesdays in June and July rotating between planned events with education activities and unstructured networking among the students. Through weekly meetings, we hope to:

- 1. Further familiarize students with base policies and procedures*
- 2. Provide information on available scholarships and professional development*
- 3. Coach students on writing resumes and CVs*
- 4. Allow students the opportunity to present their research*
- 5. Create a fun and engaging environment for students*

All interns receive a copy of the attached schedule of events during their orientation. With the exception of the orientation lunch this Wednesday, SOCHE programming is optional and the students are made aware that attendance is not required or part of their normal work hours. Project Leaders are welcome and encouraged to attend sessions of interest, and we appreciate your support in encouraging students to take advantage of these opportunities.

I will also be working from Einstein's each Wednesday this summer from 0830-1300 to be available to answer questions for students and project Leaders.

Continuation of Component #1: Joint Orientation process with SOCHE and DoD Project Leaders

In 2014, we again held a Joint Orientation with SOCHE and DoD Project Leaders (also referred to as the Faculty Advisors). Attendees at the Joint Orientation were nearly 100% participating summer students (compared with 26 of the 43 students in 2012, for a 60% response rate), the Director of SOCHE, the Director of Student Services at AFIT, the Civilian Student Coordinator at AFIT, a civilian contractor at the AFIT Center for Cyberspace Research, and several AFIT Faculty Advisors.

Continuation of Component #2: Student Cohorts through Social Activities and STEM-based games

In 2014, we again introduced activities focused on building student camaraderie and enjoyment, within the context of learning more about STEM careers. This component consisted of team games, weekly lunches (both on and off campus), and a kayak trip. Again, Component #2 included several purely social activities. These activities provided the interns with networking opportunities, as well as the chance to make friends with interns on disparate projects, in order to form a social support network. A capstone social activity again was provided by SOCHE in the form of a group kayak trip along the Mad River, ending in downtown Dayton (26.5% participation rate).

Continuation of Component #3: Weekly Seminar Meeting with Outside Presentations of General Interest

In 2014, we planned an activity at least once per week. The activities began with a joint orientation from Component #1 and concluded with the poster session from Component #4; and in the interim, we again alternated between social gatherings and professional development activities.

The 2014 full schedule of activities across all components was:

- Week 1: Joint orientation, with pizza lunch (Component #1)
- Week 2: Social lunch at AFIT cafeteria (Component #2)
- Week 3 (evening): Social kayaking trip (Component #2) (13 out of 49 participants)
- Week 4: Social lunch at Riverscape MetroPark in Dayton, Ohio (Component #2)
- Week 5: Social lunch at AFIT cafeteria (Component #2)
- Week 6 (evening): Backup date for Kayak trip (Component #2)
- Week 7: Resume workshop (Component #3)
- Week 8: Social lunch at AFIT cafeteria (Component #2)
- Week 9: Poster creation workshop at AFIT (Component #3)

- Week 10: Social lunch at AFIT cafeteria (Component #2)
- Week 11: Poster session with sandwich lunch (Component #4)

Two activities specific to Component #3 were the workshop on resume writing and the workshop on poster creation. The resume writing workshop was held at AFIT, and it provided an industry perspective by Sandy Mudry, Employee Care Manager at JJR Solutions (Wednesday, 2 July 2014). Seventeen students participated in the 2014 Resume session (34.7% participation rate). Twenty students participated in the 2014 Poster Creation workshop (40.8% participation rate).

The one-hour poster creation workshop was held two weeks prior to the student poster session. The poster workshop occurred on the AFIT complex during the weekly seminar to the students. The poster workshop main purpose is to provide guidance on developing posters similar those presented at technical conferences and workshops. The guidance starts with providing reasons explaining why posters are important to research for presenting project information to an audience. We provided information on arranging research details on posters. This discussion was followed by advice on how to present the poster information in a professional manner. Speech rehearsal and practicing are key for an effective presentation. This was then followed by advice on poster organization which captures the audience's interest. Prior to a question and answer period, a faculty member demonstrated a poster presentation as an example for the students.

In the previous year (2013), we held the poster workshop in a restaurant. Based on the low turnout, the committee decided that this year we would set up the workshop on campus. This provided a comparison for the number of students who attended the workshop based on having the workshop at an on-site location as compared to going out to a local restaurant. The on-site workshop had the larger turn-out for interns. One reason is the on-site workshops are easily accessible for the students to attend without consuming a long lunch period. They are not restricted by the travel time to a restaurant. For this reason, the interns were able to field more questions on presenting posters.

Continuation of Component #4: Poster Session Development, Implementation, and Judging

In 2014, the poster session again focused on student presentation skills and their summer research topic. Table 2 (next page) lists the poster title, students, and participating AFIT department. The purpose of the student poster session was to provide an opportunity to create a research poster and explain their summer research project. Participation in the poster session was voluntary. It was left up to the student and their advisor to create the posters.

The poster session focused on providing students with the opportunity to develop their presentation skills while explaining their summer research project to a panel of judges. The first skill concerns providing reasons for presenting a poster. The second skill involves understanding how posters are used to discuss research.

Table 2. 2014 Summer Poster Session

<i>Poster Title</i>	<i>Students</i>	<i>Gender</i>	<i>AFIT Department</i>
Using Discrete-Event Simulation to Predict Workload Performance	(1) Lindsey Bates	Female	Systems & Engineering Management
Satellite-Derived Atmospheric Profiles of C _{n2}	(1) Kegan Buchhop	Male	Engineering Physics
Global Navigation Satellite System Simulation & Signal Generation Test Bed	(3) Tim Arnett, Cooper Deiterle, Ben Wagner	Males	Electrical & Computer Engineering
Diode-Pumped Alkali Laser (DPAL) with Helium-Rubidium Vapro Circulation System	(1) Kevin P. Lapp	Male	Engineering Physics
Upgrade and Integration of AAPT (AFIT Active Point Tracker) into Falcon-10 for AAOL-T (Airborne Aero-Optics Lab Transonic)	(1) Riley Hampton	Male	Engineering Physics
Fate of Organophosphate Chemical Warfare Agents in Wastewater Treatment Systems	(2) Ogechi Irondi, Betty Nguyen	Females	Systems & Engineering Management
Radio Tomographic Imaging for Target Tracking	(2) Alton Vaughan, Ryan Newport	Males	Electrical & Computer Engineering
Using Regression Trees to Predict Operator Workload	(1) Ian McQuaid	Male	Systems & Engineering Management
Modeling Cognitive Workload and Fatigue for Defensive Cyber Operations	(1) Jayson Boubin	Male	Systems & Engineering Management
Investigation of the Use of Ultraviolet Light Emitting Diodes in Water Treatment Systems	(2) Sarah Fyda, Nate Godby	Female, Male	Systems & Engineering Management
Narrowband Interference	(1) Andrew Wallis	Male	Electrical & Computer Engineering
Enhancing Department of Defense Human Performance Models Through Improving Probability Distributions	(1) Timothy Van House	Male	Systems & Engineering Management

Session talks were provided to give examples of a poster presentation and to explain why it is important to present posters as a part of the education experience. Again, two weeks prior to the poster session, a presentation was offered to the students to explain how to prepare a poster for the session. The judges focused on the skills discussed during the poster workshop to determine the top three presentations.

The one-hour poster session took place in an open room setting at the Atrium of the institution's School of Civil Engineering. Attendees at the poster session included AFIT faculty, the Director at SOCHE, and SOCHE's marketing intern.

In 2014, 12 posters were presented at the session (compared with seven posters in 2013 for a 16% participation rate). Four presentations were co-authored by two students. There were 13 male and 4 female authors. The poster topics covered during the session varied from modeling and simulation to human behavior. Table 2 lists the student poster titles. The students were members of the following Departments at AFIT: Electrical and Computer Engineering, Engineering Physics, and Systems and Engineering Management. Table 2 provides a list of the posters, number of students presenting the poster, gender and their department.

At the conclusion of the poster session and meeting, the winners were announced for the poster session. Each winner was provided a "Poster of Excellence" certificate. The other participants were provided participation certificates. After handing out the certificates, the closing remarks were provided by SOCHE Director.

Introduction of Component #5: Counseling

In the 2014 Program, we introduced and implemented a fifth component. This component is: (E) Counseling. This component provides personal interaction among the students and SOCHE at the Government Institution (where the students are pursuing their research projects). In this component, the Director of SOCHE drove to the Government Institution for one day (Wednesday) each week and spent four hours meeting informally with students and answering student questions regarding the Program. Approximately 20 students met the Director each day.

This component was added in 2014 due to a variety of difficulties the students had in prior years, such as difficulties with computer access, miscommunication by supervisors regarding the students' duties, and confusion regarding SOCHE policies. In past years, some students expressed that they did not have adequate communication with their peers, supervisors, and SOCHE; and this component was one step towards remedying that. Moreover, it provided the SOCHE director with a much stronger feeling for the issues the students were dealing with this year.

The counseling component was implemented by the SOCHE Director who brought a laptop and set up a makeshift office in the AFIT dining facility every Wednesday morning. This was a common gathering place for the interns, since those who did not have access to official AFIT email accounts typically used the wireless internet access in the dining facility to access alternate email accounts. This facility was also located centrally in the AFIT campus, making it

convenient for students to drop by. In order to ensure adequate student contact, the interns were instructed by SOCHE that it was mandatory for them to check in with the SOCHE Director at these sessions at least twice across the summer. In practice, most students availed themselves of this opportunity much more frequently.

Standardization of Component Events: Timing and Location

In the 2014 Program, in addition to introducing Component (E), we also standardized the location and time of each event in the four components (A)-(D). Each event was held at the same time (noon-1pm) each week in the same location. The consistency of the programming helped the students remember each weekly event and contributed to increased participation.

In previous years, turnout at weekly events was low. This was determined to be largely because students either forgot there was an event that week or did not recall where and when it was held. Thus, this year, an event was scheduled for every other week in the same room and at the same time and day of week, and students were given a schedule of events at the start of the summer. The meeting location was chosen to be a tiered lecture hall with an overhead projector and whiteboard, with enough seating for all of the students and a few faculty members. This standardization is believed to be the primary factor leading to increased student participation in weekly events; for example, between 2013 and 2014 participation in the resume session increased from 27.9% to 36.7% and participation in the poster preparation workshop increased from about 15% to 42.8%.

It was also noted that students were less likely to attend weekly functions when they were off campus, since some students felt that they could only be absent from their lab for one hour in the middle of the day, so they could not go off campus for a discussion at a local restaurant or park. Thus, standardizing the location on campus made the events more practical for many students.

Student Responses to the 2014 Program's Effectiveness (Student Learning through the Program)

In 2014, the assessment plan for the program's effectiveness was to administer surveys to the interns at the start and end of the summer program. The pre-survey asked about their interest in STEM careers, professional development activities (such as resume building), and social activities. The post-survey followed up with similar questions regarding their interest in STEM careers, whether or not they still wanted resume assistance, their plans for further education, and their opinion of the social program. Participating students in the 2014 Post-survey are in five departments. These are the Electrical and Computer Engineering Department (12 participating students), Systems Engineering and Management (7 participating students); Aeronautical engineering (7 participating students), Engineering physics (4 participating students), and Operations research (1 participating student).

We now discuss student responses to the 2014 pre-survey. Of the 30 students who responded to the pre-survey, 13 (a response rate of 43.3%) responded that they had no prior research experience. Reasons that the respondents applied to the intern program can be grouped into several themes:

- (1) Opportunity to work at AFIT
- (2) Beneficial opportunity to gain experience and skills
- (3) Being able to work with graduate level research participants
- (4) The internship would stand out on the resume

Specific reasons that the students applied are: “I worked at AFIT last year, and it was a great experience;” “I have always held the belief that the United State’s government does research into some of the most exciting fields in the world. The ability to work with the best minds in my field while getting a taste of what real STEM work (outside the classroom) is like is why I applied for this intern program;” “I thought that the internships through WPAFB would be very interesting and challenging;” “It seemed like a great opportunity to learn/network in areas related to space research. I already have some experience in space-related research but I’d like to get as much as possible as my ultimate goal is to work in the area of spacecraft control;” “WPAFB was strongly recommended as a great place to work by a fellow classmate who had done research there. From what I hear, AFIT has a great program with cutting edge technology;” “I have an interest in water distribution;” “The work done at the ANT center looks relevant to my research interests.”

Responses provided by the students describing what they hoped to accomplish in the summer 2014 can be grouped into several themes:

- (1) Gain experience of a technical internship in a technical environment;
- (2) Apply skills and knowledge learned at the student’s university;
- (3) Gain insight into graduate level studies and applications;
- (4) Gain an outlook on real life applications;
- (5) Help projects on base;
- (6) Learn something new (about technology, the student’s studies);
- (7) Become more familiar with collecting, processing, and interpreting data collected in the lab;
- (8) Make valuable connections with staff and other interns at AFIT;
- (9) Learn more programming skills.

Responses provided by the students describing how the internship is enriching their educational experience can be grouped into three themes:

- (1) The internship gives the student an opportunity to apply what the student learned in school to real-world problems;
- (2) The internship gives the student an opportunity to collaborate with several PhDs;
- (3) The internship gives the student an opportunity to do directed and independent work.

Student Observations: Outcomes Describing How the Program is Helping Students Prepare for their Futures

In the 2014 Post-survey, students were asked what was most helpful about the program. Responses can be grouped into themes:

- (1) The student has an opportunity to learn about what research is;
- (2) The student has an opportunity for networking;
- (3) The student has an opportunity to learn about expectations for working in a government position.

Specific responses provided by individual students are:

- (1) “Working in pairs help me understand more of what researching is and how to do it”
- (2) “Networking with staff and faculty at AFIT”
- (3) “It was helpful to see what I would be doing if I worked in a government position, and how the SMART program works”
- (4) “I enjoyed that this internship exposed me to areas of study outside of my major.”
- (5) “The ability to ask for help”
- (6) “The deep learning environment where each student is assigned a meaningful project.”
- (7) “Learned to use new equipment and software”
- (8) “Learned a lot of Matlab programming that I can apply to the rest of my career.”
- (9) “Everything.”
- (10) “That it exists”
- (11) “Networking with leading professors and military personnel during cutting-edge research”
- (12) “It was a great way to meet other engineers from different schools and use the knowledge I have gained from schooling in the practical work/educational environment here at AFIT”

In the 2014 Post-survey, students were asked what they were able to accomplish. Responses from the students can be grouped into themes:

- (1) The students were able to write software code (MATLAB, C, C++; graphical user interfaces; OpenCL);
- (2) The students used computer-aided design (CAD) software;
- (3) The student administered several databases;
- (4) The student helped move a lab;
- (5) The student developed technical drawings of parts and submit to the AFIT model shop for construction;
- (6) The student used lab equipment (UV Spectrometer, Agilent signal generator, Spirent GNSS8000 series signal generator);
- (7) The student wrote and edited a manuscript and read published manuscripts by other scientists and engineers;
- (8) The student conducted research;
- (9) The student met new friends, coworkers, and professionals;

- (10) The student felt proud about contributing to a program;
- (11) The student networked;
- (12) The student prepared a poster presentation;
- (13) The student learned better how to communicate with others and prepare weekly progress reports;
- (14) The student learned what it is like working for the U.S. Government.

Specific responses in which students connect their accomplishments to their futures are the following:

- (1) “Making good business connections and possibly a path to go to graduate school if I wanted to”
- (2) “Take a look inside how large research organizations operate. I was also able to see what it was like working for the U.S. Government, which was very helpful as I plan on pursuing a career in government work.”

In the 2014 post-survey, students were asked to describe how the internship enriched the student’s educational experience. Responses support the development of key attributes of **strong analytical skills, communication, high ethical standards, and professionalism** and can be grouped into themes:

- (1) The student gained skills and knowledge that are transferable to a career in the student’s field. Using the knowledge gained to better prepare for the future while still in school;
- (2) The student broadened the student’s research knowledge and coding skills to help with student’s major;
- (3) The student obtained professional contacts and references;
- (4) The student learned survival skills;
- (5) The student learned communication skills;
- (6) The student learned to use new technology;
- (7) The student learned the difference between real world problems and what is taught in the classroom.

Specific responses from students describing how the internship enriched the student’s educational experience are now listed here:

- (1) “It gave me a taste of what a career in my field will look like. I will use this knowledge to better prepare myself for my future while in school.”
- (2) “It allowed me to research a relevant topic to signal processing and gave me professional contacts in the navigation and GNSS research field”
- (3) “...this internship gave me the opportunity to work with individuals much older and much more experienced than me and glean as much information from them as possible. I also learned how to use technology I had never seen before.”
- (4) “I got experience related to the design process [of] parts/products and at least one of my designs will actually be used on a NASA payload”

(5) “My internship showed me the difference between real world problems and what is taught in the classroom. In the classroom, restrictions are placed on you to make the problems more like a test. However, in the real world, one has access to far more resources and as a result has to make far more design choices and real world problem-solving decisions.”

(6) “Allowed me to see and experience first-hand new research while developing me as a person and leader”

(7) “It showed me that learning doesn’t stop once you graduate. That in order to be great at what you do, you must put tremendous effort into your own self-education so that you can stay relevant in the modern research field.”

(8) “Work experience is a tremendously useful addition for anyone’s engineering education.”

In the 2014 post-survey, students were asked to comment on the statement: “My internship prepared me for a research career.” Specific favorable responses provided by the student are listed here:

- (1) “Gave me a sense of what it’s like to do research, and I enjoy researching new things as well as learning them.”
- (2) “I now feel like I am much more knowledgeable about the technology and information that I will be presented with as I progress in my major and future career. Hopefully I will be able to return next year and learn even more about the Computer Science field”
- (3) “I never really thought about myself as a researcher and always figured I would be better in commercial business but this has really enlightened me in a new direction and opened up many possibilities for my future”
- (4) “I know the process that needs to be taken to when doing research”
- (5) “Yes. It gave me a look into the design and implementation of research project from beginning to end.”
- (6) “Greatly improved my coding skills and experience with Aerospace-related software. Also the documentation for the programs developed will be a good experience for similar developments later.”
- (7) “Affirmed my desire to attend graduate school at AFIT”
- (8) “A glimpse at what a career would be like”
- (9) “I will be a civil engineering officer in the Air Force”

Other students responded with the following feedback:

- (1) “The research I am doing is not as engaging or educational as the research I did in high school. I feel that I could’ve been challenged more.”
- (2) “I probably will not pursue a research career, but I did learn a lot about what is involved with research”
- (3) “I am more interested in working for an aircraft company”
- (4) “I didn’t feel like I was the one doing the research, simply because it wasn’t my experiment”

Scholarships students have received, as reported in the 2014 post-survey include the Kiwanis Scholarship, Gates Millennium Scholarship, National Charity League Scholarship, Valedictorian scholarship, Undergraduate Research Scholarship at the College of Engineering at Ohio State University, and Warren G. and James M Elliott Scholarship. Scholarships students will be applying for, as reported in the 2014 post-survey are the Astronaut scholarship, Rhodes scholarship, SMART scholarship, Dayton Defense STEM Scholarship, Dayton Amateur Radio Association Scholarship, Kim and Shelley Goldenberg Hillel Scholarship, NDSEG, Tau Beta Pi Fellowship, NSF Fellowship, DAGSI award, Direct Accession Program at AFIT, and AFIT Cybercorps Scholarship for Service.

Steps to Increase Faculty Participation in the Faculty Advisor Survey

This paper also describes steps taken in 2014 to increase faculty participation in the Faculty Advisor survey administered to faculty who provided the Statements of Work to SOCHE. These steps are: (1) Rather than administering the survey in late fall (Oct/Nov), the survey is administered within 1-2 weeks after the Poster Session; (2) a hard copy of the survey is provided to the faculty in a personal visit to each faculty in the faculty office. If a faculty is out of the office, they are visited again at a different time when the faculty is in. An appointment is made if necessary, if the faculty is travelling or in many meetings; (3) Wait to see if faculty wants to fill in survey during the visit; if so, wait while the faculty completes survey. Many of the faculty have participated previously and in 2014 are filling in the survey for second or third time, and are interested in continuing to improve the program to support the students.

Faculty Responses in 2014 to the Program's Effectiveness (Student Learning through the Program)

Eleven of the 14 faculty advisors in the 2014 Summer Research Program (78.6% response rate) completed the Faculty Advisor survey. The Faculty Advisors are from the following departments: Electrical and Computer Engineering (3); Aeronautical and Astronautical Engineering (2); Engineering Physics (3); Operational Sciences (3).

In the survey, Faculty Advisors were asked to describe results the students produced. These responses can be grouped into the following themes:

- (1) Design, build, and test hardware;
- (2) Create computer software;
- (3) Prepare poster presentations and oral presentations.

These themes also support the development of key attributes of **strong analytical skills, communication, high ethical standards, and professionalism.**

Specific responses from Faculty Advisors regarding results the students produced are now listed here:

- (1) "Design, Build, and test small satellite systems called CubeSats;"

- (2) “Oral presentation of [the student’s] work to students and faculty body within [the department];”
- (3) “Configured and demonstrated operation of autonomous group and air vehicles; Supported MS research in autonomous and cooperative control;”
- (4) “Prototype Excel model for aeromedical evacuation ... planning;”
- (5) “Expanded MATLAB toolbox for controlling hardware; Produced a comprehensive literature survey for sensor fusion; Developed a jammer for Bluetooth transmissions;”
- (6) “Models of advanced semiconductors in TCAD; simulations of device operation in TCAD; Radiation measurements; Database construction and operation;”
- (7) “Creating 12 computer models; Generating machine learning algorithm; Literature review;”
- (8) “Their experimental results validate a new inverse heat transfer algorithm and shed light into the physics of unsteady flows in gas turbine engines and heat transfer;”
- (9) “Enhanced our understanding of our Lidar’s aerosol classification scheme; An outstanding poster and presentation and laid the groundwork for us to write out own aerosol classification scheme;”
- (10) “Software drivers for sensory components, algorithm wrappers; hardware integration of a small remote control system for future experiments;”

Faculty Observations in 2014: Outcomes Describing How the Program is Helping Students Prepare for their Futures

Faculty Advisors were asked to describe how the summer intern is better prepared as a result of the summer internship. These responses can be grouped into the following themes:

- (1) The student gains experience with real systems;
- (2) The student learns about graduate school;
- (3) The student gains computer skills;
- (4) The student learns written and oral presentation skills;
- (5) The student learns about the engineering environment in the DOD.

These themes support the development of key attributes of **strong analytical skills, communication, high ethical standards, and professionalism**. Specific responses from the Faculty Advisors are now listed here:

- (1) “Development experience on real systems;”
- (2) “[The student] appreciates difficulty and complexity associated with experimentation and data processing; [The student] has appreciation for what graduate school is like;”
- (3) “They gain experience with hardware, software, and theoretical research;”
- (4) The student “understands better scientific computing and the role of research in the AF and DOD;”
- (5) “They gained computer/research skills;”
- (6) The students “now have discrete even simulation or machine learning experience. Have Poster Session experience;”
- (7) “They obtained practical research experience in an academic setting. They will also be

- co-authors on two papers resulting from their work;”
- (8) “[They] have been exposed to the context in which engineering principles are applied in support of national defense.”

One faculty advisor also noted that “The three students were open to guidance and new experiences with various technologies. They commented that this was challenging and rewarding.”

Discussion

The addition of the fifth component, Counseling, has helped to increase the participation of the students and faculty in the 2014 Summer Research Program. Each of the five components introduced provides participating students with the opportunity to develop and exhibit the key attributes of **strong analytical skills, communication, high ethical standards, and professionalism**. First, as introduced in 2013 and 2014, the Joint Orientation provided students with an opportunity to communicate their background and intended project to fellow students, participating faculty, and DOD personnel. These opportunities continued for students participating in the Student Cohorts, Weekly Seminar, and Poster Session. The Poster Session provides an opportunity for the students to exhibit their technical skills and research knowledge that they have gained to fellow students, participating faculty, SOCHE leaders, and DOD personnel.

Summary and Conclusions

This paper presents the next steps to increase student and faculty participation and student learning in the transformation of all internships in the undergraduate STEM Summer Research Program in the federal government at the Air Force Institute of Technology (AFIT) to prepare students for engineering careers in the 21st century. Outcomes describing how the summer internships are helping the students to prepare for their futures are described in detail with responses from the students in detailed surveys.

In 2014, students are provided with five career broadening program components that are informed by student survey results in 2012 and 2013. Because of government restrictions, student participation is voluntary. The five components presented in this paper are (A) A joint orientation; (B) Student cohorts through social activities and STEM-based games; (C) A weekly seminar meeting; (D) A Poster Session; and the new component in 2014: (E) Counseling.

In this paper, we described the importance of the five career-broadening components, focusing on Counseling, that resulted in an increase in the student and faculty participation in 2014 during our transformation of the internships at AFIT. Students who participated in the 2014 program responded that the level of programming introduced by the five components was well received and explained how the program is helping the student prepare for their futures. Specific quotes from the students are provided as evidence to support the conclusion that the summer program, with these components, is helping the students to prepare for their futures in

the 21st century. We are pleased to report these results and look forward to working together to continue to improve the AFIT Summer Research Program.

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