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CUR Focus

Enriching Undergraduate Research at the Air Force Institute of Technology Through *COEUR* Principles

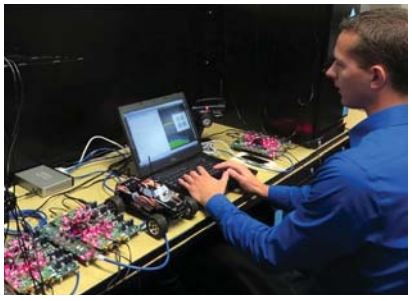
Undergraduate research programs in the United States date at least to 1969. Early programs include those at the Massachusetts Institute of Technology (1969) and Utah State University (1975) (MIT 2013; Allen, 2010). In recent years, undergraduate research programs have become widespread in both public and private institutions and include a long-standing program for civilian students at the Air Force Institute of Technology, a graduate institution of higher education focused on educating military officers (NRC 2010), as well as programs at more than 65 civilian institutions currently participating in the Research Experiences for Undergraduates (REU) program funded by the National Science Foundation (AFIT 2013: NSF 2008: NSF 2013). Indeed, more than 33 funding vehicles foster undergraduates' interest in science, technology, engineering, and mathematics (STEM) fields through various undergraduate research programs (DHS 2013; Grinnell 2013: NASA 2013a; NASA 2013b; NASA 2013c).

The benefits for students of an undergraduate summer research experience are well documented, and characteristics of excellence in undergraduate research are catalogued in the Council of Undergraduate Research publication entitled *Characteristics of Excellence in Undergraduate Research* (*COEUR*). These benefits for students include the ability to attract, retain, and develop STEM majors and steer students toward careers in STEM fields (Adhikari and Nolan 2002; Barlow and Villarejo 2004; Bauer and Bennett 2003; Boyd and Wesemann 2010; Hathaway et al. 2002; Hensel 2010; Lopatto 2004a; Lopatto 2004b; Lopatto 2007; Lopatto 2008; Lopatto 2010; Nagda et al. 1998; Russell 2005; Seymour et al. 2003; Ward et al. 2002; Zydney et al. 2002; STEM 2009). Factors critical to the success of undergraduate research are being classified (Mancha 2014).

In a typical undergraduate research program, students are provided the opportunity to pursue technical research. Some programs also include additional components in addition to the traditional research project. Such additional components include an orientation session, formation of student cohorts, a seminar, and development of students' presentation skills (Boyd and Wesemann 2010; U.S. DHS 2013; U.S. DOE 2013; Hensel 2010; Lopatto 2004a; Lopatto 2004b; Lopatto 2007; Lopatto 2008; Lopatto 2010; NASA 2013a; NASA 2013b; NASA 2013c, NSF 2008; NSF 2013). The additional components are designed to provide students with increasingly well-rounded research experiences. These experiences offer students the opportunity to learn "hands on" skills necessary to thrive in the 21st century STEM workforce where successful engineers, for example, must exhibit "human" skills in order to be effective in their careers (Mills and Treagust 2003; NAS 2007a; NAS 2007b, NAS 2010).

The Air Force Institute of Technology (AFIT) is a graduate school offering engineering and applied-science courses focused on defense-related, research-based education (AFIT 2013; NRC 2010). At AFIT, between 40 and 50 undergraduates participate annually in 12-week research internships offered from May through September to accommodate differences in the academic schedules of the students' home institutions. These summer interns work individually with faculty advisors in each of the six departments of the Graduate School of Engineering and Management at AFIT. The summer interns are referred to as SOCHE interns because SOCHE (the Southwestern Ohio Council for Higher Education) holds the government contract for the internship program and actually employs the summer students. SOCHE also is able to assess the research experiences of the summer students. SOCHE has coordinated internships for over 25 years in southwestern Ohio.

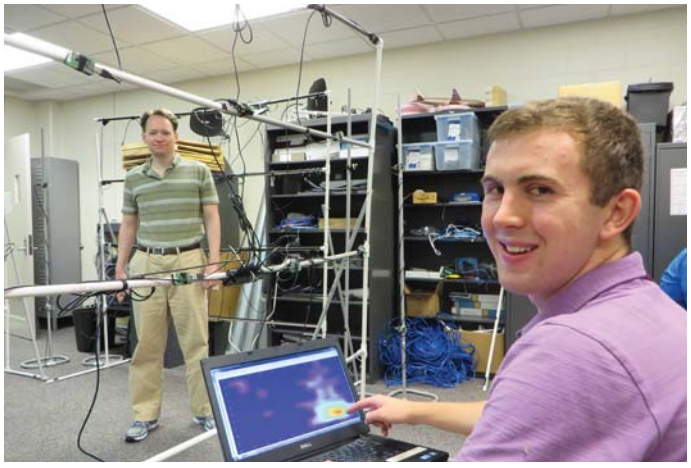
Examples of hands-on student work are shown in the photographs through-out the manuscript, several show a through-the-wall imaging network developed by two interns, Alex Folkerts and Tyler Heinl, who participated in the 2013 internship program. The student work from 2013 was used as part of a journal publication (Martin et al. 2014), significantly boosting the participating interns' resumes, as well as providing a project that could be further developed by the 2014 interns. One photo (left) shows, 2014 intern, Andrew Wallis, using software radios to jam a remote-controlled car. He is developing methods for sensing and exploiting the radio spectrum using hardware that supports flexible software radios in order to fully explore



Intern Andrew Wallis develops code for jamming wireless devices using software radios on June 5, 2014.

the capabilities of this new hardware. Below the photo shows intern, Ryan Newport, who participated in the 2014 program, using a test configuration to evaluate modifications he has made to the algorithms within the user interface.

The goals of this article are to: (1) present a comprehensive overview of two new student-assessment tools and a new faculty assessment tool; (2) discuss assessment results obtained in 2012 using characteristics of undergraduate research programs identified by *COEUR*: (3) discuss changes made to the internship program to address student feedback; (4) discuss a "rehire" assessment tool introduced by SOCHE in 2013; (5) discuss assessment results in 2013 of important characteristics identified by *COEUR*; (6) discuss how outcomes of the assessments are being used to improve the 2014 summer research program; and (7) present a summary of the findings and lessons learned from the assessment measures.



Ryan Newport, right, demonstrates the intern-developed software for radio tomographic imaging experiments on June 5, 2014.

Assessment Tools Introduced in 2012

Beginning in 2012, a survey was administered to participants before and after the undergraduates participated in the internship program. SOCHE administered an online survey to all participating students at the beginning of the summer (the "pre-survey"), before the students' research was well under way. Following the summer internships, SOCHE then administered another online survey (the "post-survey") to all participating students. Each faculty advisor is also surveyed each year following the summer program.

The pre-survey contained 21 questions, which were the same in 2012 and 2013. The post-survey contained 22 questions, which also were the same in 2012 and 2013. Both online surveys were designed to take 10 to 15 minutes to complete (Drennan et al. 2012; Drennan et al. 2013). The 21 pre-survey questions can be grouped into four main categories. The first category covered the background of the student; the second category covered the students' prior knowledge; the third category covered the student's internship; and the fourth category included questions, using a Likert scale, regarding students' knowledge of STEM programs.

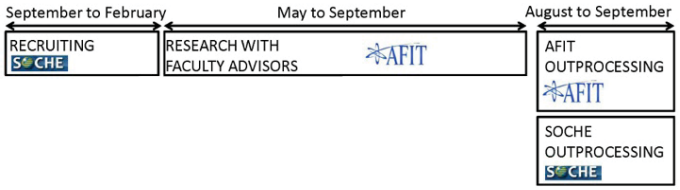
Questions in the first category inquired about such topics as citizenship, gender, institution, major, grade-point average, why the student applied to the summer research program, and the name of the department in which the student was working. Questions in the second category inquired about any prior research experience, whether the student knew about the internship program previously, and whether the student knew about SMART Scholarships. The SMART (Science, Mathematics, and Research for Transformation) Scholarship for Service Program was established by the Department of Defense "to support undergraduate and graduate students pursuing degrees in Science, Technology, Engineering, and Mathematics (STEM) disciplines." (SMART 2013).

Questions in the third category inquired about whether the student would like feedback on his or her resume/CV, what the student hoped to accomplish during the summer, whether the student planned to apply for scholarships and fellowships, how the internship was enriching the student's educational experience, whether the internship was preparing the student for a research career, and whether the student was interested in social activities with other interns. Questions in the fourth category inquired about whether the student planned to graduate with a major in a STEM field, whether the student planned to attend graduate school and attain a PhD in a STEM field, and whether the student understood avenues for obtaining funding for graduate work. Responses to questions in the fourth category were obtained using a Likert scale with the possible answers being: strongly disagree, disagree, neutral, agree, strongly agree, and N/A.

The 22 post-survey questions can be grouped into the same four categories as the categories in the pre-survey. The only differences were that the post-survey asked the students if they planned to apply for the next year's summer program (rather than if the students knew about the program previously), whether the students would apply for a SMART Scholarship (rather than whether the students knew about SMART scholarships), what the students found most helpful about the program (rather than why they applied to the program), what the students were able to accomplish (rather than what they were hoping to accomplish), and whether the internship prepared the students for a research career (rather

than if the students hoped the internships were preparing them for a research career). The one additional question in the post-survey asked the students what they thought could be changed or improved about the summer program.

Figure 1. Timeline and Structure in 2012 Summer Research Program.



The survey of faculty advisors was given to all principal investigators who signed statements of work with SOCHE in 2012 and 2013. This survey contained 15 questions, which were the same each year. The survey was designed to take approximately 5 to 10 minutes to complete. The 15 questions can be grouped into three main categories. The first category solicited general background information on the faculty member, the second category included questions related to the students, and the third category included questions related to the advising role. Questions in the first category inquired about the citizenship, gender, affiliation, department, title, whether the faculty member had previously served as a faculty advisor to summer students, and number of students supervised. Questions in the second category inquired about the student(s) of the faculty advisor, including the results the student(s) produced, whether the student(s) plans/planned to apply for scholarships and fellowships, and the preparedness of the student(s) as a result of the summer internship. Questions in the third category asked the faculty advisor what the advisor found most helpful about the summer internship program, what the advisor thought could be changed or improved about the program, whether the advisor was interested in participating in activities for the summer interns, and whether the advisor would participate in the following summer.

Assessment Results in 2012 of Characteristics Identified by *COEUR*

Several aspects of the AFIT Summer Research Program align with characteristics identified in the *COEUR* publication described above (Hensel 2012). The following section explains these characteristics in the 2012 program, with the timeline shown in Figure 2. Seven of the twelve characteristics identified by *COEUR* are shown in Table 1.

SOCHE is the students' employer and is responsible for recruiting and the steps to bring the students to work for SOCHE in the summer. Students employed by SOCHE are government contractors at AFIT performing research.

The LEADER Consortium provided $5,000 to author Lanzerotti in Year 1 for assessment -- as the LEADER Mini-Grant in 2011-2012. The LEADER Consortium is funded by an ADVANCE Institutional Transformation Award from the National Science Foundation (Award #0810989) and is a partnership of four institutions of higher education in the Dayton (Ohio) region: The Air Force Institute of Technology, Central State University, University of Dayton, and Wright State University.

SOCHE surveyed all students (N=48) in the 2012 program by email using Constant Contact. A baseline survey was sent

Table 1. Relationship of *COEUR* Best Practices and the 2012 AFIT Summer Research Program

Best Practice	*COEUR* Description (Hensel 2012)	Summer Research Program
2.2 Startup funding	p. 4: "New faculty should be awarded startup research funding to establish the necessary infrastructure and research materials to enable them to begin effective and productive research."	This project is funded through an NSF-supported $5,000 LEADER Consortium mini-grant to Lanzerotti, a first-year faculty memeber at AFIT.
2.7 Research grants office	p. 6: "Institutions should have a research grants office to keep track of and alert faculty to funding opportunities."	This project was funded through an opportunity advertised by the AFIT Office of Sponsored Programs.
3.6 Research oversight structures	p. 8: "Any institution conducting research with undergraduates needs to have certain research oversight structures in place, including an Institutional Review Board (IRB) for research projects involving human subjects."	The faculty advisor survey is given a Survey Control Number (SCN) by AFIT since there are N>20 faculty who participate each year.
5. Recognition	p. 9: "An institution that values undergraduate research as a high-priority activity that is integral to its educational mission will provide clear, tangible forms of recognition for faculty and students who engage in it."	Students who participate in the poster session are given Certificates of Excellence, and the top posters receive special recognition.
10.3 Student compensation	p. 16: "Students should receive adequate compensation for conducting summer research. ... Typical summer stipends for a 10-week, full-time research assistantship are $3,500 to $5,000."	A participating student in the Summer Research Program can receive over $6,000 for a 12-week internship.
11. Assessment activities	p. 18: "Institutions and programs of excellence will have multiple approaches to assessment to recognize success."	Faculty-advisor surveys are given to faculty following each program.
11.2 Program assessment and evaluation	p. 18: "Exemplary undergraduate research programs will ... collect assessment and program-evaluation data."	Pre-program surveys and post-program surveys are given each year to participating students.

in June, 2012 (receiving a 54.2 percent response rate), and a post-survey (39.6 percent response rate) was sent following each student's completion of the program (Lanzerotti et al. 2014).

Students who participated in the 2012 program were all U.S. citizens majoring in STEM fields with GPA's greater than 3.0 out of 4.0. More than 63 percent of the survey respondents had a GPA greater than 3.33, and approximately half of the survey respondents had research experience prior to the 2012 program. Of the survey respondents, 10 percent were female; 96 percent of the survey respondents were undergraduates, and 4 percent were graduate students. Half of the survey respondents majored in electrical engineering or computer engineering.

The students' suggestions about improvements in the program focused on four areas—a need for mentors and increased communication among the students, AFIT, and SOCHE; a need for increased interactions among students; a need for guidance to improve their resumes and better information about the SMART Scholarships (SMART 2013); and a need to gain engineering experiences, skills, and confidence in research.

The survey of faculty advisors (a response rate 62 percent) was hand-delivered to all advisors participating in the 2012 program. Of the faculty who responded to the 2012 survey, 100 percent were U.S. citizens, and 8 percent were female.

Faculty advisors reported that the students produced the following results: an upgrade to a data-acquisition system; new software code and programs to control hardware for experiments; data analysis of Yuna and Iraq sand; design and building of CubeSats, a miniaturized satellite in the shape of a cube for space research; computational modeling; the design, specification, quotes, and orders for parts for experiments; and data for a patent disclosure. The advisors reported that the students were better prepared as a result of the summer internship because they gained work experience, solved real-world problems, and learned new laboratory skills. In addition, some were accepted to graduate school.

Captain Derrick Langley (left), the 2013 AFIT Summer Poster Session Coordinator, and Maggie Varga (right), the Director of SOCHE, present "Certificates of Excellence" to SOCHE interns, Tylor Rathscak and Annamarie Price.

The advisors, however, identified several areas in need of improvement. They cited needs for centrally coordinated activities; an awards program; arrangements for housing; establishment of an orientation program; sharing of research among students and faculty; more funding; and better computer access and ability to send e-mail attachments since the interns are not issued government identification cards.

Changes Made to Address Student Feedback

Several components were added to the 2013 summer program based on students' feedback (see Tables 2 and 3).

Component 1: A joint orientation. Following the 2012 internships, an orientation was added with the intention of increasing communication among AFIT, SOCHE, and the summer students. The orientation introduces the students to AFIT, SOCHE, the expectations of the program, the AFIT library, other facilities and resources on campus, and regulations for accessing and driving on the Air Force base where the AFIT campus is located, as well as the use of cell phones. At the orientation, each student is provided with a packet of information introducing AFIT, including a copy of the American Physical Society Professional Development Resource Guide, coauthored by Lanzerotti, with information about where to obtain more resources to develop their careers (Lanzerotti et al. 2007). A pizza lunch is provided by SOCHE to welcome the students to the program.

Component 2: Developing a student cohort. Steps also were taken to increase interactions among the students. Cahill wrote a Civilian Student Survival Guide that now is given to the interns. Some general student social activities and STEM games now are coordinated regularly throughout the summer.

Component 3: A seminar. A seminar program was added to provide the students with an informal opportunity to meet and take turns presenting the results of their research and activities. Lunches held on and off campus encourage a sense of camaraderie among the students. SOCHE arranges for presentations of general interest to students, with topics including writing of CVs and resumes, information about scholarships such as the SMART scholarship, graduate school, and careers in STEM fields. The summer internship program also added work on presentation skills and development of research posters, in order to provide students with the experience of communicating their research results to an audience of other summer students, faculty, and researchers.

Component 4: Presentation and poster skills. At the conclusion of the program, we organize a small conference at which the students present their research results in a poster format to the research community. They also describe their engineering-research experiences. SOCHE provides refreshments during the poster session.

At the poster session, each student has the opportunity to present a poster that describes the goal of his or her project, the research objectives, methodology, results, analysis, and conclusion. This experience in written and oral communication is valuable for students intending to go into academia, government, or industry, all areas where they will be called on to demonstrate the ability to make an effective presentation. A certificate of participation is given to each student who prepares a poster. A poster competition is held to select the best student posters, and the students whose posters are selected receive Best Poster Certificates. The photo below shows the 2013 poster session.

Two of the posters on display at the 2013 Poster Session.

In the research literature Seymour et al. provide a list of seven categories describing the benefits to undergraduate students from their participation in research (Seymour et al. 2003). These benefits are also tabulated, for example, in Lopatto (2004b). The seven benefits are: personal/professional development; thinking and working like a scientist; development of research skills; clarification, confirmation, and refinement of career/education goals; enhanced career/graduate-school preparation; changes in attitudes toward learning and working as a researcher; and other benefits such as a good summer job and access to laboratory equipment. We charted these benefits in Tables 2 and 3 in relation to the additional components we added to the 2012 summer program—which we labeled as components 1, 2, 3, 4—based on the student and faculty feedback outlined above.

Table 2. Benefits Provided by Components 1, 2, 3, and 4 Added in Response to the Student Survey in 2012

	Student Feedback			
Seven Benefit Categories Presented by Seymour et al. (Lopatto 2004b, Seymour et al. 2003)	Increase organization & communication among SOCHE, AFIT, and students	Increase interactions with other students	Improve CV/ resume; apply for SMART scholarship	Gain engineering experience, skills, and confidence in research
Personal/ Professional	Components 2, 3, 4	Components 2, 3, 4	Components 2, 3	Components 2, 3, 4
Thinking and working like a scientist	Components 2, 3, 4	Components 2, 3, 4	Component 3	Components 3, 4
Skills	Component 4	Components 2,3,4	Components 2,3	Components 3,4
Clarification, confirmation and refinement of career/education goals	Component 3	Component 2	Components 2,3	Components 2,3
Enhanced career/ graduate school preparation	Component 3	Component 2	Component 3	Components 2,3,4
Changes in attitudes toward learning and working as a researcher	Components 2,3,4	Components 2, 3, 4	Components 2, 3	Component 4
Other benefits (a good summer job, access to lab equipment)	Components 1, 2, 3, 4	Components 1, 2, 3, 4	Components 1, 2, 3, 4	Components 1, 2, 3, 4

Assessment Tool Introduced in 2013

Starting in 2013, SOCHE administered a "rehire" survey to the 10 students in the 2013 program who also had participated in the 2012 program. This survey contained seven questions sent to the students through a link to an online survey; it was designed to take approximately five minutes to complete. Additional sections were added to allow the student respondents to provide comments with each response. The questions on this survey asked the students to rate their overall experience in each year from the perspective of gaining technical experience in their field; gaining non-technical but work-related experience, such as resume building and professional communication; interacting socially and networking with their peers; and being satisfied with administrative aspects of the program. Questions also asked whether the students would like

Table 3. Benefits Provided by Components 1, 2, 3, and 4 in Response to 2012 Faculty Advisor Survey

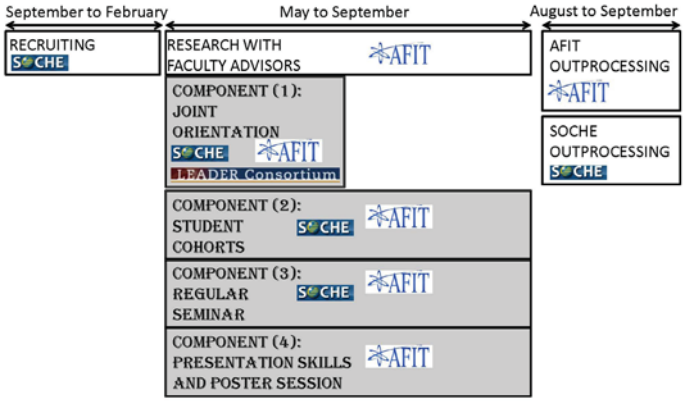
	Faculty Advisor Feedback						
Seven Benefit Categories Presented by Seymour et al. (Lopatto 2004b, Seymour et al. 2003)	Centrally coordinated activities	Awards	Housing	Orientation	Sharing of Research	Funding vehicle	Limited computer access
Personal/Professional	Components 1, 2, 3, 4	Component 4	Future	Component 1	Components 3, 4	Future	Future
Thinking and working like a scientist	Components 1, 2, 3, 4	Component 4	Future	Component 1	Components 3, 4	Future	Future
Skills	Components 2, 3, 4	Component 4	Future	Component 1	Components 3, 4	Future	Future
Clarification, confirmation and refinement of career/education goals	Components 2, 3	Component 4	Future	Component 1	Components 3, 4	Future	Future
Enhanced career/graduate school preparation	Components 2, 3	Component 4	Future	Component 1	Components 3, 4	Future	Future
Changes in attitudes toward learning and working as a researcher	Components 2, 3, 4	Component 4	Future	Component 1	Components 3, 4	Future	Future
Other benefits (a good summer job, access to lab equipment)	Component 1	Component 4	Component 1	Component 1	Components 3, 4	Future	Future

to see more or less professional programming and social programming than in the previous year and sought any additional comments the students wanted to add.

Assessment Results in 2013 of Characteristics Identified by COEUR

In the following section, we explain characteristics of the revised AFIT Summer Research Program, offered in 2013, that align with characteristics identified in *COEUR* (Hensel 2012). Figure 2 shows the timeline and structure of the 2013 Program. Characteristics identified by COEUR that align with the four components added in 2013 and 2014 are shown in Table 4. Eight of the twelve categories of *COEUR* characteristics are identified.

Figure 2. Timeline and Structure in 2013 Summer Research Program



The four components added based on 2012 feedback are shaded in Figure 2. SOCHE is the students' employer and is responsible for recruiting and for the process to hire the students at SOCHE. Students employed by SOCHE are government contractors at AFIT performing research. SOCHE introduced four components after 2012 and coordinated these components with AFIT faculty.

After the 2013 program, SOCHE again surveyed all student interns (N=43) by email. SOCHE sent each student a baseline survey in June 2013 (receiving a 33-percent response rate) and a post-internship survey (19-percent response rate) following each student's completion of the program. Students who participated in the 2013 program were also U.S. citizens majoring in STEM fields with GPA's greater than 3.0 out of 4.0. Nearly 100 percent of interns participated in orientation events (Component 1), and 13 percent participated in each of the other events (Components 2, 3, and 4) (Lanzerotti et al. 2014).

More than 71 percent of the survey respondents had GPA's greater than 3.33, and 57 percent of the survey respondents had research experience prior to the 2013 program. Of the respondents to the pre-internship survey, 14.2 percent were female, 14.2 percent were sophomores, 28.5 percent were juniors, and 50 percent were seniors (one student selected "other"). Of the respondents to the post-internship survey, 12.5 percent were female, 12.5 percent were freshmen, 12.5 percent were sophomores, 25 percent were juniors, and 50 percent were seniors (one student selected "other"). Approximately one-third of the pre-survey respondents and

post-survey respondents majored in electrical engineering or computer science.

Of the students who responded to the pre-internship survey, 71 percent were interested in participating in social activities (Component 2 and Component 3), and of the students who responded to the post-internship survey, 57 percent indicated that they were interested in participating in social activities during the internship. This decline indicates less interest following the program. Students who were interested in group social activities indicated that they would be interested in sports activities and in inviting local businesses in STEM fields to campus during the summer.

Of the responding students, all indicated "agree" or "strongly agree" in both the pre-survey and post-survey when asked if they planned to graduate with a major in a STEM field. In response to the statement, "I plan to attend graduate school in a STEM field," there was a statistically significant increase from 4.0 to 4.38 (out of 5.0 on a Likert scale) between the responses to the pre-internship and post-internship surveys. In response to the statement, "I plan to attain a Ph.D. in a STEM field," there was also a statistically significant increase in the response from 3.15 to 3.43 out of 5.0 between the pre-survey and the post-survey.

In the 2013 poster session (Component 4), nine students presented seven posters, and two posters were prepared by two students. Of the participating students, seven were male, and two were female. Four departments contributed the seven posters: students in the Department of Electrical and Computer Engineering contributed two posters; students in the Department of Systems and Engineering Management contributed two posters; students in the Department of Operational Sciences contributed two posters; and students in the Department of Aeronautics and Astronautics contributed one poster (Lanzerotti et al. 2014).

The survey of faculty advisors in 2013 was sent to 16 advisors and received a response rate of 56 percent. Among the respondents, 100 percent were U.S. citizens, and 6 percent were female. Faculty advisors reported that the students produced the following results: wrote software and graphical-user interfaces to run computer software; built hardware; collected and analyzed data related to biosensors; developed a video of a real-time implementation of software and hardware; wrote reports; and submitted journal articles and conference abstracts.

The advisors reported that the students were better prepared as a result of the summer internship because they gained hands-on experience and experience with applied independent research, as well as experience with coding software, with modeling and analysis, and with writing (including professional reports and a blog). One advisor asked the students to prepare research portfolios outlining their accomplishments so that the students could show them to potential employers. The advisors also reported that the students gained improved life skills because they gained experience with tasks such as setting up housing and making contacts with other interns.

Table 4. Incorporation of *COEUR* Best Practices into 2013 and 2014 AFIT Summer Research Programs

Best Practice	COEUR Description (Hensel 2012)	AFIT Summer Research Program
1.2 Scholarly faculty	p. 3: "It is important for faculty to be current and active scholars in their fields."	Components 1, 4
1.3 Faculty commitment	p. 3: "Faculty members must also be committed to undergraduate research as an important part of their roles and responsibilities."	Components 1, 4
1.5 Accessible opportunities for undergraduates	p. 3: "Undergraduate research opportunities should be accessible to as broad a range of students as is practical."	Components 1, 2, 3, 4
2. Administrative support	p. 4: "Administrative support and commitment are essential to sustain the undergraduate research enterprise."	Component 1, 3, 4
8.4 Community of student scholars	p. 13: "Peer-to-peer interaction in the context of a community of undergraduate research scholars provides an opportunity for student learning and for exploration of research and academic disciplines beyond their own experiences."	Components 2, 3
9.2.2 Professional skills workshops	p. 15: "Undergraduate students should receive specific training in the appropriate oral and written research communication skills, ..."	Components 3, 4
10.5 Student programming	p. 16: "Institutions should devise mechanisms to bring the summer research community together for common activities ..... In addition to social activities, educational activities for students should include professional development workshops, ethics training, and speakers on research areas and careers.	Components 1, 2, 3, 4
10.6 Summer research symposia	p. 17: "Students should have the opportunity to present the results of summer research to their peers and to faculty and administrators. Typical venues include poster session ..."	Component 4

The advisors also identified some areas in need of improvement. Two of the areas were the same as those identified in 2012, namely centrally coordinated activities and assistance with arrangement of housing for interns. New areas identified for improvement in 2013 were an expanded pool of applicants through more extensive advertising for the program; the ability to contact potential interns earlier in the recruiting process; increased pay for the interns; and an improved process to provide faculty advisors with information about applicants.

When SOCHE surveyed the 10 students in the 2013 program who also participated in the 2012 program, it received a 60-percent response rate. Of the students who responded, 33 percent rated their overall experience as "excellent" in both programs; 17 percent rated their experience as "good" in 2012, and 50 percent rated their experience as "good" in 2013. The overall rating score on this question thus improved from 3.8 to 4.2 out of 5.0 from 2012 to 2013 (Lanzerotti et al. 2014).

Of the students who responded to the question about their overall experience from the perspective of gaining non-technical but work-related experience (such as resume building and professional communication), 67 percent indicated that their experience was either "good" or "excellent" in the 2012 program, and 100 percent indicated that their experience was either "good" or "excellent" in the 2013 program. Thus the rating on this question improved from 3.7 in the 2012 program to 4.2 in the 2013 program.

From the perspective of interacting socially and networking with their peers, 67 percent of the respondents rated the 2012 program as either "good" or "excellent," and 83 percent of the respondents rated the 2013 program as either "good" or "excellent." The rating thus increased from 3.7 in the 2012 program to 4.2 in the 2013 program on a 5-point Likert scale.

Eighty-three percent of the respondents indicated that they would like to see "about the same" amount of professional programming and the same amount of social programming as in the 2013 program.

Lessons Learned

Several changes were implemented in the 2014 program for the 50 interns. During the 2014 Summer Research Program, the SOCHE coordinator was available to the interns every Wednesday morning all summer in the AFIT cafeteria, and all of the seminars were scheduled in the same room and at the same time to make it easier for students to attend. The kayaking trip was scheduled much earlier in the summer than it was in 2013, to help interns begin networking sooner. The students' advisors were encouraged to discuss the social activities with the students and to state explicitly whether or not the students could consider attendance as part of their summer employment. These changes were intended to increase students' interaction with SOCHE and with AFIT and to encourage students to participate in all the programming and to fill in the voluntary surveys about their experiences.

In summary, this article presented the strategy for and the assessed outcomes of a summer undergraduate research program at the Air Force Institute of Technology. Two important lessons were learned during the process of evaluating the program. First, the adjustments made in response to student feedback can be adapted by others running similar types of programs. For example, other programs might benefit from organizing a joint orientation among all stakeholders in a summer research program; forming student cohorts; arranging a weekly seminar; and organizing a poster session with recognition of the best posters. We are aware of a few similar components, such as poster sessions and seminars in some NSF-sponsored Research Experience for Undergraduate (REU) programs.

Second, we learned that students respond eagerly to the opportunity to present their research in a setting open to participation of faculty, students, and staff. We are taking steps with SOCHE to encourage increased participation of students in future poster sessions. In this way, students who present their research through the poster session will increase their visibility as researchers and will be exposed to technical interactions with their colleagues, which is a fundamental experience in the ongoing professional development of the students. We look forward to continuing our partnership to improve the summer research internship program.

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References

Adhikari, Ani, and Deborah Nolan. 2002. "'But What Good Came of It at Last?': How to Assess the Value of Undergraduate Research." *Notices of the AMS* 49(10): 1252-1257.

The Air Force Institute of Technology (AFIT). Accessed March 30, 2013. http://www.afit.edu .

Allen, Megan, 2010. "USU Undergrad Research Second Oldest in Nation." *Utah Statesman* (April 2). Accessed March 30, 2013. http://rgs.usu.edu/htm/news/articleID=9004.

The American Society for Engineering Education. "The Science, Mathematics and Research for Transformation (SMART) Scholarship for Service Program." Accessed March 15, 2013. http://smart.asee.org.

Barlow, Amy E. L., and Merna Villarejo. 2004. "Making a Difference for Minorities: Evaluation of an Educational Enrichment Program." *Journal of Research in Science Teaching* 41(9): 861-881.

Bauer, Karen W., and Joan S. Bennett. 2003. "Alumni Perceptions used to Assess Undergraduate Research Experience." *Journal of Higher Education* 42(2): 210-230.

Boyd, Mary K., and Jodi L. Wesemann, Eds. 2010. *Broadening Participation in Undergraduate Research*. Washington, DC: The Council of Undergraduate Research.

Drennan, Jessica, Mary Y. Lanzerotti, and Maggie Varga. "Developing Best Practices for an Undergraduate STEM Summer Research Program in a Government Institution through a Campus-Community Partnership." Presented at 2012 Ohio Teaching and Learning Conference, Nov. 9, 2012. Abstract available: http://www.soche.org/2012-ohio-teaching-and-learning-conference.

Drennan, Jessica, Mary Y. Lanzerotti, Maggie Varga, Sean Creighton, Derrick Langley, and Diana L. Cahill. 2013. "Developing Best Practices for an Undergraduate STEM Summer Research Program in a Government Institution through a Higher Education Partnership." *ASEE Annual Meeting*. Atlanta, GA.

Grinnell College. "Survey of Undergraduate Research Experiences (SURE) Survey." Accessed March 30, 2013. https://survey.grinnell.edu/se.ashx?s=251137453FF43883.

Hathaway, Russel S., Biren A. Nagda, and Sandra R. Gregerman. 2002. "The Relationship of Undergraduate Research Participation to Graduate and Professional Educational Pursuit: An Empirical Study." *Journal of College Student Development* 43(5): 614-631.

Hensel, Nancy, Ed. 2012. *Characteristics of Excellence in Undergraduate Research* (COEUR). Washington, DC: The Council of Undergraduate Research. Accessed March 30, 2013. http://www.cur.org/assets/1/23/coeur_final.pdf.

Lanzerotti, Mary Y., John Orrell, and Brian D'Cruz. 2007. "American Physical Society Professional Development Resource Guide," American Physical Society (APS). Accessed March 30, 2013. http://www.aps.org/careers/guidance/ upload/professional_development.pdf.

Lanzerotti, Mary Y., Maggie Varga, Sean Creighton, Derrick Langley, Diana L. Cahill, and Richard K. Martin. 2014. "Transforming Undergraduate STEM Summer Internships in a Federal Government Institution for 21st Century Engineering Careers." *ASEE Annual Meeting*. Atlanta, GA.

Lopatto, David. 2004a. "Survey of Undergraduate Research Experiences (SURE): First findings." *Cell Biology Education* 3: 270-277. Accessed March 30, 2013. http://www.lifescied.org/content/3/4/270.full.pdf+html.

Lopatto, David. 2004b. "What Undergraduate Research Can Tell Us About Research on Learning." *Washington, DC: Project Kaleidoscope* IV. Accessed March 30, 2013. http://www.pkal.org/documents/Vol4WhatUndergradResearch CanTellUs.cfm.

Lopatto, David. 2007. "Undergraduate Research Experiences Support Science Career Decisions and Active Learning." *CBE – Life Sciences Education* 6(4): 297-306. Accessed March 30, 2013. http://www.lifescied.org/content/6/4/297.full.

Lopatto, David. 2008. "Exploring the Benefits of Undergraduate Research: The SURE survey." In *Creating Effective Undergraduate Research Programs in Science*, edited by R. Taraban and R. L. Blanton, 112-132. NY: Teacher's College Press.

Lopatto, David. 2010. *Science in Solution: The Impact of Undergraduate Research on Student Learning*. Tucson: The Research Corporation. Accessed March 30, 2013. http://www.grinnell.edu/files/science_in_solution_lopatto.pdf.

Mancha, Ruben, and Carol Y. Yoder. 2014. "Factors Critical to Successful Undergraduate Research." *CUR Quarterly* 34(4): 38-45.

Martin, Richard K., Alex Folkerts, and Tyler Heinl. 2014. "Accuracy vs. Resolution in Radio Tomography." *IEEE Transactions on Signal Processing* 62 (10): 2480-2491.

The Massachusetts Institute of Technology. *MIT's Undergraduate Research Opportunities Program*. Accessed March 30, 2013. http://web.mit.edu/urop/basicinfo/index.html.

Mills, Julie E. and David F. Treagust. 2003. "Engineering Education – Is Problem-Based or Project-Based Learning the Answer?" *Australasian Journal of Engineering Education*. Accessed March 30, 2013. http://www.aaee.com.au/journal/2003/mills_treagust03.pdf.

Nagda, Biren A., Sandra R. Gregerman, John Jonidas, William von Hippel, and Jennifer S. Lerner. 1998. "Undergraduate Student-Faculty Research Partnerships Affect Student Retention." *Review of Higher Education* 22(1) 55-72.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine. 2007a. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine. 2007b. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, Revisions. Washington, DC: The National Academies Press.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine. 2010. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. Washington, DC: The National Academies Press.

National Aeronautics and Space Administration (NASA). 2013a. "NASA Langley Undergraduate Student Research Program (USRP)." Accessed April 18, 2013. http://usrp.usra.edu/about/.

National Aeronautics and Space Administration (NASA). 2013b. "Internships at NASA Goddard." Accessed April 18, 2013. http://www.nasa.gov/centers/goddard/education/internships.html.

NASA Jet Propulsion Laboratory (NASA). 2013c. "Internships and Fellowships at JPL. Accessed April 18, 2013. http://www.jpl.nasa.gov/education/index.cfm?page=313&pt=internship&d=&el=&p=Summer&c=&dur=&x=49&y=4 .

National Research Council. 2010. *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*. Washington, DC: National Academy Press.

National Science Foundation (NSF). 2008. "Research Experiences for Undergraduates (REU) in the Directorate for Engineering (ENG): 2003-2006 Participant Survey, NSF08-XXX." (Arlington, VA). Accessed March 30, 2013. http://www.nsf.gov/eng/eec/EEC_Public/REU.pdf.

National Science Foundation (NSF). 2013. "Research Experiences for Undergraduates (REU) Sites." Accessed March 30, 2013. http://www.nsf.gov/crssprgm/reu/list_result.cfm?unitid=5044.

National Science Foundation (NSF). 2014. "ADVANCE Institutional Transformation Award, NSF Award #0810989." Accessed March 30, 2013. http://www.nsf.gov/awardsearch/showAward?AWD_ID=0810989.

Russell, Susan H. 2005. *Evaluation of NSF Support for Undergraduate Research Opportunities: Survey of STEM Graduates*. Arlington, VA: SRI International. Accessed March 30, 2013. http://csted.sri.com/projects/evaluating-benefits-undergraduate-research-opportunities-uro-nsf.

Seymour, Elaine, Anne-Barrier Hunter, Sandra L. Laursen, and Tracee DeAntoni. 2003. "Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-Year Study." *Science Education* 88(4): 493-534.

SMART Scholarships. Accessed March 15, 2013. http://www.smart.org/.

Southwestern Ohio Council for Higher Education (SOCHE). SOCHE website. Accessed March 30, 2013. https://www.soche.org.

Southwestern Ohio Council for Higher Education (SOCHE). "SOCHE Intern." Accessed March 30, 2013. http://www.socheintern.org.

STEM Development Office. 2009. *Department of Defense Science, Technology, Engineering, and Mathematics STEM Education and Outreach Strategic Plan*, 2010-2014. Washington, DC: Office of the Secretary of Defense.

U.S. Department of Energy (U.S. DOE). 2013. "STEM Internships, Fellowships, and Mentoring." Accessed April 18, 2013. http://energy.gov/diversity/stem-careers-and-engagement.

U.S. Department of Homeland Security (U.S. DHS). 2013. "National HS-STEM Summer Internship Program." Accessed April 18, 2013. http://www.dhs.gov/national-hs-stem-summer-internship-program.

Ward, Christine, Joan S. Bennett, and Karen W. Bauer. 2002. "Content Analysis of Undergraduate Research Student Evaluations," Accessed March 30, 2013. https://www.sarc.miami.edu/ReinventionCenter/Public/ assets/files/contentAnalysis.pdf.

Wright State University. "LEADER Consortium Mini-Grant National Science Foundation Award #0810989." Accessed March 30, 2013. www.wright.edu/leader.

Zydney, Andrew L., Joan S. Bennett, Abdus Shahid, and Karen W. Bauer. 2002. "Impact of Undergraduate Research Experience in Engineering." *Journal of Engineering Education* 91(2): 151-157.

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