# Innovation Leadership Honors Program: Addressing Engineering Education Needs through Curriculum Enhancement

Karl K. Stevens, Tim VanEpps, Sharon M. Schlossberg, Ankur Agarwal, and Georgiana L. Hamza-Lup
Florida Atlantic University, {stevens, tvanepps, sschloss, aagarwa2, ghamzal} @fau.edu

*Abstract* – **The emerging challenges of the "engineer of 2020" have been clearly identified and extensively discussed. It has become evident that there is a crucial need for change in the practice of engineering and the education of future engineers. Specifically, engineering disciplines need to be broadened and enriched to better prepare graduates for working in a constantly changing global economy. In response to these challenges, the Executive Advisory Council of the College of Engineering and Computer Science undertook the task of advising the College on the strategic changes needed in the engineering curricula. As a result a new program was conceptualized and designated by Florida Atlantic University as the *Innovation Leadership Honors Program*. This program, which we believe to be the first of its kind, was designed as an overlay for our existing curricula in engineering and computer science, and is intended to provide a select group of students an enhanced background and training in innovation, entrepreneurship, leadership, and communication. Program content, criteria and procedures for selection of student participants, Advisory Council participation in delivery of the program, and other administrative details are described in the paper.**

*Index Terms* – Assessment, Engineer of 2020, Entrepreneurship Program, Innovation Curriculum

## INTRODUCTION

Advances in technology and globalization are having a dramatic impact on the engineering practice and education. Technical expertise has become more of a commodity, available elsewhere in the world, at costs often lower than those in the U.S. Increasingly, design and manufacture are being done elsewhere, with emphasis in the U.S. shifting more toward the "softer" sides of engineering. As a consequence, the requirements of the engineering profession have expended beyond its domain, blurring the boundaries between disciplines, specifically with the management and leadership fields. Future engineers are required to develop an enhanced understanding of non-engineering disciplines such as business and bio-medicine, and to comprehend the impact of engineering on the environment and the economy. In addition, engineers must be exposed to social issues such as international relations, intellectual property laws and national security.

The emerging requirements of the "engineer of 2020" have been clearly identified and extensively discussed in the engineering communities [1], [2], [3]. It has become evident that there is a crucial need for change in the practice of engineering and the education of future engineers. Specifically, engineering disciplines need to be broadened and enriched to better prepare graduates for working in a constantly changing economy driven by the explosion of knowledge, globalization, and a myriad of other factors described aptly in Thomas L. Friedman's book, "The World is Flat" [4]. Every College of Engineering in the U.S. is wrestling with this paradigm shift.

To address this need, the Dean of the College of Engineering and Computer Science (CoECS) at Florida Atlantic University (FAU), in collaboration with the College Executive Advisory Council (EAC), has taken the initiative to craft a new program, the Innovation Leadership Honors (ILH) program that implements the changes required in the education of future engineers. Given that these changes were needed in all engineering fields and drastic curriculum modifications are exceedingly difficult to accomplish, the program was designed as an "overlay" that builds on current engineering programs with a minimum intrusion upon existing curricula. We believe this initiative is unique and places the College at the forefront of innovations in engineering education. Many colleges across the nation have addressed some of the recent engineering challenges by introducing additional course-work in the areas of management, leadership, innovation and entrepreneurship. However, no one has provided as comprehensive and coordinated a solution to these future engineering needs as the program proposed by CoECS at FAU. The program began in Fall-2008 with an initial group of 26 students.

The broader impact of this program is strengthening the knowledge and proficiency of the future engineering workforce. To maintain US leadership in technological innovation in a global economy, we must address the future needs of the engineering profession [5]. The ILH program is targeted towards enhancing and enriching engineering education to better address the challenges of the "engineer of 2020". It uses an educational approach that gives engineering students a broader background that goes beyond technical aspects and introduces them to critical issues such

as leadership, innovation, entrepreneurship. This more holistic approach to engineering emphasizes the importance for engineers to comprehend the interactions between engineering and non-engineering aspects of a system [6].

The remainder of this paper is organized as follows. Section 2 presents the ILH program conception and objectives. Program course descriptions are provided in Section 3. Program assessment and criteria for selection of student participants are described in Section 4. The Advisory Council participation in the delivery of the program and other administrative details are described in Section 5. Finally, Section 6 concludes the paper.

## PROGRAM OVERVIEW

Design of our program rests heavily upon our experiences with our highly successful Students to Engineering Practice (STEP) program, an NSF sponsored project that started July 2000 and ended in July 2008. It provided enhanced professional development opportunities, along with a variety of student support activities that resulted in a near-perfect retention rate. The details and the results of the STEP program have been previously disseminated [7]. In this paper our focus is to discuss only the three concepts that were adopted into the ILH program, specifically, a tighter integration between academia and industry, a closely monitored student cohort of size thirty, and an emphasis on module-based teaching.

The notions of a paid internship in industry, supported by the College's industry, business and community partners, as well as, academic support and professional development activities in the form of a four-semester sequence of one semester-credit Leadership Development Workshop courses are direct products of the lessons learned during our eight-year project with NSF. With regard to mentoring cohorts, a class size of thirty is small enough to enable a high level of personal attention, yet large enough to be able to divide the class into a reasonable number of working teams. The emphasis on module-based teaching will mandate utilization of team-teaching approaches and methods within the program courses. Appropriate teaching teams will involve multiple faculty members and instructors, partners, and mentors provided by the College's industrial, business, government, and service community partners. This approach provides lower student-to-faculty ratio and exposes students to instructors with a variety of backgrounds, experiences, and professional points of view.

### I. *Program Conception*

In 2005, the Advisory Council of the CoECS at FAU undertook the task of advising the College on the strategic changes needed to help ensure that their graduates were prepared for the workplace of tomorrow. They appointed a marketing specialist to lead a year-long planning process that utilized research, surveys, personal interviews, and focus groups. The specialist had a vast experience in concept development and testing, marketing strategy and planning, in various economic sectors such as, technology, automotive, consumer products and healthcare among others. A diverse group of people, with various backgrounds and areas of expertise, were engaged in the program planning process. Participants included faculty from various colleges, and business, education, and community leaders locally and across the country. During this process of identifying the future engineering needs, it became evident that curriculum changes needed to be infused in all engineering disciplines.

With regard to curriculum, the Council recognized the technical strengths of our existing curricula and wanted to maintain these. However, they also wanted to provide a select group of students with enhanced background and training in innovation, entrepreneurship, leadership, and communication. Realizing that curriculum change is exceedingly difficult to accomplish, they proposed that this additional background be accomplished through an "overlay" to our existing curricula (shown in Figure 2).

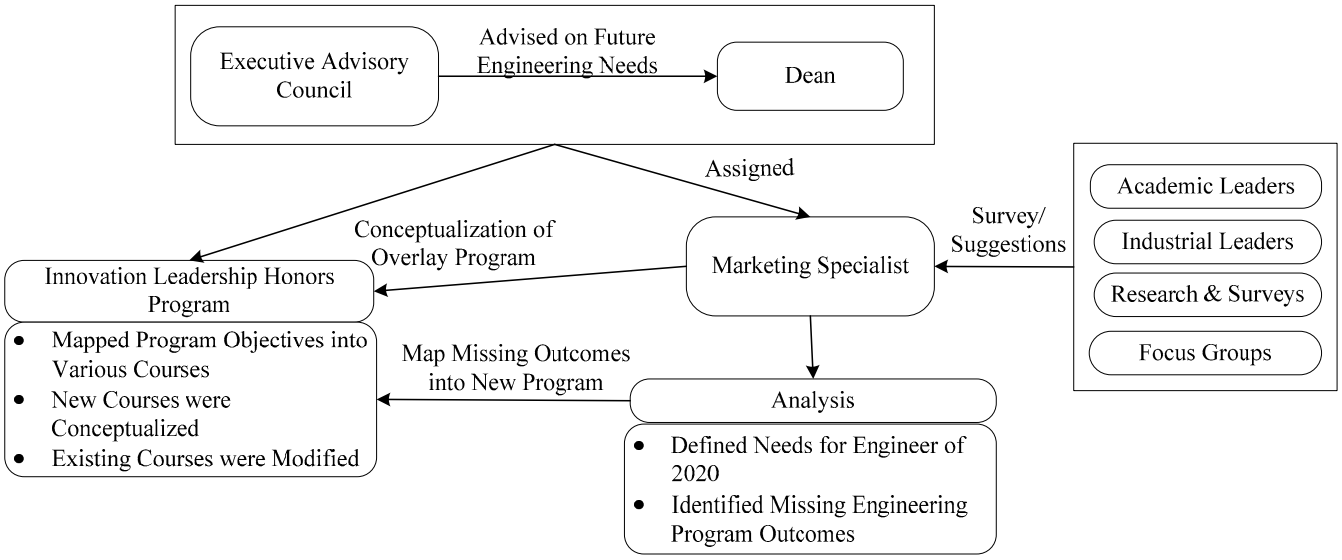


FIGURE 1. ILH PROGRAM CONCEPTION PROCESS

*II. The "Overlay" Concept*

While genius in nature, the "overlay" concept is challenging to design and implement. We worked for more than a year to craft an overlay that fits with the diversity of programs in our College and has minimum intrusion upon existing curricula. Designing a new minor as opposed to an overlay program would have resulted in a substantial increase to the number of credits required for graduation. Therefore, such an approach would have been less appealing to students, as it would increase the length of their undergraduate studies. In contrast, using the "overlay" concept, the ILH program infuses its new components into existing core engineering courses common to all engineering disciplines. These new, enhanced courses will count as replacements for the existing courses in the current engineering curriculum, thus requiring student participants to complete few, if any, additional credit hours. Thus, the advantage of the "overlay" is two fold: first, it minimizes the additional credit requirement; second, it enriches all engineering disciplines.

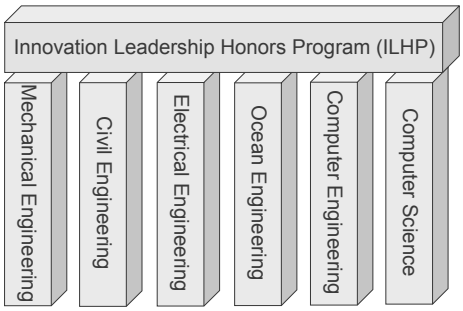


FIGURE 2. INTEGRATION OF ILH PROGRAM AS AN OVERLAY ON EXISTING ENGINEERING PROGRAMS

*III. Program Objectives*

During the ILH program conception process, the Dean, the EAC and our marketing specialist worked on identifying the program objectives and outcomes that were missing from the current engineering programs. These objectives were then mapped into a set of new courses which formed the ILH program overlay illustrated in Figure 2. These objectives are:

1. To provide students with knowledge and experience in the area of leadership and leadership development
2. To provide students with entrepreneurial coursework and introduce them to entrepreneurial activities
3. To provide students with an understanding of the principles of sustainability and sustainable development
4. To emphasize on developing creativity and ingenuity
5. To expose students to social issues such as international relations, intellectual property and national security
6. To provide students with fundamental knowledge of biology, in addition to chemistry and physics
7. To expose students to non-engineering disciplines such as business, medicine and social sciences
8. To provide students with enhanced soft and interpersonal skills
9. To provide students with enhanced verbal and written communications skills

**PROGRAM DESCRIPTION**

Innovation Leadership scholars must complete both the degree requirements of their major and the special requirements of the ILH program. These requirements consist of a combination of existing and new courses, a Leadership Development Workshop series, and special enrichment activities. The descriptions of the ILH program courses and objectives they achieve are provided below.

***Technical Writing (3 credits)*** will substitute the current required course (***College Writing II)***. It will expand on the College Writing II curriculum by emphasizing on the writing skills needed by engineering professionals, such as writing technical reports, manuals, specification documents, and technical object and process descriptions. Course outcomes include familiarization with the tools and technologies of contemporary technical writing, and content, organization, format, and style of specific types of engineering documents. (Program objectives achieved: 8, 9.)

***Fundamentals of Engineering (3 credits)*** is an existing, well-established engineering-majors course numbered EGN 1002. ILH program students will be required to enroll in a special section of this course emphasizing a "systems approach" to show the integrated and interconnected nature of the seemingly disparate parts of an engineering problem. The course demonstrates that fundamentals are common to all disciplines and exposes students to the value of modeling and systems analysis in the design process. The intent is to provide students with an even-handed exposure to all engineering disciplines to help them determine which discipline best matches their needs and interests. (Program objectives achieved: 4, 8.)

***Biology for Engineers (3 credits)*** is a new course developed in collaboration with the College of Science. Demand for engineers with knowledge of biology is growing rapidly, fueled by environmental concerns and by growth in the biomedical and health care industries. Engineering skills ranging from design of micro robots to pattern recognition and large-scale data analysis are of crucial importance in these areas. This course introduces cells as robust complex networks of genes and proteins and adopts a systems view to discuss communication of cells with other cells and with the external environment. (Program objectives achieved: 6, 7.)

***Green Engineering (3 credits)*** is a new course that will introduce the concept of sustainable design as a necessary tool for producing places, products and services in a way that reduces the use of non-renewable resources, minimizes environmental impact, and relates people with the natural environment. Tools such as life cycle assessment and life cycle energy analysis will be introduced as appropriate means to judge the environmental impact or sustainability of various design choices. This course will also expose students to sustainability leaders who aim to integrate social, environmental and competitive financial returns through

their products, services and other business practices. Students are required to develop an engineering project using the principles of sustainability. (Program objectives achieved: 3, 4.)

***Economics of Sustainable and Regenerative Engineering (3 credits)*** is a new practice-oriented course presenting a wide variety of analysis tools as appropriate means to judge the technical, social, environmental, and financial aspects of various design choices. Topics presented include: analyzing the relationship between our economic system and environmental and social sustainability, uses of monetary valuation and cost-benefit analysis for valuing market and non-market ecosystem and social services, analyzing the causes of environmental degradation and social problems, and measuring sustainable development. (Program objectives achieved: 3, 5, 7)

***Leadership Development Workshops (1-3 credits)*** is a sequence of workshops based on the well-tested Professional Development Workshops we developed and have delivered for eight years as part of the Students to Engineering Practice (STEP) program. These will be refinements of the existing courses, EGN 3937 and EGN 4937, with continued heavy reliance on outside speakers and facilitators, team exercises and projects, and special assignments. Our plan is to hold these sessions in an FAU TV studio and record them for future reference. Each student is required to maintain an electronic portfolio covering their activities. (Program objectives achieved: 1, 4, 5, 8, 9.)

***Innovation & Entrepreneurship (3 credits)*** is a new course that replaces the existing ***Senior Design I*** course, EGN 4410C. It presents the core issues involved in the decision to pursue an entrepreneurial vision. The first part of the class addresses the creativity, critical thinking and innovation necessary to generate new places, products, or services as well as how to evaluate the true opportunities. Next, the need to handle issues including risk versus return, business structure, and intellectual property is explored. Thirdly, operational and organizational issues such as marketing and sales will be presented. Fourthly, the financial plan, exit strategy, and funding opportunities are covered. Finally, student teams develop and present to potential sponsors a proposal for a venture funded team project. Entrepreneur/Industry mentors are provided for each student team. (Program objectives achieved: 2, 4, 5, 7, 9.)

***Venture-Funded Team Project (3 credits)*** is a new course replacing the existing ***Senior Design II*** course. It provides the opportunity for student teams to implement their proposals developed in the ***Innovation and Entrepreneurship*** course. Results are presented in written reports and through oral presentations to project sponsors and a broad audience of other interested individuals. (Program objectives achieved: 1, 2, 4, 5, 8, 9.)

***Enrichment Experience (1-3 credits)*** is intended to be a distinctly collaborative effort between an individual student, the University through the Center for Innovation Leadership, and a University partner providing the enrichment experience. The effort starts with an appropriate proposal agreed to by all parties that defines the scope of work to be accomplished and a schedule for completion of the effort. Proposed deviations from the original proposal will have to be negotiated by the collaborating parties. Each student is required to satisfactorily complete a semester-long internship/service learning/research/or international experience (normally over the summer between the junior and senior years). A written report and oral presentation of their work and experiences is required. (Program objectives achieved: 1, 4, 8, 9.)

## PROGRAM ASSESSMENT

As in our highly successful STEP program, cohort groups of thirty students are expected to enter the ILH program each year, building to a total enrollment of approximately 150 participants when the program is fully implemented. This number represents approximately 10% of our current undergraduate enrollment. Being an Honors program in the CoECS, the ILH program is designed to allow only the outstanding students to enter into the program. In addition, providing industry advisors that can closely mentor all ILH program students, poses a challenge in expanding the program to all engineering students.

*I. Student Selection*

To be eligible for the ILH Program students must satisfy the following entry requirements:

a) be accepted into a CoECS program (they may enter the ILH program in their freshman or sophomore year; juniors and transfer students may enter, but may need to make up for some program requirements)
b) submit a written application, including a statement of interest documenting their leadership and/or innovative aspirations, activities, and experiences, and three letters of reference attesting to their character and potential fit with the program
c) pass a personal interview with a four-person selection committee, including a representative from industry and sign a Student Agreement Form covering program benefits and student obligations and responsibilities

Student selection will not be based upon academic performance alone. We do not wish to overlook candidates whose personal attributes and passion for innovation and entrepreneurship overshadow their past academic performance. Therefore, the selection process involves two criteria: (1) evidence of leadership skills and innovative capabilities and (2) academic performance: High School non-adjusted GPA above 3.0 and/or SAT scores above 1100.

*II. Assessment Process*

The program assessment process is based on ABET guidelines [8] and has been expanded through the involvement of the College EAC, which together with the Program Director form the Assessment and Improvement Committee (AIC). AIC is responsible for collecting various data as shown in Figure 3, and for making recommendations and proposing changes to the program and its courses. Table 1 summarizes the assessment forms, their flow and objectives.

For each course module taught, faculty associate the desired Program Outcomes and Performance Criteria (POPC) with a set of test methods, such as assignments, projects, exams, discussions and presentations. Using these methods faculty assess each student's performance in the course and assemble this information in a Student Achievement of Outcomes Form (SAOF). For courses that require industry mentors, each student is also evaluated by their Industry Advisor. Based on their extensive industry experience, these advisors complete for each student a Student Evaluation Form (SEF) that characterizes the students in terms of industry related skills such as communication, leadership, teamwork, organization and planning.

Student Advisors collect and maintain the SAOF for each course and the SEF for each student. Based on these forms the advisors will summarize the data for each student, so that they can check student progress, assign future courses and recommend supplemental instruction in case of unsatisfactory performance. The SEF is further passed to AIC for their review of student progress.

The statistics compiled from each SAOF is used by faculty to prepare the Faculty Comments for Course Improvement Form (FCCIF) at the end of each semester. Through this form each faculty provide comments about the course taught and future course improvements.

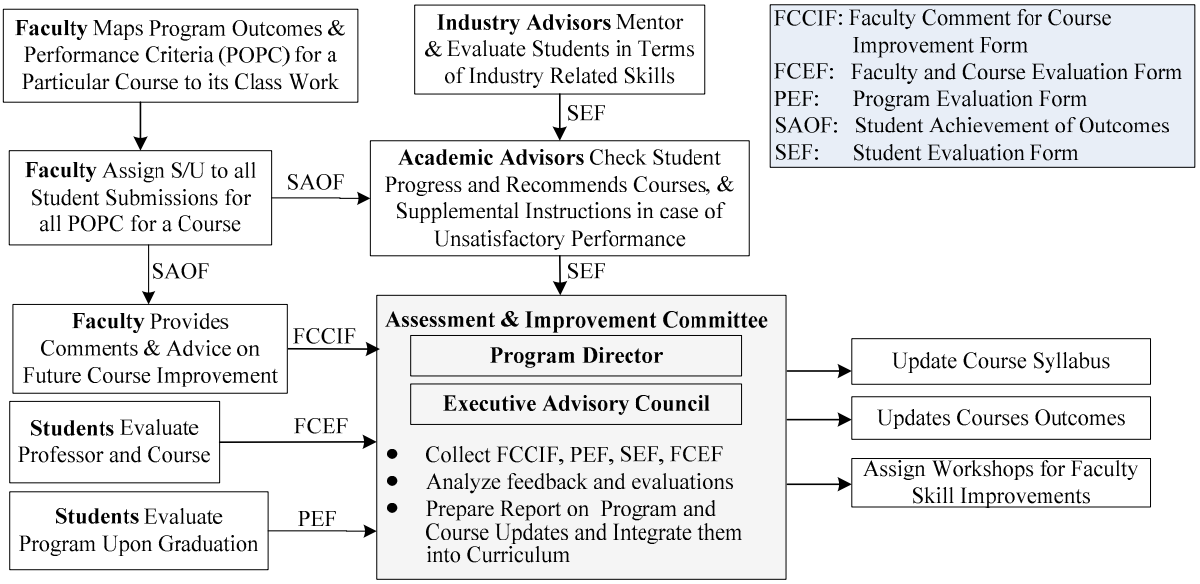


FIGURE 3. PROGRAM ASSESSMENT PROCESS

TABLE 1
FORM CATEGORIZATION, FLOW AND OBJECTIVES

| Evaluator | Evaluated | Form Name | Measurement Type | Objectives |
|---|---|---|---|---|
| Student | Faculty & Course | FCEF | Qualitative | This form is divided in two sections, faculty evaluation & course evaluation, and allows students to express their opinions about the course content and teaching effectiveness. |
| Student | Program | PEF | Qualitative | This is a standard university form that all students must complete upon graduation. In this form there is a supplement that contains ILH program specific information and is submitted only to the AIC. Through this form students can express their opinion and experience with the program as a whole. |
| Faculty | Course | FCCIF | Qualitative & quantitative | This form is a part of the continuous improvement effort. It allows faculty to make comments about their experiences with the students in the class. For example, it evaluates whether students had the right background, if they progressed well through the class, and if the objectives specified in the course syllabus were achieved. In addition, future recommendations for course improvement, such as additional references, textbook changes, course content changes, are made. Statistics from SAOF are compiled and included in this form, such as, the % of students that satisfied course objectives. |
| Faculty | Students | SAOF | Quantitative | This form allows faculty to evaluate if students have achieved the course outcomes. |
| Industry Advisor | Students | SEF | Qualitative | This form is used by industry advisors to assess student skills and performance in practical projects or work environment. Specific skills evaluated are: communication, critical and innovative thinking, leadership and teamwork, organization and planning. |

After each course, students complete a Faculty and Course Evaluation Form (FCEF) which is based on student perception of teaching. Upon graduation, each student is required to complete a Program Evaluation Form (PEF) based on students experience through out the program. The results from the FCEF and PEF forms (from all students) are compiled into statistics representing quantitative measures of faculty and course effectiveness and program achievement of outcome.

Based on the forms collected from students (FCEF, PEF), faculty (FCCIF) and academic advisors (SEF), the AIC will evaluate the program and prepare a report on program, faculty, and course effectiveness. Based on this report the program director would implement suggested program and course improvements.

## PROGRAM ORGANIZATION AND MANAGEMENT

Dr. Maria Petrie, Associate Dean for Academic and International Affairs, will assist with program and course approvals. Dr. Karl Stevens, Dean, will handle communications and interactions with the College's EAC and with other interested governmental and corporate entities. Mr. Tim VanEpps, Associate Director of the Center for Innovation Leadership has overall management responsibility for the ILH Program. Dr. Sharon Schlossberg will help provide student support, assistance and mentoring. She will be responsible for recruitment and selection of student participants and will assist with development and delivery of the Leadership Workshop series. Our Division of Engineering Career Development will assist student participants with arrangement of internships and employment upon graduation.

Dean's EAC, the original "architects" of the ILH Program, are heavily involved in the execution of the program. Members of this Council are individual mentors for the current class of IHL students. They have initiated a "Lunch & Learn" speaker series wherein members of the Council and other community business representatives will provide lunch and a speaker once a month at the University on a variety of topics related to the program objectives. The topics include: "Team Building and Team Work", "Corporate Culture and You", "Professional Portfolios and Developing a Career Plan" and "Knowing Yourself –True Colors" among others. This series has been an effective mean of linking students with industry and helping them understanding its environment and requirements. Further, the expertise of experienced industry leaders is brought into the classroom, with the help of the EAC that provides guest lecturers for specific classroom topics. In addition, the Council is involved in the assessment and continuous improvement process of this program.

## CONCLUSION

The program described in this paper is targeted towards enhancing engineering education to better address the challenges emerging in the engineering profession. The program objectives are to provide engineers with enhanced background and training in innovation, entrepreneurship, leadership, and communication, needed to be successful in a continuously changing global economy. The "overlay" concept used in the design of the program is as an innovative approach that allows infusion of additional skills into all engineering disciplines with a minimum additional credit requirement. The paper further evolves and discusses an integrated program assessment and continuous improvement process. The program has a strong support from the EAC, which is involved in program delivery, assessment and continuous improvement. EAC ensures adequate industry experience and mentoring for each participating scholar.

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## AUTHOR INFORMATION


**Karl K. Stevens,** Dean, College of Engineering and Computer Science, Florida Atlantic University, stevens@fau.edu.

**Tim VanEpps,** Director, Innovation Leadership Honors Program, College of Engineering and Computer Science, Florida Atlantic University, tvanepps@fau.edu.

**Sharon M. Schlossberg**, Assistant Director, Innovation Leadership Honors Program, College of Engineering and Computer Science, Florida Atlantic University, sschloss@fau.edu.

**Ankur Agarwal,** Assistant Professor, Department of Computer Science and Engineering, Florida Atlantic University, aagarwa2@fau.edu.

**Georgiana Hamza-Lup,** Visiting Assistant Professor, Department of Computer Science and Engineering, Florida Atlantic University, ghamzal@fau.edu.