MAKER: 48-hour Rapid Prototype Development

Mr. Rodney Boehm, Texas A&M University - Dwight Look College of Engineering

Rodney Boehm has joined the Engineering Academic and Student Affairs (EASA) team as an Industry Mentor with very broad experiences, including the creation of a telecommunications standard for the fiber optics industry that is still in use internationally over 25 years later, a wide variety of business experiences in an international company, and start up experience that have helped him hone his ability to quickly determine a direction and execute to it.

He is also formerly the Chief Operating Officer for GroundFORCE, a company that specializes in a unique patented construction technology. His extensive experience in running sales, marketing, manufacturing, and large multi-national organizations was applied to introducing this new technology to the construction industry.

Formerly he was a Senior Vice President of Fujitsu Network Communications, headquartered in Richardson, Texas. With over 30 years of experience in telecommunications, Rodney was responsible for developing partnerships with leading network technology providers and driving marketing efforts for optical, access and data products developed by Fujitsu. Along with Yau Chow Ching, Rodney conceived (and wrote the standards for), the SONET (Synchronous Optical Network) architecture, which served as the base for today's North American telephone network. Rodney was Chairman of the T1X1 Technical Sub-Committee (the organization responsible for SONET standardization) from 1990 through 1994. He has been active in SONET's National and International Standardization since 1985. In addition, Rodney has published numerous papers and presentations on SONET.

Rodney began his career with Fujitsu Network Communications in 1989 as the Director of Strategic Planning. He also held the positions of Director of Transport Product Planning, Vice President of Business Management, Senior Vice President of Sales Management, Senior Vice President of Manufacturing, and Senior Vice President of Business Development. Before joining Fujitsu, Rodney worked for Bell Laboratories, Bellcore (now Telcordia), and Rockwell International. He earned both his bachelor's and master's degrees in electrical engineering at Texas A&M University.

Ms. Magdalini Z Lagoudas, Texas A&M University

Magda Lagoudas, Executive Director for Industry and Nonprofit Partnerships, Dwight Look College of Engineering, Texas A&M University. Mrs. Lagoudas holds a BS and MS in Mechanical Engineering. She worked for the State of New York and industry before joining Texas A&M University in 1993. Since then, she developed and taught courses in the Departments of Mechanical Engineering and Engineering Technology. In 2001, she joined the Spacecraft Technology Center as an Assistant Director where she was responsible for the structural and thermal analysis of payloads. She served as Director of the Space Engineering Institute and in 2010 she accepted a position with the Academic Affairs office of the Dwight Look College of Engineering where she oversaw outreach, recruiting, retention and enrichment programs for the college. Since 2013, she serves as the Executive Director for Industry and Nonprofit Partnerships with responsibilities to increase opportunities for undergraduates engineering students to engage in experiential learning multidisciplinary team projects. These include promoting capstone design projects sponsored by industry, developing the teaching the Engineering Projects in Community Service course, and developing curricular and co-curricular programs at the Engineering Innovation Center which promote innovation and entrepreneurship among engineering students and in collaborations with other colleges on campus and partnering with other institutions across the country.

Designing an Intensive Innovation Experience – Aggies Invent

Background

In 2013, the National Academy of Engineering publication, *The Bridge: Linking Engineering and Society*, two papers highlighted the need to bring experiential learning opportunities to engineering education. Ambrose stated “experiential learning opportunities prompt learning when students are put in unfamiliar situations for which they are not prepared and yet must act in order to get a job done.” [1]. Further, Stephens highlighted the need for diverse skills by stating “Today’s engineers need to be not only technically strong but also creative and able to work well in teams, communicate effectively, and create products that are useful in the “real world””. [2]. In addition, research conducted in two Intensive Innovation Experiences, called Aggies Invent, indicates that over 90% of the student participants agree or strongly agree that the program increased their ability to identify critical requirements, develop and evaluate conceptual designs, and understand the process of design. Complete discussion of assessment information about Aggies Invent is contained in a companion paper, developed by the authors, and presented at the same conference.

Goals

The authors undertook the development of a program to address the needs in engineering education being highlighted in research. The following goals were established.

- Answer the call to develop entrepreneurial minded engineers who are innovative and creative in their design approaches
- Push teamwork in a concentrated period to practice leadership, followership, compromise, attaining a goal, and working through interpersonal relationships
- Provide a design experience in a short, intense program that has students practice the process
- Challenge students to unleash creativity by pushing them to accomplish and build their design within a deadline
- Practice “selling” solutions through oral, written, and video presentation methods to judges and an audience who needs to be convinced that their solution is the best solution to the problem

Intensive Innovation Experience (IIE)

Capturing the attention of college students to do something on a weekend can be extremely difficult. Especially when it is an activity that is not related to a grade, but would benefit them greatly. It is almost like getting a child to eat their vegetables. It is good for their health, but might not be the most favorite activity at that time.

It is clear from research that creativity, innovation, entrepreneurial mindset, and great presentation skills are all very valuable skills industry desires in an employee. The trick is to get students to practice these skills in a way that they find to be fun, challenging, and will instill these skills. At the Texas A&M University, this is accomplished with an Intensive Innovation Experience called Aggies Invent. This paper will discuss the key elements and lessons learned from hosting three of these events. We will discuss the facility, the program, and the logistics.

The Engineering Innovation Center (EIC)

In designing the IIE, it was recognized that a critical element would be the space and facilities which would support and inspire students in their creativity to develop solutions for their provided Need Statement. The goal was to find/develop a space which would foster rapid prototyping, contain equipment and material needed, and host the needed support resources to enable effective, efficient use. The Engineering Innovation Center (EIC) was a newly opened 20,000 SF that fit the program needs perfectly.

The EIC was developed to provide a multi-functional workspace for undergraduate engineering students. Primary users fall into three categories, Senior Design teams, Multi-Disciplinary Challenge teams, and Engineering Competition teams. The EIC provides workspace, computer resources, storage space, conference rooms, equipment, parts, fabrication facilities, and professional staff. Secondary functions include special engineering events, EIC specific training courses, and support of 48 hour build events. The EIC can be best described in three interlocking components. These are the Design Studio, Fabrication Center, and Administration/Staffing.

Design Studio. The main portion of the EIC is the Design Studio Lab. It is approximately 10,000 sq. ft. and contains 70 tables dedicated to group projects reserved on a need basis. It maintains a general use table area (come and go) for students that do not wish to reserve space. Also, one area can be configured for a general use area or a special events center. Additional services in the Design Studio include the Digital Media Center, storage lockers, Help Center, and computer support.

Fabrication Center. The EIC has a 7,000 sq. ft Fabrication Center. A full time machinist and a crew of student technicians maintain the machine shop. The Fabrication Center consists of a machine shop, prototyping center, woodshop, project assembly, welding center and paint room. Additionally, specialized student projects that have certain size constraints, safety requirements, or power needs are kept in the Fabrication Center. Students are given access to use the Fabrication Center after completing two safety courses and a shop orientation with the EIC shop supervisor. All students must work under the supervision of the shop manager or the lead shop technician. The Prototyping area has a laser cutter, 3D printers, PCB (Printed Circuit Board) machines, and facilities to clean plastics and is the most highly utilized section of the Fabrication Center.

Administration/Staffing. In a facility such as the EIC, instructing proper use, maintenance of equipment, administration of safety policy, establishing a Help desk, and checking out equipment becomes a critical part of a smooth operation. If students are unable to understand how to use various equipment, use it safely, or don't have the material when they need it, they will not use a facility such as the EIC to its fullest potential. Therefore, the EIC has full time administration, full time machinist, and student workers to facilitate proper operation of this unique space.

Because the elements of a Design Studio, Fabrication Center, and Administration are all combined into a single space, the EIC was the perfect place for the IIE.

The Program

The IIE at Texas A&M University is called Aggies Invent. It is designed in a unique manner to engage students in solving Industry or Agency Need statements in a 48 hour period of time. Need statements, which are centered on a common event theme, are design challenges that an Agency or Industry partner would like solved. Key learning objectives include experience in teamwork, engineering design process, effective communications, and experiencing principles and application in an intersection of engineering disciplines. Engaging Industry and Agency partners solidify the importance and application of these solutions and provide students a rich interaction with partner mentors. Key elements of the IIE are Preparation and delivering the Experience.

Preparation. Any good program requires a certain amount of preparation. Each of these items can be laid out in an organized manner so they can be anticipated and handled. Table 1 provides a list of key preparation items used in each IIE.

Weeks Before	Tasks	Notes
10 - 16	• Establish Date, Theme, and Budget • Reserve Facility	Successful Themes center around a hot topic, relevance to University programs, and ability to recruit Need Statements
8 - 14	• Recruit Sponsors/Partners • Collect Need Statements • Identify Mentors	Need statements are clear problems that can be advanced in a weekend. Also, Needs do not contain Intellectual Property restrictions.

4 - 12	• Market Event
	• Recruit and Register Students
	• Develop Logistics
	• Solution Planning
	  ○ Gather Material
	  ○ Support Faculty/Staff Needed
		Obtaining relevant information from Students aids in the selection process. Combining disciplines and levels fosters teamwork, creativity, innovation, and enhances the learning experience at all levels

1	• Notices to Sponsors, Mentors, Students, Staff • Distribute Need Statements to Students, Staff, and Mentors • Finalize Logistics	Mentor and student confirmation leads to a successful experience

Table 1

As established in the companion paper by the authors in the same conference, setting the Theme drives inspiration and interest from potential partners and students. Equally important is selecting the proper date. The authors avoid any major holidays or university events and attempt to coordinate with any other engineering events that are scheduled during the year. In addition, the authors have found that due to the amount of time needed to host one of these events, they are spaced to one per semester. If conducted more frequently or if they are not unique, sponsors' tire of them, and students are not inspired to attend. During the preparation phase, Need statements are gathered. These are design challenges that have been established by Industry, University, or Agency partners that are in line with the theme of the event. Many times, the authors have helped the partner modify their initial Need into something that can be substantially advanced or actually built during the weekend. These cannot be too complex or too simple. If they are too complex, then it fails to motivate the students and impedes their innovation/entrepreneurship experience. In contrast if the need is too simple, then students are not sufficiently challenged and they feel they have "wasted" their time.

Marketing and advertising of the event starts with the end of the previous IIE. The best way to interest students is to create a buzz during the current event by using social media, traditional media, and capturing video and images during the event. The authors found that production of a short video after the event, websites with content developed previously, media stories published, and simply students telling other students about the event are the best ways to attract the next participants. This same information provides potential sponsors with examples and rationale about what is happening and allows them to see the excitement generated. Numbers of applicants have grown from 90 to 150 in the previous two events. Most students apply within 48 hours of opening of the registration process. During the registration process, the students are asked questions about their skill levels, level of interest, classification, and major. This is used to select a diverse range of students for the program that will accomplish the goals established to have a multi-discipline and multi-level experience. Past Aggies Invent have accommodated between 55 to 65 selected student participants. This seems to be an appropriate number which balances proper team size (4 to 6), use/access for the facility, mentor interaction, and length of final presentations.

The Experience. Once all of the preparation has been completed, the weekend schedule takes over. This is referred to as the Dance, the Design, the Build, and the Sell phases of the weekend. During the Dance, students explore the presented Need statements to determine which one interests them. Next they self-select team members they will work with during the weekend. Successful teams look for diversity in skill levels and capabilities. While this is discussed during the initial opening presentation to set up the weekend, the authors have found that students inherently understand diversity is critical and team formation actually has happened with ease. The Dance is an opportunity for the students to get to know each other, start that initial team formation, meet their mentor, and develop the interpersonal relationships needed for the weekend.

The Design happens as quickly as teams form. To create an intensive experience, little time is allotted for teams to finish and present their solution – the deadline is ever present in their minds. During the Design phase, teams start brainstorming their possible solution. This is normally a messy process filled with sticky notes, cardboard, string, rubber bands, paper, and glue. The Fabrication Center is not open at this time to force students into conceptual design and tradeoffs before a final solution is selected. A handbook is provided that outlines the capabilities and equipment in the Fabrication Center as well as a listing of the various electronics, software, and collaboration capabilities in the EIC. This enables students to grasp the possibilities. Staff requires the teams to present three initial concepts to the overall group, describe the selected one, and provide physical representations of initial designs. Requiring three solutions forces teams to consider more than one possible solution and down select the best. Many times the selected design approach is a combination of key elements from each of the conceptual designs. Most teams are enthused and challenged by other teams with questions and want to continue to work, but everyone is sent home that first night for sleep. However, teams normally come in the next morning after doing additional research and have refined their ideas to the next level.

Now comes the Build phase. Starting Saturday morning, teams come into the EIC ready to build. Having resource personnel at this time is critical to the success of a team actually building working prototypes during the weekend. These include relative experts in microcontroller platforms, software programming, fabrication, 3D printing, and video production. Each expert is asked to make themselves available to teams who need them and help jump start teams who might be struggling to make a platform work. In addition, teams are required to build a physical prototype and review it with a 3D printing expert before their job is accepted to print. This is because many times design suggestions can be made of how to use 3D printing more efficiently, have students determine dimensional mistakes before printing, and sometimes suggest other ways of accomplishing their design more rapidly or efficiently.

Finally comes the Sell. The entire weekend is targeting the final presentation where teams get 10 minutes to describe to judges and the audience how they have solved the Need they tackled, why this is important, and convince everyone that they should win the competition. Engineers typically want to deeply explain the technical details of their solution and while this is important, the authors strive to encourage an entrepreneurial mindset in the presentations by describing the solution in not only technical terms but also why this is important to a market. Incorporating business students into the weekend provides an additional perspective that helps push engineering students to consider the larger impact – not just the technical design. Training in giving elevator pitches, video production, and presentation skills is provided on Saturday night to demonstrate to students what will be successful. In addition, practice sessions for presentations are required on Sunday morning to make the student teams ready for the final competition presentations.

Once Its Over

At the end of the experience, students, mentors, and staff are elated and exhausted. In previous experiences, students have built working prototypes to monitor medical conditions, built new tools for HazMat teams, helped locate firefighters in buildings, and identified ways to track survivors in disaster situations. More importantly, they have practiced innovation, experienced rapid prototyping, and participated in a design process in an intensive experience that mimics what they might see when they start their careers. Partners get to see new ways of solving their problems and work with students pushing both to new limits in creativity. It is this interaction between students, industry mentors, faculty, and staff in a unique experience that becomes the value each person takes away with them.

The authors are happy to provide any documentation, details, key learnings, or other material to those interested in implementing an Intensive Innovation Experience.

References

[1] S. A. Ambrose, "Undergraduate Engineering Curriculum - The Ultimate Design Challenge," *The Bridge,* pp. 16-23, 2013.

[2] R. Stephens, "Aligning Engineering Education and Experience to Meet the Needs of Industry and Society," *The Bridge,* pp. 31-34, 2013.