Advances in Engineering Education

SPRING 2020

Aggies Invent: How an Intensive Design Experience Teaches an Entrepreneurial Mindset

RODNEY BOEHM
Texas A&M University
College Station, TX

ABSTRACT

Entrepreneurial skills are being sought by companies as they consider college graduates, particularly engineers, for future employment. Technical skills have become the baseline while the ability to apply these skills in a business environment has become a key differentiator in the value of employees in corporate environments. To address this need some universities have incorporated entrepreneurial skill development in curricular and extra-curricular offerings. This paper chronicles how Texas A&M University has developed an extra-curricular program which focuses on experiential learning to develop an entrepreneurial mindset in students whilst following the engineering design process. Appropriately named: *Aggies Invent*.

Key words: Entrepreneurship, Co-curricular, Design

MOTIVATION

In Jim Clifton's book, "The Coming Jobs War", he argues that entrepreneurship is about creating jobs and that for countries, such as the US, creating entrepreneurial minded people is critical to our continued success (Clifton, 2011). Further, a letter to the Secretary of Commerce from the National Advisory Council on Innovation and Entrepreneurship [NACE] strongly recommended development of entrepreneurial courses and programs for students. This letter was submitted in 2011 and signed by 146 of America's leading institutions (NACE, 2011). The question is what are the best practice on how to provide this education in an academic setting with tangible results?

From ancient time, a quote often attributed to Confucius is "I hear and I forget. I see and I remember. I do and I understand." The concept underscores the recognized value of learning by

doing. Fast forward 25 centuries, David Kolb makes the case that experiential learning is where skills and concepts are developed both inside and outside of the classroom (Kolb, 1984) and a more effective entrepreneurship education will be realized if it includes experiential education. Further, Gibb, develops the concept that an entrepreneurial mindset requires learning by doing (Gibb, 2011). It is the intersection of classroom learning and practical application. Participation in experiential learning activities has been shown to increase multiple entrepreneurial ability scores throughout engineering entrepreneurial education (Duval-Couetil, Shartrand, & Reed, 2016). Pryor, et. al. argue that entrepreneurs, because they are surrounded by uncertainty, require intuitive decision making, effectuation, and passion to be successful (Pryor, Morris, & Schindehutte, 2012). They found that intuition was required to make sense of uncertainty, effectuation was to transform the ideas from the consciousness of the entrepreneur to the organization, and passion was required to persevere through the obstacles they encountered. Through research, they concluded that "an experienced based lens of the entrepreneurship process in which actors operating in an uncertain environment create their own versions of reality, which ultimately manifest as an emerging venture". (Pryor, Morris, & Schindehutte, 2012)" Without the engineers personal experience, their own versions of reality have no basis for a potentially successful enterprise.

Applying this body of knowledge, the Texas A&M University engineering entrepreneurship training includes multiple experiential learning opportunities, offered to students through programs developed specifically to address the needs of industry. One of the more unique programs implemented is called Aggies Invent. This paper is focused on student self-assessment demonstrating that participation in an Aggies Invent improves skills in interdisciplinary teamwork, implementing/understanding an engineering design process, innovative thinking, incorporating modern prototyping techniques, time management, and developing concise, focused presentations. All of which are key to successfully developing an entrepreneurial mindset.

EXPERIENTIAL LEARNING THROUGH AGGIES INVENT

Aggies Invent is an integrative educational paradigm, tailored to the learning styles of today's students, that inspires the next generation engineering leaders through a highly focused, multidiscipline strategy. This program leverages the technical resources of the Texas A&M University College of Engineering, the industry relationships that emphasize business acumen, and the environment of an intensive innovation experience to provide the necessary setting whereby students can surpass their own expectations to creatively solve problems facing today's society.

In just 48 hours, *Aggies Invent* combines the following unique properties to help shape and inspire future engineering leaders:

- A structured, intensive, innovative design experience that starts with an industry/agency supplied need statements, requiring building of a working prototype, and 48 hours later "selling' the solution in a competition to a panel of expert judges.
- Interdisciplinary participation (registered students are from different colleges within the A&M system) and multilevel students (freshman through doctoral) working collaboratively on one design based on the need statement.
- Communication and cooperation at the team level and using media in a formal presentation environment.
- Interacting with industry mentors, who provide feedback on design choices

Aggies Invent is offered three times per semester thereby allowing students multiple opportunities for engagement throughout the academic year. The combination of these elements into one weekend provides a unique learning paradigm for students that is not experienced in the classroom.

WEEKEND STRUCTURE

Each Aggies Invent revolves around a relevant, topical theme in today's environment. A few past topics include medical devices, Internet of Things (IoT), First Responders, Veterinary Medicine, and STEM education. Themes allow students to gain vital experience and knowledge in a field outside of his/her major and are selected based the needs of today's society. Topics are also chosen specifically to encourage female participation as female participants are more attracted to themes that affect greater societal impact. Figure 1 illustrates the gender mix for themes of past Aggies Invent weekends.

The weekend, designed to emulate a high-performing product team that students will encounter during their careers, is compressed into a 48-hour period, simulating a typical product development job. Time management skills are required to meet the scheduled, identified deliverables. Inclusion of a competition creates a focus in a collaborative atmosphere that pushes the students to surpass the boundaries of their own skills and personal knowledge. Students understand they are competing for first, second, or third-place awards of $1,000, $750, and $500, respectively.

Prior to the academic year, themes for Aggies Invent weekends are suggested and chosen by a team under the direction of the Engineering Entrepreneurship program at TAMU. Then partnerships are established with relevant companies and industry mentors to provide need statements based on

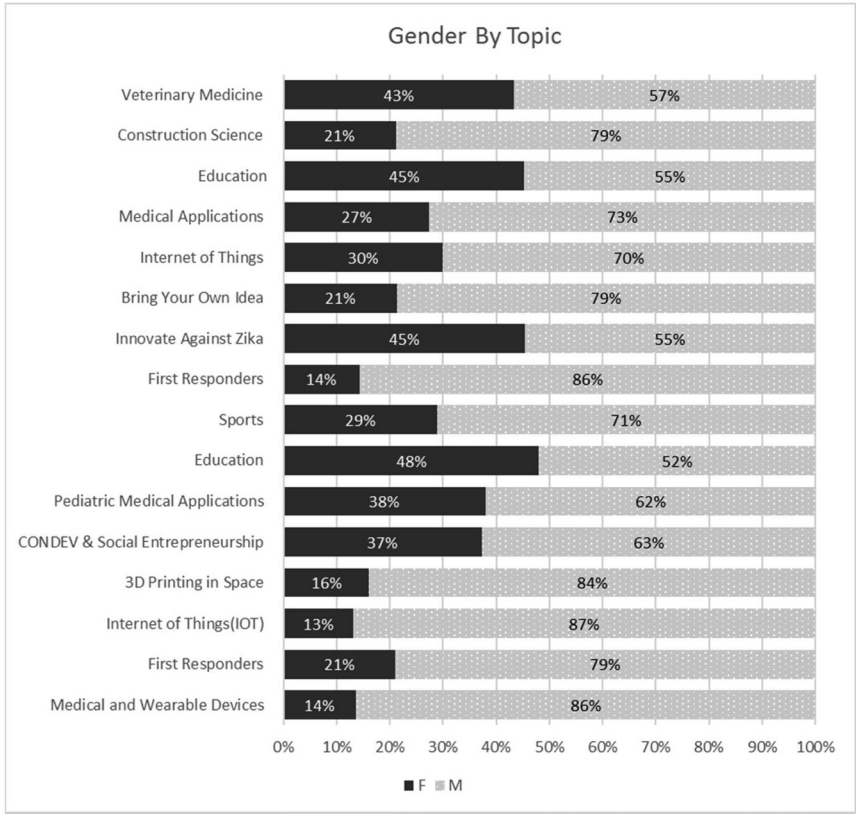


Figure 1. Gender by Topic.

the weekend theme. Need statements provide the starting point for challenging students to solve problems in new, innovative ways.

Aggies Invent begins on a Friday evening and ends on a Sunday afternoon. The framework of the weekend is divided into four phases: The Dance, The Design, The Doing, and The Deal. Each of the four phases represent different stages within the entrepreneurial design process, thereby furthering students' understanding of how to take a need statement (or problem) from conception to completion. By the end of 48 hours, students must create a 90-second video explaining their designed solution and give a 10-minute presentation to a panel of expert judges. This challenges their communication skills and introduces them to business principles such as identifying a value proposition, pitching to investors, and customer validation.

The entirety of the event takes place at the Engineering Innovation Center (EIC) located on the Texas A&M campus. The EIC is a 20,000-square foot maker space that contains a full fabrication shop, a modern prototyping lab, equipment checkout library, 30-plus student technicians and two

full-time staff members. Throughout the 48-hour weekend, students have complete access to any necessary equipment or technical experts needed to be successful. Aggies Invent also provides participating students with essential resources such as:

- Guided design structure
- Librarians
- Industry and graduate mentors
- Fabrication and software experts

All of these resources enable a learning environment to help support students in working through the engineering design process in a short, focused time period that is free from normal distractions. This fosters a rapid learning experience, which promotes the following learning outcomes:

- Team formation/performance
- Concentrated decision making, and
- Perseverance through prototype construction

By leveraging the research expertise of librarians, the field proficiency of industry mentors, and the technical resources of the EIC, participating students are provided with an environment where they can truly test the bounds of their innovation and creativity. Furthermore, exposure to the benefits of these resources encourage students to continue using them throughout their academic career.

Due to of the popularity of Aggies Invent, an application is required. Student participants are selected based upon their skill sets (ie coding, CAD, microcontroller, hardware prototyping), majors, and participation in past Aggies Invents. Teams are typically multi-disciplinary and vertically integrated. To date, fifty-nine (59) different majors from 11 colleges have participated in 16 Aggies Invent weekends.

PHASES OF AN AGGIES INVENT

The Dance

Students enter the EIC on Friday afternoon as individuals, but depart on Sunday as teams. On Friday evening, whilst eating pizza, the students are introduced to the goals of the weekend as well as the submitted need statements. An introductory presentation instructs students how best to form teams by selecting members who represent diverse backgrounds but have common interests. Teams self-form as participants begin discussing the need statements that have caught their interest and how they might approach the design challenge. The multidisciplinary framework has graduate students on teams with undergraduate students, thereby allowing participants to experience teamwork, leadership, and delegation in a mixed teaming environment. While this is a bit different than industry practice, experience has shown that this is a good way to quickly form teams that will work on a common solution because it is based on their interests.

The Design

By 9:30 p.m. Friday evening, students are required to implement the engineering design process, which entails developing multiple initial design concepts and deciding on one to pursue for the weekend. In particular, students must provide the mentors with five design requirements of their product (demonstrating complete understanding of the problem), three different design iterations (demonstrating that multiple solutions have been considered), one selected design (demonstrating use of a selection process based on criteria), and a physical representation (making the solution real to the team). The physical representation is built with simple crafting supplies to illustrate what they think their final product will look like and its capability as a solution to the problem. Although students can pivot their product design during the weekend, they must come together quickly as a team to identify an initial starting point.

The Doing

On Saturday morning, students return to the EIC to begin building their prototypes, filming their videos, and developing their final presentations. There are several benchmarks placed throughout the weekend that allow mentors to check in with teams and make sure that they are progressing forward and simulate briefing design supervisors as will be required in their future jobs. Students have full access to all EIC resources, along with continued access to librarians, computers, software tools, and industry mentors. During this phase, students concentrate on building a working prototype of their solution.

The Deal

Sunday afternoon at 3:00 PM sharp, students must return all tools and unused materials and present their solutions and prototypes to a panel of judges. The presentation has a 10-minute time limit. Within this framework students must present a 90 second video, a working prototype, and describe how they solved the selected need statement. Judges evaluate the student teams on product innovation, product feasibility, quality of presentation and overall value of the prototype. After all the presentations, the judges are sequestered to discuss and rate each team. The top student teams are awarded prize money. All teams are encouraged to enter the College of Engineering's product incubator program.

IMPLEMENTATION

As with any program, certain resources must be allocated for implementation. A handbook has been developed which outlines the development sages, timeframes, and resources required. While the specific Aggies Invent described in this paper involves a rapid prototyping facility and occurs over a weekend, it has been successfully implemented in a classroom over a period of 4 to 6 hours

with only office supplies available. The unique aspect of this experience is to have students focus on industry/agency provided problems that are currently relevant.

RESULTS

After every Aggies Invent, students are asked to rate their ability in various skills through a post-program survey. A rating scale of 1 to 5 was used (where 1 represented strongly disagree and 5 represented strongly agree). Two hundred forty-eight (248) surveys from 14 different Aggies Invent weekends, were returned which represents a 49% response rate. The list below is a summary of the students' self-assessment outcomes of skill development learned in the program since its inception in 2014. This data represents the number of students who indicated they agree or strongly agreed with their increase in ability for a skill.

Engineering Design Process

- 97% of students indicate they better understand how to define the requirements in an open-ended problem
- 95% of students indicate they are better able to apply several designs to solve a problem
- 94% of students indicate a better ability to assess designs and select the best fit
- 94% of students indicate they can "do" design through an engineering process
- 94% of students indicate a better understanding of the engineering design process
- 94% of students indicate they are better able to apply an abstract concept or idea to a real problem or situation
- 94% of students indicate they can better identify what information is needed to solve a problem
- 92% indicated an improvement in ability to discuss strategies and analyze a problem
- 92% indicated an improvement in their ability to identify the constraints on the practical application of an idea

Communications

- 92% of students indicate they experience improvement in presentation skills
- 92% indicate improvement in verbal communication

Teamwork

- 95% indicated they are more able to listen to the ideas of others with an open mind
- 95% indicated they are better prepared to ask probing questions that clarify facts, concepts, or relationships

- 95% indicated they are more able to be patient and tolerate the ideas or solutions proposed by others
- 94% indicated they are better in understanding that a problem may have multiple solutions
- 92% indicated improvement in working collaboratively as a team
- 84% indicated they are better able to evaluate arguments and evidence so that strengths and weaknesses of competing alternatives can be judged

Impact

- 97% of students indicate they better understand what engineering can contribute to society

With respect to career interest (students can select multiple entries), the survey results indicated the following:

- 49% of students identified that they plan on pursuing a career in industry
- 57% indicated they plan on pursuing a graduate degree at some point in their career
- 53% indicated they plan on starting their own business at some point in their career

Aggies Invent focuses on developing a student's overall entrepreneurial mindset. Fifty-eight percent (58%) of student teams continue developing their invention after the weekend. To date, four student teams have filed or begun the process of filing for a patent. Aggies Invent teams have competed in more than 24 pitch competitions, both locally and nationally. Ten teams are currently active in the College of Engineering's accelerator program. Additional breakdown of this data is available upon request.

With respect to retention, 96% of undergraduate engineering students who participate in Aggies Invent have continued their studies within the College of Engineering or received their engineering degree.

CONCLUSIONS

An entrepreneurial mindset has been identified as important for future job creation and is one of the skill sets universities have targeted for development. Further, companies are looking for engineering students who have both technical and entrepreneurial skills that create economic value for the company as they develop new products and services. In discussions with hiring managers and business leaders, an engineering student must be technically competent and also possess skills in communication, evaluating designs, working on teams, and solving undefined problems. Experiential education is a valuable tool in developing these skills through practical application thus increasing a student's confidence and ability. Aggies Invent has become a key program for students in their development of an entrepreneurial mindset.

REFERENCES

Clifton, J. (2011). *The Coming Jobs War: What Every Leader Must Know About the Future of Job Creation.* New York, NY: Gallup Press.

Duval-Couetil, N., Shartrand, A., & Reed, T. (2016). The Role of Entrepreneurship Program Models and Experiential Activities on Engineering Student Outcomes. *Advances in Entienering Education*, 1–27.

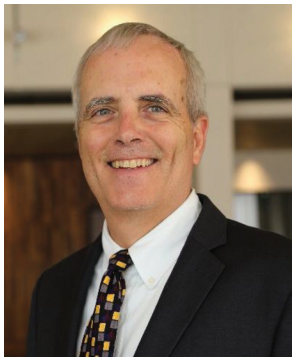
Gibb, A. (2011). Concepts into Practice: Meeting the Challenge of Development of Entrepreneurship Educations Around an Innovative Paradigm. *International Journal of Entrepreneurship Behavior and Research*, Vol. 17 No. 2, pp. 146–165.

Kolb, D. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* Englewood Cliffs, NJ.: Prentice-Hall.

NACE, U. P. (2011, April 19). Retrieved from http://www.innovationamerica.us/images/stories/2011/NACIE_Letter-University_Commercialization-20110617084146-20110617215655.pdf

Pryor, C., Morris, M., & Schindehutte, M. (2012). Enterpreneurship as Meaning Making: An Experience-Based Perspective in Intution, Effectuation, and Passion. *USABE Conference Proceedings* (pp. 793-811). Ipswich, MA: Small Business Refernce Center.

AUTHOR



Rodney Boehm is the Director of Engineering Entrepreneurship and an Associate Professor of Practice in the Texas A&M University College of Engineering. He has broad industry experiences, including over 35 years in all aspects of the telecommunications industry (sales, marketing, manufacturing, business development, and technical design), extensive experience in international companies, and running a startup. Currently he is using his technical business experiences to develop and run innovation and entrepreneurial programs for the College of Engineering, including Aggies Invent, Engineering Inc, and courses focused on developing an entrepreneurial mindset. He holds a BS and ME in Electrical Engineering from Texas A&M University.