Integrating an Entrepreneurial Mindset into an Avionics System Design Class

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Abstract

This paper describes how an entrepreneurial mindset was integrated into an Avionics System Design class at Baylor University. This junior/senior level three credit class is an elective and is taken by both engineers and Aviation Sciences students. Students in this class learn about a broad range of avionics systems for civil and military aircraft. Topics include avionics system technology and architectures, system engineering principles, radar, electro-optical, and radio frequency sensors, displays, and communication and navigation systems. A major semester project is assigned to give students an opportunity to develop a deeper understanding of a specific area. An entrepreneurial mindset is fostered in three ways: First, students are encouraged to be curious and explore an area of interest. Second, students make connections among aviation systems both philosophically and physically. Finally, students are encouraged to make a project that creates value. The process of this integration and the learning enhancements and assessment tools and methodology are described as well as student project examples. Finally, survey data is presented to assess the results of this entrepreneurial process integration.

I. Introduction

This paper describes the process of adding an entrepreneurial mindset component into an upper level undergraduate engineering elective. Forward thinkers in engineering have identified this mindset as important. For example, The National Academy of Engineering (NAE) has identified Entrepreneurship as a key program concept in their Grand Challenges Scholars Program. They say that Entrepreneurship is "Preparing students to translate invention to innovation; to develop market ventures that scale to global solutions in the public interest [1]". The Kern Entrepreneurial Engineering Network (KEEN) is also actively working to engage engineering students with integrating the entrepreneurial mindset into students' education [2]. KEEN has developed a pedagogy that highlights three concepts that can be cultivated in students to promote entrepreneurship. Like the NAE, a desired outcome of this pedagogy is that students' curiosity will ultimately be a mechanism for solving important societal problems. KEEN uses three *C's* to define an entrepreneurial mindset [3]. Each of these with a brief description follows:

- **Curiosity**: This leads to discovery of our changing world
- **Connections**: An integration of ideas learned through discovery leads to innovative solutions
- **Creating Value**: Innovative solutions to important problems leads to value for society

This three *C* driven mindset was promoted in Baylor University's Spring 2015 Avionics System Design Class. This elective class is cross listed with both the Electrical and Computer Engineering and the Aviation Sciences programs. Because of the cross listing, this course is taken by both engineers and aviation students and this leads to class discussion which complements both majors.

In this class students learn about a broad range of avionics systems for civil and military aircraft. Topics include avionics system technology and architectures, system engineering principles, radar, electro-optical and radio frequency sensors, displays, and communication and navigation systems [4], [5]. The organization of this paper is as follows: Section II describes the integration method, Section III describes student project examples, Section IV describes the Desired Outcomes from Learning Enhancements, Section V describes Assessment tools and Methodology, and Section VI is the conclusion.

II. Integration Method

This class meets for three hours each week during the semester and is typically taken by juniors and seniors. There is not enough class time to go into great depth into all of the subjects presented in the class so a project is assigned to give students the opportunity to dig deeper into the details of specific avionics subject areas that are especially interesting to them. This major semester project is worth 40% of their final grade.

This project has three phases: Project Proposal, Project Execution, and Final Project Reporting. The grading rubric is found in Table I. In addition to a final report, each project is also presented to the class. Students work alone or with one partner. Their projects take one of two basic forms:

1) Hardware project: where students construct and demonstrate an avionics related device
2) Software project: where students simulate and analyze an avionics related device or algorithm

The next sections give more details of the three phases of the project.

Table I: Grading Rubric for Final Project

Component	Percent of Final Avionics Grade (in Percent)
Phase I: Proposal • Full credit for thoughtful completion of the proposal template.	10
Phase II: Weekly reports • Describe *at least* 1 hour of meaningful project work each week for full credit that week.	10
Phase IIIa: Final Presentation • If you give a reasonable presentation on your work and attend your classmate's presentations you will receive full credit for the Final Presentation.	10
Phase IIIb: Final Report • I will assess the hardware/software product and see if the report addresses all 9 required sections: Abstract, Introduction, Background,	10

Algorithm/Hardware Details, Experiment Design, Results, Analysis & Conclusions, Fostering the Entrepreneurial Mindset, and References.	
Total	**40**

IIA. Phase I: Project Proposal

Students were given a project proposal template to use for their proposals. These were evaluated by the professor and, if necessary, changes were suggested and students were allowed to make revisions without penalty. The project proposal template includes three main sections: Project Description, Project Goals, and Entrepreneurial Mindset Analysis. The students needed to cite at least three references to demonstrate that they have evaluated their projects to a deep enough level to create appropriate goals. The SMART mnemonic was followed where the students needed to specify Specific, Measurable, Attainable, and Relevant Goals. They needed to describe metrics to judge if their project was a success or not. They needed to identify an "attainability" estimate on a scale of 1 to 10, and they needed to identify risk factors and a risk mitigation plan. They also needed to create a schedule identifying major tasks to complete during the semester. Finally, they needed to answer the following two questions to help analyze their project from an entrepreneurial perspective:

- How are you creating Connections with your project? (For example, how does your project fit into the overall framework of an Avionics System?)
- Regarding Creating Value: What is a specific way that you could leverage your time and effort into something that will not end when the semester is over?

The students received full credit if they answered all sections of the proposal template in a meaningful way.

IIB. Phase II: Project Execution

Students were required to submit a one paragraph weekly report describing their accomplishments that week. Students were expected to describe at least one hour of meaningful project work each week for full credit that week.

IIC. Phase III: Final Project Reporting

There are two project reporting requirements:

1) In class presentation: Students presented, in randomly assigned order, over the last weeks of class. They were not required to present a finished product at the time of their presentation, but instead a snapshot of their project at that time.
2) Final written report: Students wrote a conference style report using a template that was provided. A three page report was sufficient.

If students gave a reasonable presentation on their work and attended their classmate's presentations they received full credit for the Final Presentation section. For the Final Report grade their hardware/software product was assessed to verify they addressed all nine sections of the report: Abstract, Introduction, Background, Algorithm/Hardware Details, Experiment Design, Results,

Analysis & Conclusions, Fostering the Entrepreneurial Mindset, and References. In the section "Fostering the Entrepreneurial Mindset", students were required to answer the question: "How did you foster the entrepreneurial mindsets of Connections and Creating Value?" Some responses include:

- Teaching aids for use by future students
- Inspire future students
- Developing a potential marketable product

III. Student Project Examples

Students chose both hardware and software projects. Here is an example of some of their projects:

- **Auto-Targeting Turret**: This hardware/software project is an auto-aiming, auto-firing targeting system using a webcam to guide a foam missile launcher, Fig 1.
- **Reconfigurable Radar System Using Universal Software Radio Peripherals (USRPs)**: The goal of this project was to use USRPs as a platform for developing a reconfigurable radar system that could easily change radar type, frequency of operation, and tracking algorithms on the fly.
- **Object Detection and Tracking**: These projects involved both Matlab simulations and hardware projects.
- **Radar and Jamming**: This project used MATLAB to simulate a radar and various methods of jamming it.
- **Coffee Can Radar Project**: These students designed a Printed Circuit Board (PCB) for a coffee can radar system developed at MIT, Fig 2 [6].
- **Kalman Filtering**: This used a microcontroller and Arduino software to filter data from a Gyroscope and an Accelerometer.

Figure 1. Auto-Targeting Turret Project using the Thunder Missile Launcher (with foam missiles) [7] and a Tecknet webcam [8].

IV. Desired Outcomes from Learning Enhancements

There are five areas of student outcomes which the final project seeks to accomplish:

1) Enterprising attitude: Empower students with the opportunity to develop projects that will have lasting impact.
2) Multidimensional Problem solving: Involve systems integration in class projects.
3) Productive Collaboration: Encourage the students to work in groups and provide ways to ensure everyone is a significant contributor.
4) Illuminating Communication: Produce a final project report and presentation that substantiates their results with data and analysis.
5) Resolute Integrity: Insist that work and reports be accomplished with the utmost of integrity.

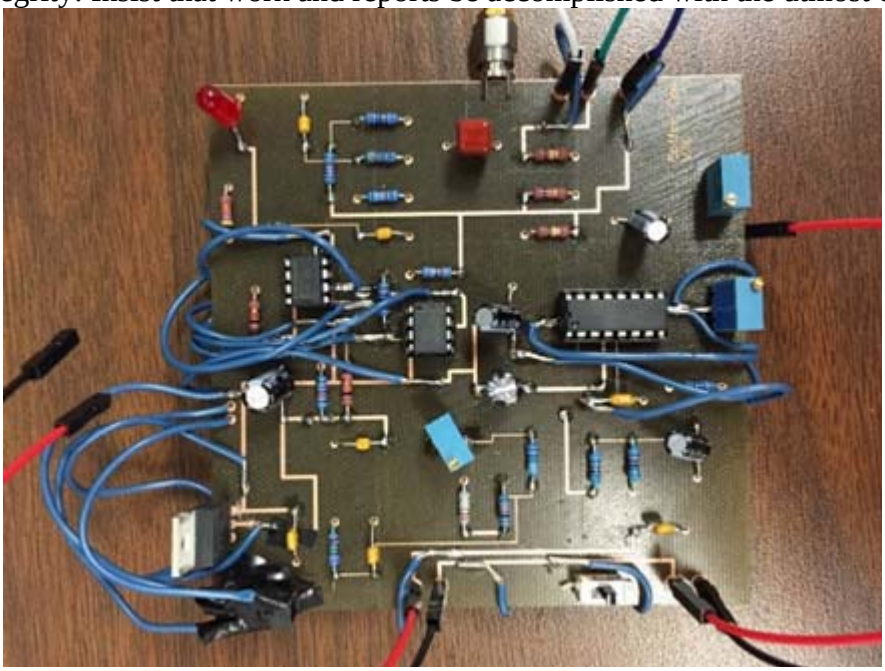

Figure 2. Electronics for Coffee Can Radar Project

V. Assessment Tools and Methodology

This section describes methods that can be used to measure the effectiveness of the integration and how it meets the student outcome goals described in Section IV.

1) Enterprising attitude: The final project presentation and report can be assessed to determine how useful the project will be in the future or if sound engineering and financial judgment reveals that the project should not be continued.
2) Multidimensional Problem solving: The number of systems and entrepreneurial concepts involved in the project's completion can be quantified.
3) Productive Collaboration: The students can score both their own and their project partners' level of group participation (in both quantity and quality of collaboration).

4) Illuminating Communication: The quality of final presentation, weekly reports, and final report can be assessed for their ability to convey their solutions and substantiate their claims.
5) Resolute Integrity: Ensure that references are cited as needed

An optional anonymous survey was conducted at the end of class. It was administered at the same time as the final exam. There were a total of twenty-nine students in the class. Of these, twenty-five were Electrical and Computer Engineering students and four were Aviation Sciences students. Twenty-seven students chose to participate in the survey. This is a 93.1% survey participation rate. The survey had three questions, and four possible answers for each question. The questions were:

1) Before this class, I've thought about linking Entrepreneurial ideas and Engineering.
2) In general, this class enhanced my thinking about linking Entrepreneurial ideas and Engineering.
3) The Entrepreneurial component of the final project helped me to think specifically about ways to about linking Entrepreneurial ideas and Engineering (*sic*).

For each question, the multiple choice responses were: *A lot*, *Some*, *Very little*, and *None*.
Fig 3 shows that before this class about half of the class had thought about linking entrepreneurial ideas and engineering. Fig 4 is the main result of this paper. This quantifies that the class had a positive effect on the students for linking entrepreneurial ideas and engineering. Fig 5 shows that the final project was an effective method of helping the students link these two areas.

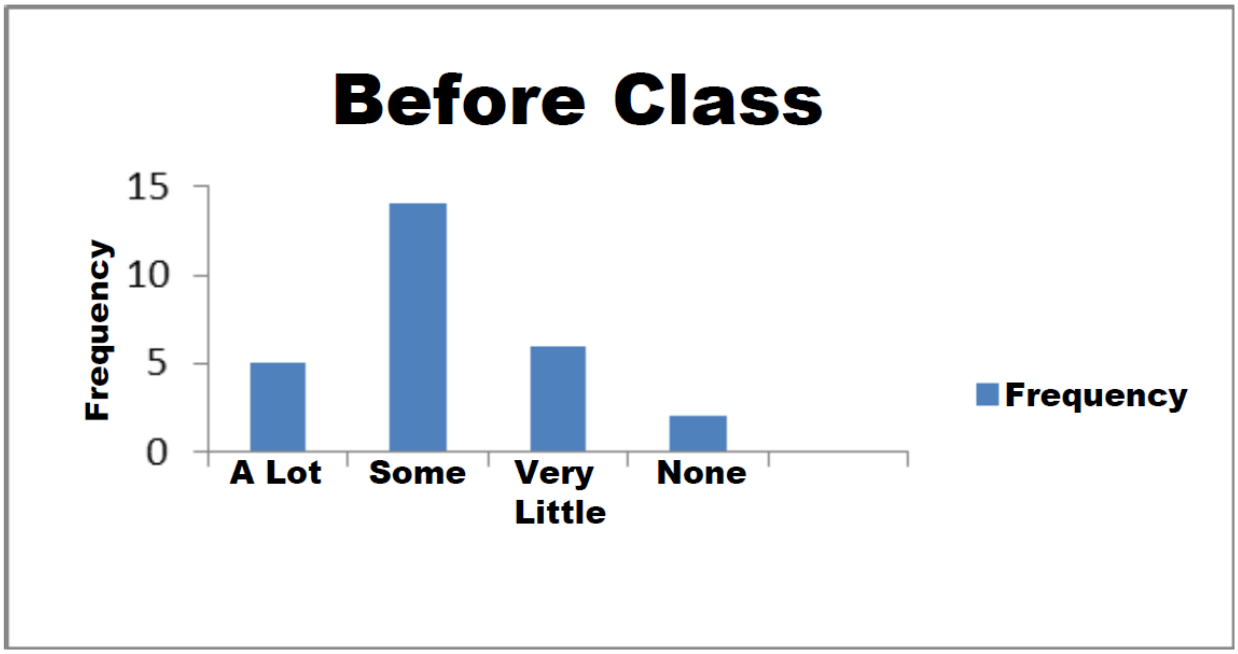

Figure 3. Before this class, many students had thought about entrepreneurial ideas

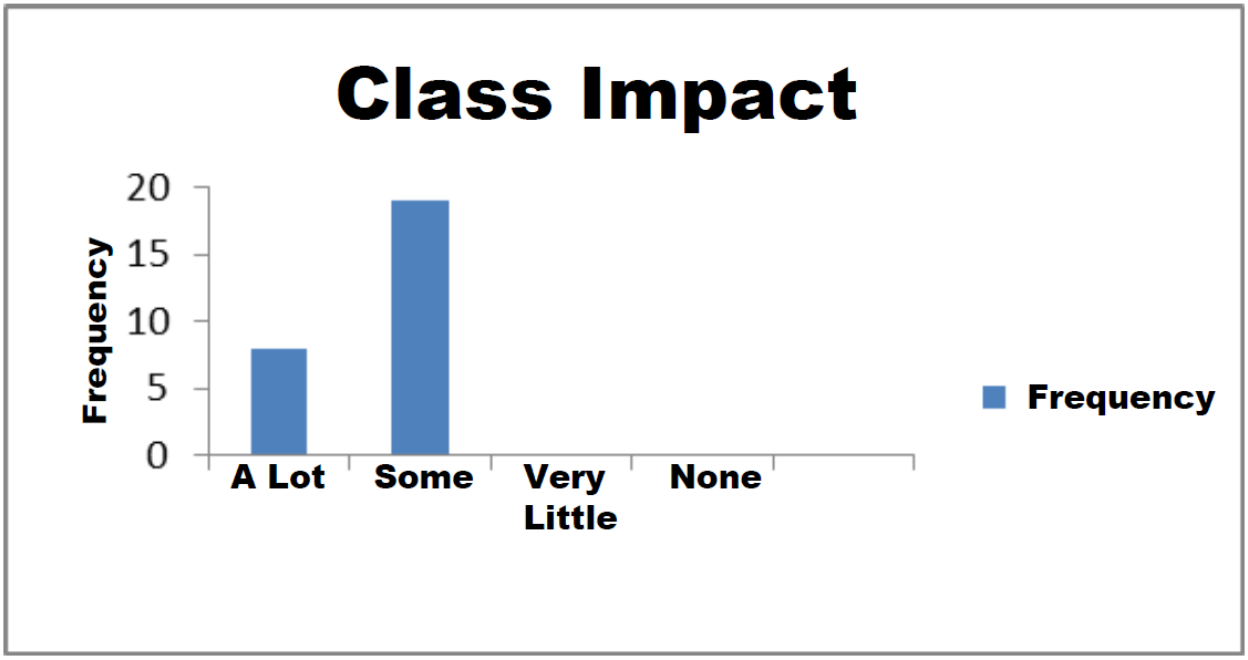

Figure 4. This class enhanced all survey respondent's thinking about linking engineering and entrepreneurship

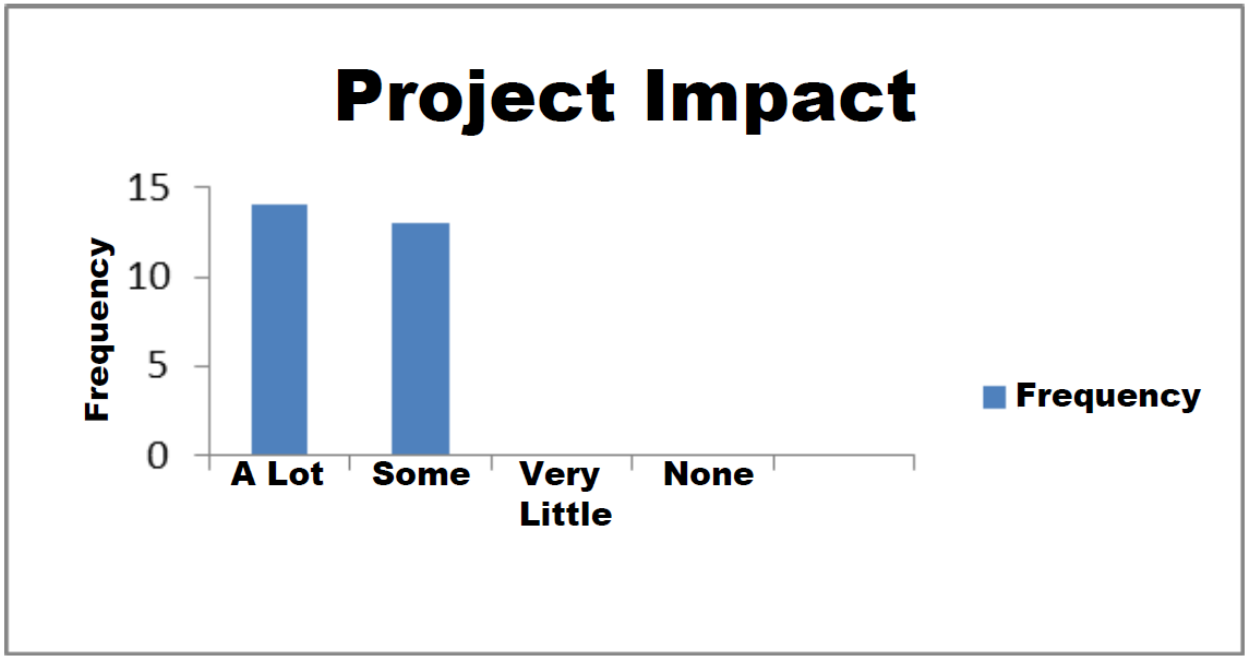

Figure 5. This shows the final project's efficacy in helping link engineering and entrepreneurship

VI. Conclusion

An entrepreneurial mindset - curiosity, connections and creating value - was integrated into the above project in the following ways:

Curiosity: Students choose a semester project on an avionics topic that peaks their interest. Although some students may find this open ended choice as daunting, others should find it empowering to explore more about a specific area of avionics that interests them and then to demonstrate through analysis or design that they learned.

Connections: Many aspects of avionics involve system integration. For example, a navigation system involves the integration of knowledge of theoretical algorithms with sensors and computers. This integration step is an integral part of many projects. In the proposal phase of the project, students needed to scope their project into something which is specific, manageable, and attainable. This forces them to assess their project and manage the risk of proposing a reasonable project. It was common for students to propose projects which were too ambitious for a semester long project. These students were given time and guidance on how to scale their project or choose one more suitable given the timeframe.

Creating Value: The students were encouraged to use these projects as opportunities to leverage their time and effort into something that will not end when the semester is over. Examples of this include: 1) Developing systems that can be used as teaching aids for future avionics classes, 2) Developing hardware and software systems that can be used as platforms for engineering research, 3) Developing marketable products.

Finally, the survey results in Section V quantitatively showed that the class had a positive impact on the students' entrepreneurial mindset.

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