

Framework for Integrating Entrepreneurially Minded Learning in Upper Level Courses

Dr. David Jamison IV, Villanova University

Dr. David Jamison is a Visiting Assistant Professor of Mechanical Engineering at Villanova University. His expertise and teaching focus is in orthopedic biomechanics and solid elastic mechanics. Dr. Jamison earned his Ph.D. in Biomedical Engineering from Drexel University in 2013.

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Abstract

Many institutions now offer extracurricular activities to help hone engineering students' entrepreneurial skills and encourage ideation. However, there remain few co-curricular opportunities for students to develop an entrepreneurial skillset and practice entrepreneurial thinking. In particular, opportunities are rare for students to merge entrepreneurially minded learning (EML) with the high-level subject-, project- and collaboration-based learning approaches typically seen in senior-level elective courses. Developing the entrepreneurial mindset will serve our students well by preparing them to be more impactful engineers.

We have developed, implemented and assessed a framework for integrating EML into senior-level elective courses via an Ideation Project. In the affected course – Introduction to Biomechanics – ***the curricular project focused on developing skills related to opportunity identification and impact evaluation. Expected EML outcomes from implementing this framework were behaviors related to expressing curiosity and creating value.*** We evaluated how well the students met the desired learning objectives and assessed the effectiveness of the framework in developing an entrepreneurial mindset, as evidenced by successful completion of the project deliverables and demonstration of the skill areas and behaviors mentioned previously.

Assessment was conducted via summative course assessments and project pre and post surveys, which required students' self-assessment of their entrepreneurial skills and ability to practice entrepreneurial behaviors. Increases in EML skill level and behavior before versus after completing the ideation project were statistically significant ($p < 0.05$) in some cases; moreover, all but one area (“persisting and learning through failure”) had a higher post-project score compared to the corresponding pre-project score. The results indicate that the framework was successful in integrating EML in a senior-level elective and developing an entrepreneurial minded skillset.

Introduction

Engineering Entrepreneurship has become an integral part of many engineering colleges in the United States. The aim is to build a complementary skillset so that engineering students are successful in innovative, multidisciplinary teams in the workplace [1]. Many universities have developed formal engineering entrepreneurship programs and minors over the last several years. Some early work in engineering entrepreneurship pedagogy involved defining and cultivating the proper campus learning environments for the development of the entrepreneurial mindset [2, 3]. Common features of this campus learning environment include integration among engineering, business, design, and product development programs and activities. More recently, much of the pedagogical work has focused on developing the entrepreneurial mindset in specific types of courses or delivery of entrepreneurial content to targeted groups [4, 5].

Villanova University has been engaged in teaching entrepreneurship/intrapreneurship skills to its engineering students since 2007, largely as a result of its involvement with the Kern Entrepreneurial Engineering Network (KEEN). KEEN is a consortium of 28 schools who are dedicated to producing graduates who add high value to their employers due to their entrepreneurial mindset along with technical expertise. An entrepreneurial mindset incorporates curiosity about our changing world, tying in knowledge from various resources to gain insight, and identifying unexpected opportunities to create value. It enables engineers to develop valuable technical solutions that address customer needs, are feasible from a business perspective, and have societal benefit. In the Villanova Mechanical Engineering department alone, entrepreneurially minded learning (EML) activities and assignments are offered in nine undergraduate courses, representing nearly 25% of our undergraduate course offerings. However, only a couple of these courses are past the sophomore and junior level. While other institutions are developing curricular modules to build student entrepreneurial mindset skills across the four years [4, 5], there are still very few offerings of senior level electives where that mindset is honed further.

Our objective was to develop, implement and assess an ideation project integrated in a senior-level engineering course. The project enabled engineering students who participated in the affected course (ME 5500: Introduction to Biomechanics) to develop KEEN framework skills in opportunity identification and impact evaluation, which they can share with their fellow students and employ throughout their professional careers. The proposed curricular project also aimed to foster entrepreneurial mindset behaviors related to “curiosity” and “creating value.”

Methodology

Course Planning and Project Implementation

The project ran through the final five weeks of the Fall 2015 semester. Students completed most of the work out of class – only four lectures (out of 45) were dedicated to in-class time for the project.

To make space in the lecture schedule (compared to prior offerings of the course where there was no ideation project) some course content was provided offline. Technical content for the course is roughly 40% anatomy and physiology and 60% mechanics. For the Fall 2015 offering of the course, the majority of the anatomy and physiology content was pre-recorded and students were required to view the videos before coming to class. Moving a substantial amount of technical content offline freed up the necessary lecture time for the ideation project, and also some additional lectures for more advanced topics that were previously unable to be offered due to time constraints.

For the four lectures dedicated to the project, one was an introduction to EML and a description of the project guidelines and deliverables, two were for in-class group work, and the final lecture was for students to present their final business pitches. These four lectures were spread out over the course of five academic weeks.

Ideation Project Description

Teams of three to four students each were instructed to brainstorm several business opportunities relevant to the biomechanics field. The proposed ideas could provide either a product or service. Teams were to identify potential customers for their ideas. Students then assessed the merits and potential impact (to the customer(s) and society at large) of their initial ideas. Over the course of several weeks, the teams continued to refine their concepts by performing market analysis to consider resources needed (costs, personnel, facilities, manufacturing, distribution, etc.), intellectual property protections, and an understanding of their competition. This iterative process continued for a couple weeks offline until the teams selected their preferred business idea.

At the conclusion of the semester, teams presented their business plan orally to the course instructor and guest judges (from the Villanova Institute for Innovation, Creativity, & Entrepreneurship and an alumnus who owns a medical device startup). The students were also required to complete a business model canvas [6]. In both the oral presentation and the business model canvas, teams were evaluated on their ability to articulate the need for their product or service, its technical and financial feasibility and why it is valuable to their customer(s). Students were also expected to identify key partners, activities and resources; customer relationships; and their projected cost structure and revenue streams.

Student Profile

Nineteen students were enrolled in the affected course during initial implementation of the ideation project. All students were seniors majoring in Mechanical Engineering. Few students had prior business or entrepreneurial experience prior to taking the affected course. Only two students were either enrolled in the Villanova Engineering Entrepreneurship minor or participated in the Villanova Summer Business Institute, a 13-week program run by the Villanova School of Business that enables students to earn a Business minor in one summer.

Survey Details

A survey was developed to assess, through self-reporting, to what extent the students' EML skills and behaviors were being developed and strengthened by completing the ideation project. IRB approval was granted to administer the survey and collect data for research purposes.

To properly assess the effect of ideation project participation on entrepreneurially minded learning, the survey was taken both before and after completion of the course project. Survey questions asked the students to rate to what extent they exhibited entrepreneurial mindset traits based on the KEEN framework [7]. Specifically, the questions focused on "Opportunity" and "Impact" related skills along with behaviors consistent with "Curiosity" and "Creating Value." Figure 1 details the targeted entrepreneurially minded skills and behaviors which students were asked to self-assess. A total of 16 questions – including demographic information – were included on the survey. The complete survey can be found in Appendix A.

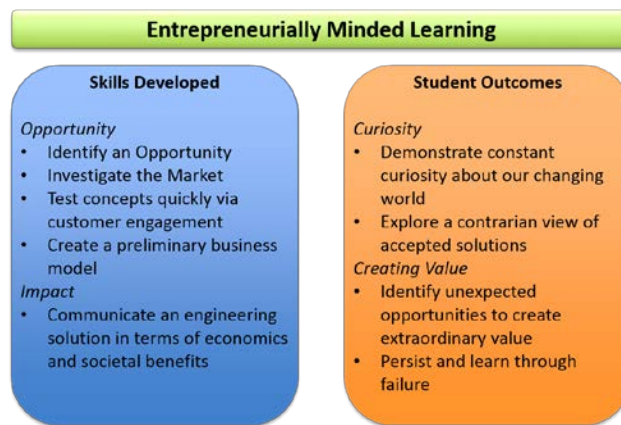


Figure 1. EML skills and outcomes targeted in the ideation project. Students assessed their abilities related to these areas before and after completion of the project.

Completion of the survey was optional. Of the 19 registered students, $n = 14$ took the pre-project survey (74%) and $n = 18$ students took the post-project survey (95%). Students assessed themselves on a five point scale, ranging from "not skilled" to "highly skilled" (skills) or "never practice" to "practice regularly" (behaviors).

Once survey data was collected, mean and standard deviation were calculated for each skill or behavior assessment pre- and post-survey. An unpaired t -test of unequal variances was performed on each question to compare the means pre- and post-survey. Statistical significance was set at $p < 0.05$.

Results

Students felt that their skill level in areas related to opportunity identification increased as a result of this project (Figure 2). Most notably, a statistically significant increase in skill level was seen for “being able to identify an opportunity” and “creating a business model” between pre- and post-project.

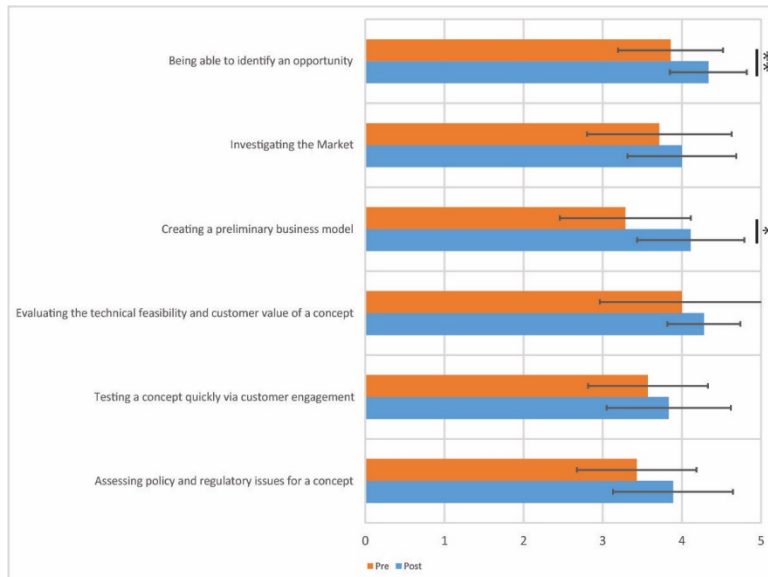


Figure 2. Aggregate results for students' self-assessed skills related to opportunity identification. * indicates $p < 0.05$ and ** indicates $p < 0.01$.

Regarding entrepreneurial minded skills related to impact evaluation, students again felt their skills increased across the board (Figure 3). A statistically significant increase was seen in the ability to “communicate an engineering solution in economic terms.”

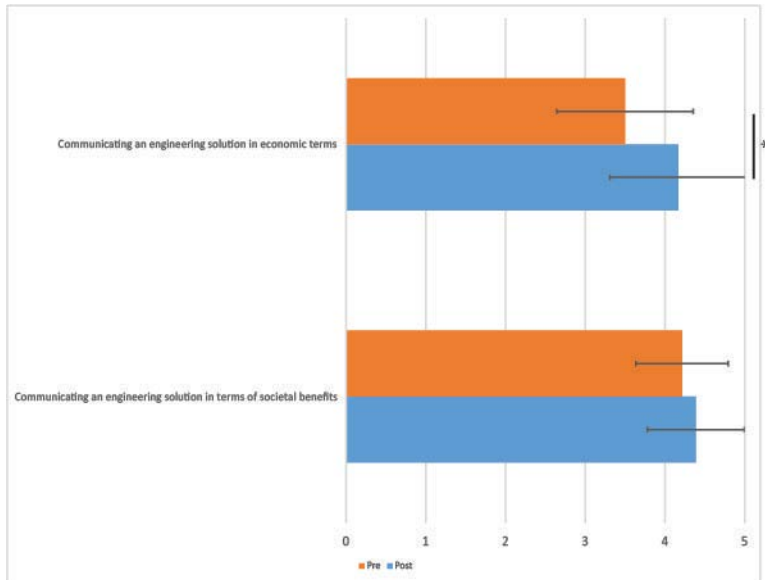


Figure 3. Aggregate results for students' self-assessed skills related to impact evaluation.

On practicing entrepreneurial mindset behaviors, students assessed that they practiced three of the four behaviors more as a result of completing the ideation project than they did before (Figure 4). Practice of the behavior of “persisting and learning through failure” actually decreased post-survey, though this decrease was not statistically significant.

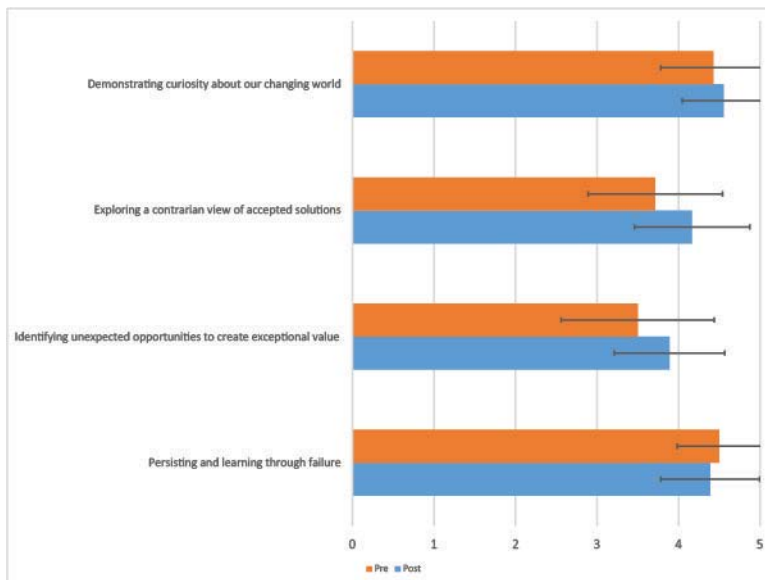


Figure 4. Aggregate results for students' self-assessed practice of entrepreneurial mindset behaviors.

Discussion

Data from the student surveys showed that the ideation project was successful in building entrepreneurial mindset skills related to opportunity identification and impact evaluation, as well as behaviors related to curiosity and creating value. It should be noted that most of the categories did not have a statistically significant difference between pre and post project. This may be due in part to the small sample size ($n = 14$ pre, 18 post).

The only category that showed a negative outcome was “persisting and learning through failure.” Given that the data comes from students’ self-assessment, it is possible that the lower rating post-project is due to students’ realization during the challenging ideation process that they do not persist through uncertainty and failure as ardently as they previously believed they did.

There are improvements that can be made in future offerings of the project. Students’ primary frustration in the beginning was with the nature of the ideation project itself, in that it is considerably different than the purely technical projects and assignments they are used to, and forces students to build skills in areas that are new to them. While the students’ frustration is noted, the purpose of the ideation project is precisely to build useful skills that they have never previously had experience with. In the end, most students did express their appreciation for the project and even enjoyed how different it was from their typical technical projects. In future offerings of the course, more resources will be made available (including prior student submissions) so that students have a better understanding from the beginning of how to approach the ideation process and provide the required deliverables. Students were not required to submit any formal progress reports or updates throughout the project. In the future, formative assessments will be required. This will provide the instructor the opportunity to provide critical feedback on groups’ ideation processes and ensure teams are on the right track.

Based on student assessment and feedback for the affected course, we believe we’ve demonstrated a successful framework for integrating entrepreneurially minded learning in upper level elective engineering courses. We specifically focused on KEEN framework skills related to opportunity identification and impact evaluation along with behaviors related to curiosity and creating value. Rather than offering course modules and single assignments, upperclassmen are better served applying their more advanced technical knowledge to a substantive project that incorporates ideation along with evaluation of intellectual property considerations, key partners, cost structures, and revenue streams. We have shown that with a relatively modest amount of effort from the course instructor to make select content available offline, EML can be integrated in a senior-level elective, without sacrificing time for exploration of technical concepts.

Acknowledgements

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ME 5500 Ideation Project Research Study - POST Survey

Survey upon completion of Ideation Project

* Required

Informed Consent: Entrepreneurially Minded Learning Study

*Please read the description of the research study below. Then indicate below whether or not you agree to participate in this study. Your participation is completely voluntary.

PURPOSE: This is a research study concerned with assessing the ability of the ME 5500 Ideation Term Project to develop skills related to the entrepreneurial mindset as identified by the Kern Engineering Entrepreneurship Network ("KEEN").

PROCEDURE: Each subject will receive a survey, which accompanies this consent form. The survey will take approximately 10 minutes to complete. Subjects are asked to fill out the survey completely and honestly.

RISKS: The risks to you in this experiment are, at most, minimal, and do not differ in any qualitative way from those you might experience in everyday life. Your participation will help the researchers to determine how integrating entrepreneurially minded learning in upper level courses can spur development of entrepreneurial mindset skills such as opportunity identification and assessing impact.

VOLUNTARY PARTICIPATION: You should understand that your participation in this experiment is completely voluntary. You have the right to have any questions answered before, during, or after the experiment. You may refuse to participate prior to beginning the study without any penalty. You may also terminate your participation at any time, for whatever reason. However, participation in the term project itself is not optional.

CONFIDENTIALITY: All data collected in this experiment will be kept entirely confidential. Your name will never be publicly associated with this experiment and your participation will be kept confidential.

ONLINE STUDY: We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a

Appendix A

breach of confidentiality is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by [describe how confidentiality will be secured, maintained, and how data will be disposed of].

QUESTIONS: If you have any questions concerning your participation in this project you should contact Dr. David Jamison at Villanova University (610) 519-4997. If you have questions about your rights as a research subject, contact Will Caverly, IRB Administrator for the Office of Research Administration, at 610-519-6127.

Appendix A

1. **Agree or Decline ***

Mark only one oval.

I agree to participate in the research study.

I decline to participate in the research study.

Stop filling out this form.

Experience

2. **Please choose your classlevel.** *Mark*

only one oval.

Freshman

Sophomore

Junior

Senior

3. **I am enrolled in the Engineering Entrepreneurship Minor *** *Mark*

only one oval.

Yes

No

4. **I have participated in the 24-hr Imagination Quest** *Mark*

only one oval.

Yes

No

5. **I have participated in the VSB Summer Business Institute (SBI)** *Mark*

only one oval.

Yes

No

Demonstrating Entrepreneurial Skills

In completion of the Ideation Project, please rate your CURRENT skill level in the following areas.

1 (not skilled), 5 (highly skilled)

Appendix A

6. **Being able to identify an opportunity ***

Mark only one oval.

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly skilled |

7. **Investigating the Market ***

Mark only one oval.

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly skilled |

8. **Creating a preliminary business model. * Mark**

only one oval.

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly skilled |

9. **Evaluating the technical feasibility and customer value of a concept * Mark only**

one oval.

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly Skilled |

10. **Testing a concept quickly via customer engagement * Mark**

only one oval.

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly Skilled |

11. **Assessing policy and regulatory issues for a concept * Mark**

only one oval.

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| | 1 | 2 | 3 | 4 | 5 | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly Skilled |

12. **Communicating an engineering solution in economic terms** * *Mark only one oval*

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| 1 | 2 | 3 | 4 | 5 | | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly Skilled |

13. **Communicating an engineering solution in terms of societal benefits*** *Mark only one oval.*

| | | | | | | |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
| 1 | 2 | 3 | 4 | 5 | | |
| Not skilled | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Highly Skilled |

Practicing Entrepreneurial Behaviors

In completion of the Ideation Project, please rate the extent to which you feel you CURRENTLY practice the following behaviors, both inside and outside of the classroom.

1 (never practice), 5 (practice regularly)

14. **Demonstrating curiosity about our changing world*** *Mark only one oval.*

| | | | | | | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|
| 1 | 2 | 3 | 4 | 5 | | |
| Never practice | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Practice regularly |

15. **Exploring a contrarian view of accepted solutions** *
(How much do you challenge what is deemed the accepted solution?) *Mark only one oval.*

| | | | | | | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|
| 1 | 2 | 3 | 4 | 5 | | |
| Never practice | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Practice regularly |

16. **Identifying unexpected opportunities to create exceptional value** * *Mark only one oval.*

| | | | | | | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|
| 1 | 2 | 3 | 4 | 5 | | |
| Never practice | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Practice regularly |

17. Persisting and learning through failure * *Mark only*

one oval

| | 1 | 2 | 3 | 4 | 5 | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|
| Never practice | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Practice regularly |

Comments

18. Feel free to leave any comments or suggestions about your experience with the Ideation Project

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