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Shaping New Student Identity as "Creatives" in the 21st Century Global Economy

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Shaping New Student Identity as "Creatives" in the 21st Century Global Economy

Abstract

Temple University became a member of the 2015 cohort of 25 schools participating in the National Center for Engineering Pathways to Innovation (Epicenter). Epicenter is funded by the National Science Foundation and directed by Stanford University and VentureWell (formerly NCIIA). One of the elements of participation involves redesigning the capstone senior design curriculum to make it more innovation and entrepreneurship oriented and as such have a positive impact on student satisfaction. This paper details the expectations of students beginning a two-course sequence in the capstone curriculum. The student survey data led to a rebalancing of the curriculum to one that was solely based on "how-to-do" senior design projects to one that still includes "how-to-do" lecture themes but now includes lecture themes in innovation and entrepreneurship. The paper also provides information that will be used to continuously improve the course.

Introduction

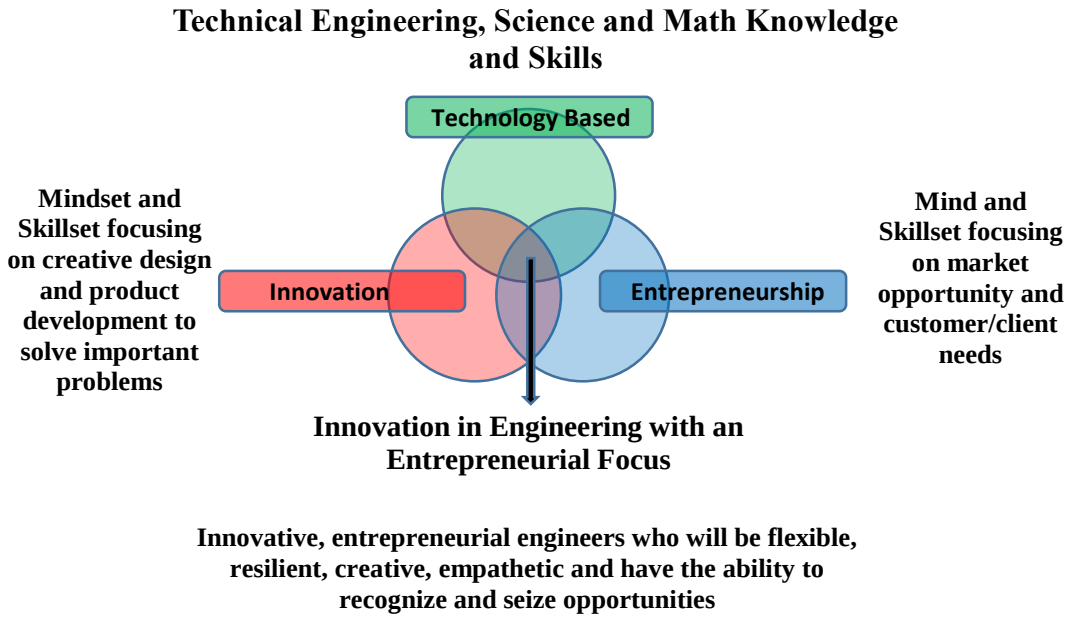
Temple University College of Engineering is a member of the 2015 cohort of 25 schools participating in the National Center for Engineering Pathways to Innovation (Epicenter). Epicenter is funded by the National Science Foundation and directed by Stanford University and VentureWell (formerly NCIIA). One of the elements of participation involved redesigning the capstone senior design courses to make them more innovation and entrepreneurship oriented with measurable impact on student satisfaction and expectations for post-graduation success.

Prior to the fall of 2014, the capstone "Senior Design" curriculum was a highly transactional two-semester course that focused on "how-to-do" senior design projects. The general student responses were relatively unfavorable due to poor format and instruction practice. Of particular concern was students' negative perception of the benefit of such a course when it came to real-life experience. In our analysis we also recognized lack of focus on design thinking, innovation and entrepreneurship. The latter became more crucial with arrival of a new university president in 2013 committed to six commitments, now the foundation of his presidency. One was specifically directed at innovation and entrepreneurship.

> *"The modern world is defined by a rapid pace of change. If pioneers on the new urban frontier are to be successful, we must help them couple their hard work and independence with an entrepreneurial spirit. For too long, that spirit has been seen as the sole domain of business schools. We must expand that view. Entrepreneurship and innovation must be valued in every discipline across our campuses. Temple students must learn to adapt to constant change and find success in fields that have not yet been invented."*

In view of our president's commitment and our participation in Pathways to Innovation, the College of Engineering decided that it was time to refocus the major capstone design experience, required by the EAC of ABET, and re-imagine the Senior Design Curriculum to include substantial instruction in design thinking, entrepreneurship and innovation. The College recognized that future engineers must have, in addition to technical-based education in engineering and math and science, exposure to innovation and entrepreneurship. In doing such, students would now have the mindset and skills to become innovative, entrepreneurial engineers who would be flexible, resilient, creative, and empathetic and, as such, have the ability to recognize and seize opportunities during their entire engineering career. [1] This is shown as Figure 1 in a Venn diagram.

Figure 1 – Venn diagram showing intersection of technology, innovation and entrepreneurship education



The schematic above became our touchstone for adding lecture themes in, amongst other subjects, design thinking, disruptive technologies, entrepreneurship and innovation and, as such, the Senior Design curriculum began its successful transition from being solely focused on "how-to-do" senior design projects to one that gave students tools to be entrepreneurial innovators and life-long learners. While Fig. 1 was our qualitative guide to drive our rebalancing from solely "how-to-do" lectures, the student surveys that are reported in this paper gave us further guidance towards the rebalancing of lecture themes and subjects.

A preliminary study was conducted at the start of the Spring 2016 semester to first determine the expectations of students concerning innovation and entrepreneurship education. These students were beginning the two-course senior design capstone program (Senior Design I). The cohorts of students currently participating in the pre-Senior Design I survey and the post-Senior Design I

[1] http://epicenter.stanford.edu/page/about

surveys will be surveyed again at the completion of the Spring 2016 semester in order to have longitudinal survey data for additional evaluations. As such, in future studies the pre-SDI cohort will be surveyed again at the completion of SDI and at the completion of SDII (Senior Design II) and the current post-SDI students will be surveyed at the completion of SDII. At the end of this paper we will show how we rebalanced the lecture themes for Senior Design I and Senior Design II based on the students' expectations.

Pre-Senior Design I Survey and Study

In order to get a baseline understanding of students who are beginning the two-course senior design curriculum, a survey was conducted containing the following questions and scored on a Likert Scale (5-Strongly Agree, 4- Agree, 3-Uncertain, 2- Disagree and 1- Strongly Disagree).

Fourteen questions comprised the initial survey of students entering Senior Design I and completed by a total of 86 students in January 2016: Mechanical Engineering – 35, Electrical and Computer Engineering – 28, Civil and Environmental Engineering – 17, Bioengineering – 6.

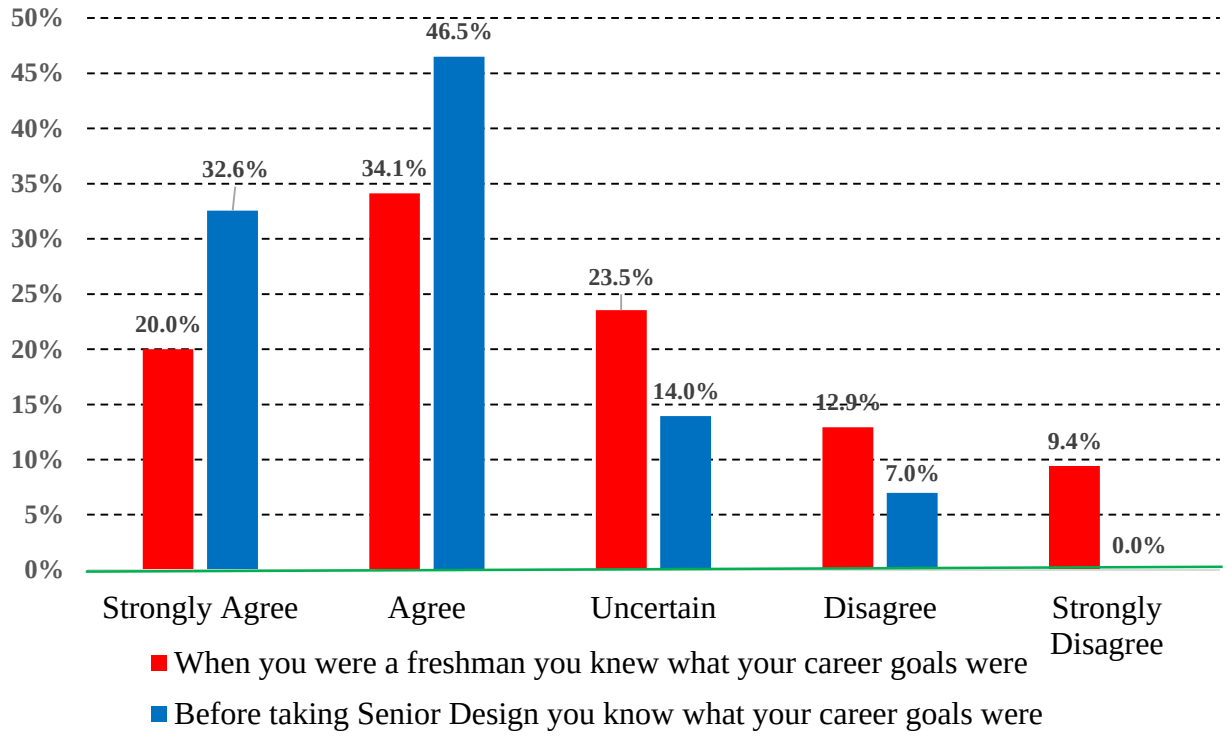
1. When you were a freshman you knew what your career goals were
2. Before taking Senior Design you knew what your career goals were
3. One of my career goals is to be an engineering innovator
4. I expect Senior design will teach me about the importance of innovation
5. One of my career goals is to be an entrepreneur
6. I hope Senior Design will give me some tools to be an entrepreneur
7. One day in the future I plan to start a business
8. In the future I plan to obtain an MBA
9. In the future I plan to get a graduate degree in engineering
10. If I work for a large company I will be expected to be an innovator
11. If I work for a large company I will be expected to be an entrepreneur
12. I expect Senior Design to improve my confidence in my ability to apply engineering to business
13. When I graduate I will have a desire to apply technology in more creative ways
14. I expect Senior Design to enhance my desire to apply technology in more creative ways

The survey responses for the entire cohort of 86 students were grouped according to question content: Career Goals, Innovation Goals, Entrepreneurship, Future Education Plans and Innovation and Entrepreneurship after Graduation. The grouping of questions is shown in Table 1.

Table 1. Grouping of student survey questions

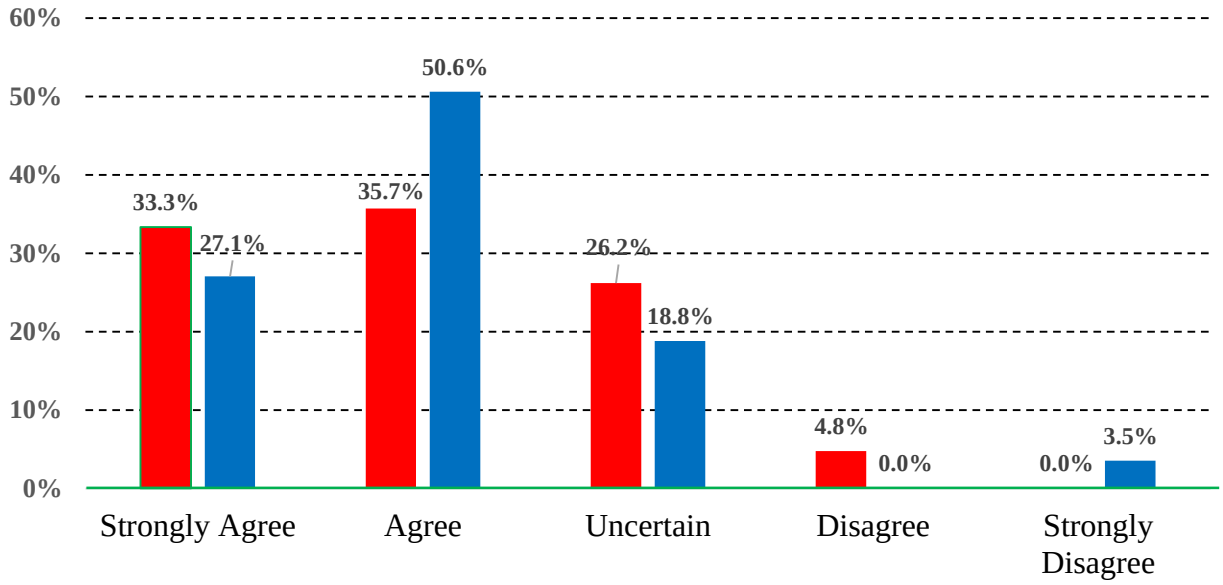
Career Goals	Innovation Goals	Entrepreneurship	Future Education Plans	Innovation and Entrepreneurship after graduation
When you were a freshman you knew what your career goals were	One of my career goals is to be an engineering innovator	One of my career goals is to be an entrepreneur	In the future I plan to obtain an MBA	If I work for a large company I will be expected to be an innovator
Before taking Senior Design you knew what your career goals were	I expect Senior Design will teach me about the importance of innovation	I hope Senior Design will give me some tools to be an entrepreneur	In the future I plan to get a graduate degree in engineering	If I work for a large company I will be expected to be an entrepreneur
		One day in the future I plan to start a business		I expect Senior Design to improve my confidence in my ability to apply engineering to business
				When I graduate I will have a desire to apply technology in more creative way
				I expect Senior Design to enhance my desire to apply technology in more creative way

Fig. 2 Likert Responses to Career Goals for Pre-Senior Design I students



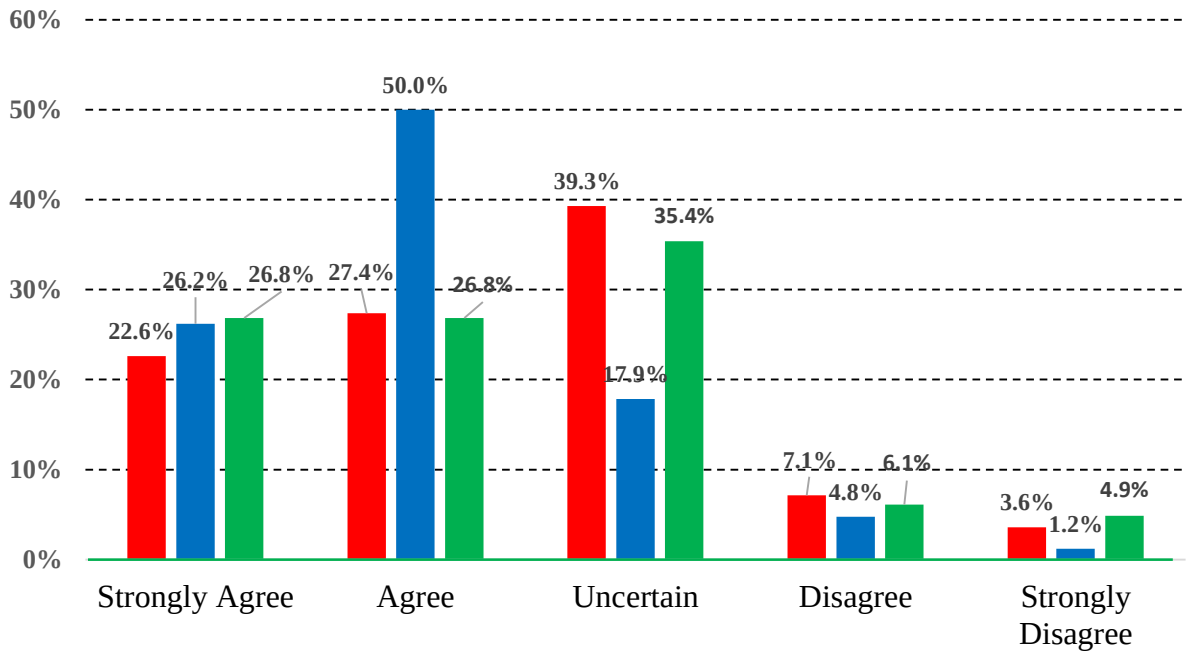
- When you were a freshman you knew what your career goals were – Likert Score: 3.4
- Before taking Senior Design you knew what your career goals were- Likert Score: 4.0

Fig. 3 Likert Responses to Innovation Goals for Pre-Senior Design I students



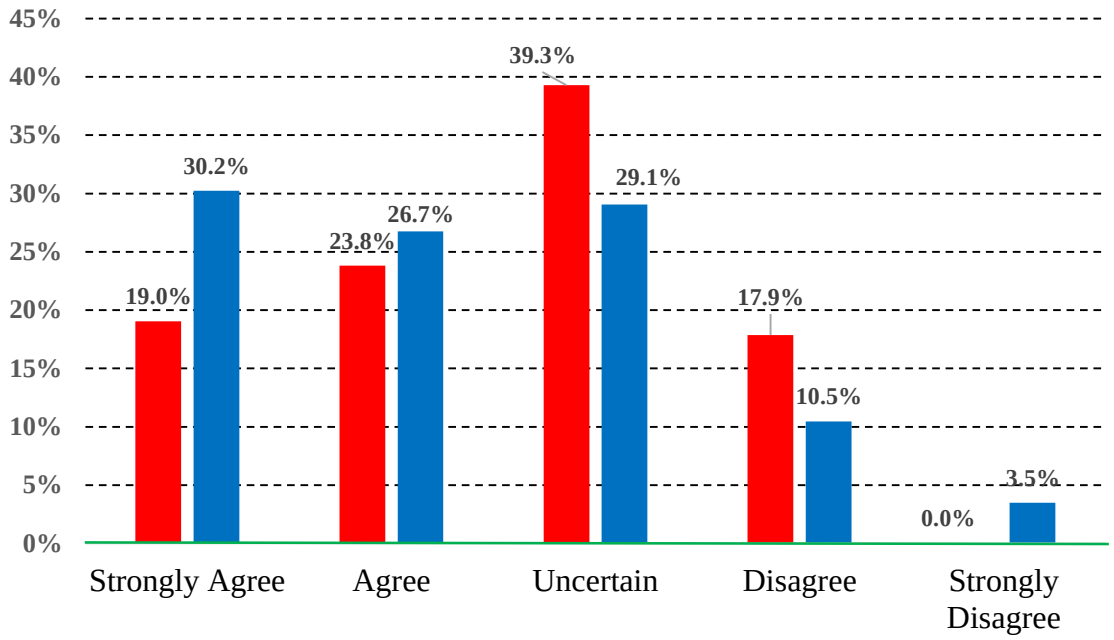
- One of my career goals is to be an engineering innovator – Likert Score: 4.0
- I expect Senior Design will teach me about the importance of innovation – Likert Score: 4.0

Fig. 4 Likert Responses to Entrepreneurship Goals for Pre-Senior Design I students



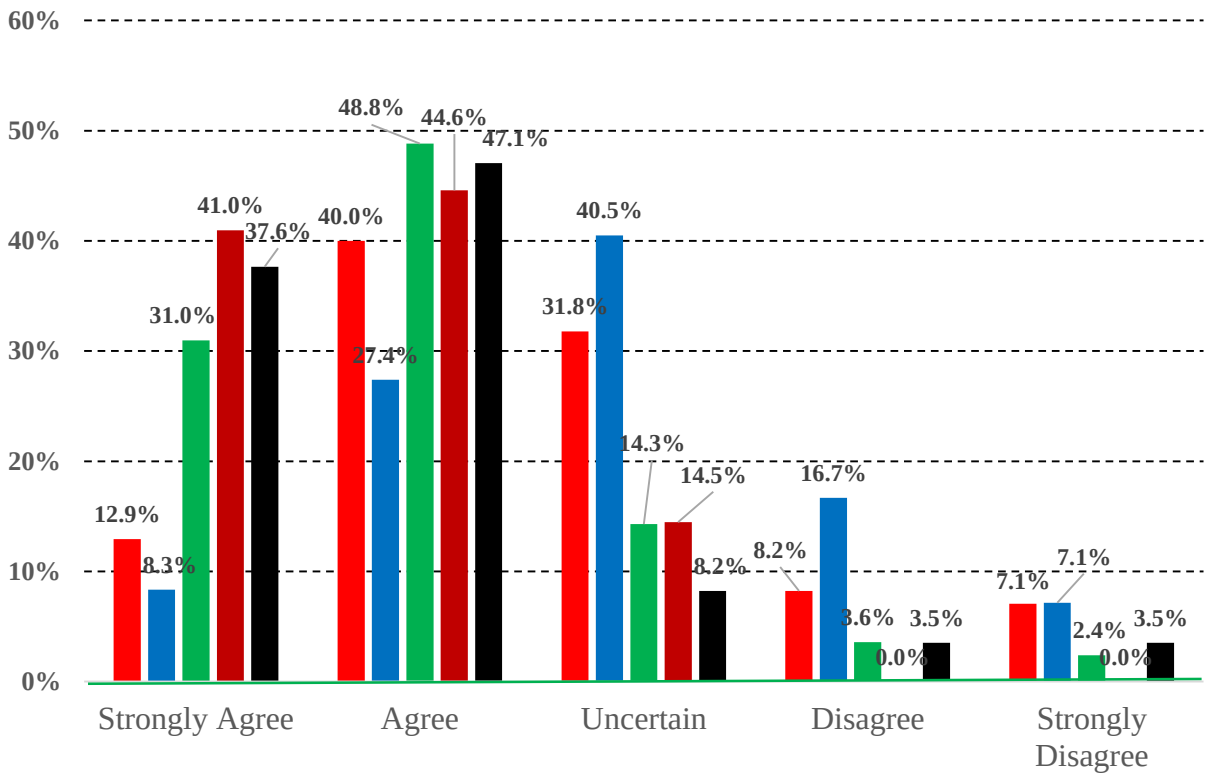
- One of my career goals is to be an entrepreneur – Likert Score: 3.6
- I hope Senior Design will give me some tools to be an entrepreneur – Likert Score: 4.0
- One day in the future I plan to start a business – Likert Score: 3.6

Fig. 5 Likert Responses to Future Education Plans for Pre-Senior Design I students



- In the future I plan to obtain an MBA – Likert Score: 3.4
- In the future I plan to get a graduate degree in engineering – Likert Score: 3.7

Fig. 6 Likert Responses to Innovation and Entrepreneurship Plans after Graduation for Pre-Senior Design I students



- If I work for a large company I will be expected to be an innovator – Likert Score: 3.4
- If I work for a large company I will be expected to be an entrepreneur – Likert Score: 3.1
- I expect Senior Design to improve my confidence in my ability to apply engineering to business – Likert Score: 4.0

- When I graduate I will have a desire to apply technology in more creative ways – Likert Score: 4.3
- I expect Senior Design to enhance my desire to apply technology in more creative ways – Likert Score: 4.1

Below is a chart which shows the percentage responses for each question and are grouped by (1) Strongly Agree or Agree, (2) Uncertain, and (3) Disagree or Strongly Disagree.

	Survey Questions # of respondents = 86	**Strongly Agree or Agree**	**Uncertain**	**Disagree or Strongly Disagree**
1	When you were a freshman you knew what your career goals were	54.1%	23.5%	22.4%
2	Before taking Senior Design you knew what your career goals were	79.1%	14.0%	7.0%
3	One of my career goals is to be an engineering innovator	69.0%	26.2%	4.8%
4	I expect Senior Design will teach me about the importance of innovation	77.6%	18.8%	3.5%
5	One of my career goals is to be an entrepreneur	50.0%	39.3%	10.7%
6	I hope Senior Design will give me some tools to be an entrepreneur	76.2%	17.9%	6.0%
7	One day in the future I plan to start a business	53.7%	35.4%	11.0%
8	In the future I plan to obtain an MBA	42.9%	39.3%	17.9%
9	In the future I plan to get a graduate degree in engineering	57.0%	29.1%	14.0%
10	If I work for a large company I will be expected to be an innovator	52.9%	31.8%	15.3%
11	If I work for a large company I will be expected to be an entrepreneur	35.7%	40.5%	23.8%
12	I expect Senior Design to improve my confidence in my ability to apply engineering to business	79.8%	14.3%	6.0%
13	When I graduate I will have a desire to apply technology in more creative ways	85.5%	14.5%	0.0%
14	I expect Senior Design to enhance my desire to apply technology in more creative ways	84.7%	8.2%	7.1%

Some Data Observations

- 69% of students have a career goal to be an engineering innovator and 77.6% expect Senior Design to teach them about the importance of innovation.
- 50% of students have a goal to be an entrepreneur and 76.2% expect Senior Design to give them some tools to be an entrepreneur.
- 53.7% of students plan to start a business in the future.
- 79.8% of students expect Senior Design to improve their confidence in their ability to apply engineering to business
- 84.7% of students expect Senior Design to enhance their desire to apply technology in more creative ways.

Post- Senior Design I Survey and Study

Seniors who completed the first course in senior design (Senior Design I) and were now entering the second and terminal course in senior design were surveyed in early January 2016. The purpose of the post-Senior Design I survey was to see if expectations were met and, if not, provide faculty some guidance on how senior design could be further improved to incorporate more educational programming in innovation and entrepreneurship.

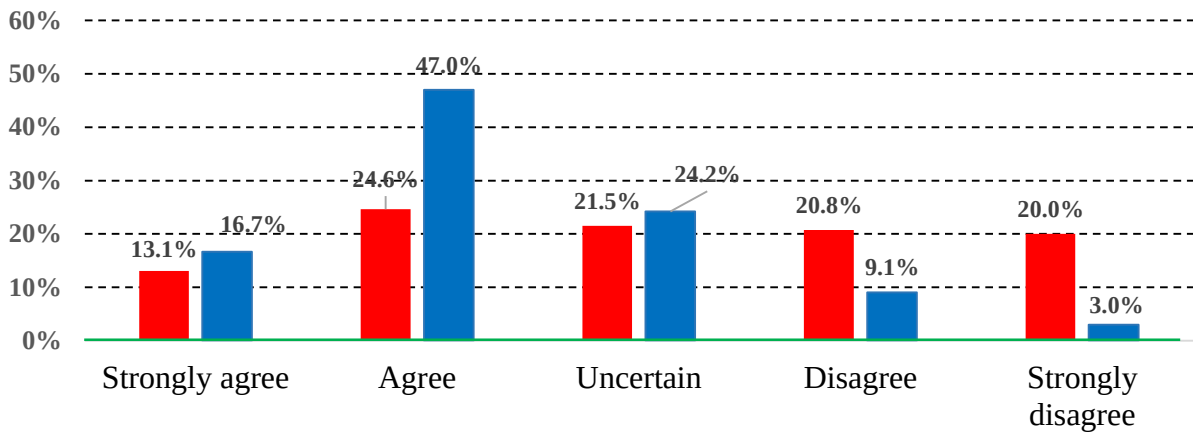
Fourteen questions comprised the initial survey of students who just completed Senior Design I. Many of the questions were similar, or of a similar nature to those found in the pre-Senior Design I survey and was completed by a total of 133 students in January 2016: Mechanical Engineering – 66, Electrical and Computer Engineering – 17, Civil and Environmental Engineering – 42, Bioengineering – 8.

Again a survey was conducted with the following questions that were scored on a Likert Scale: 5- Strongly Agree, 4- Agree, 3-Uncertain, 2- Disagree and 1- Strongly Disagree.

1. When you were a freshman you knew what your career goals were
2. After taking Senior Design you now know what your career goals are
3. One of my career goals is to be an engineering innovator
4. Senior Design has taught me about the importance of innovation
5. One of my career goals is to be an entrepreneur
6. Senior Design has given me some tools to be an entrepreneur
7. One day in the future I plan to start a business
8. In the future I plan to obtain an MBA
9. In the future I plan to get a graduate degree in engineering
10. I learned in Senior Design that even if I work for a large company I will be expected to be an innovator
11. I learned in Senior Design that even if I work for a large company I will be expected to be an entrepreneur
12. Senior Design has improved my confidence in my ability to apply engineering to business
13. When I graduate I will have a desire to apply technology in more creative ways
14. Senior Design has enhanced my desire to apply technology in more creative ways

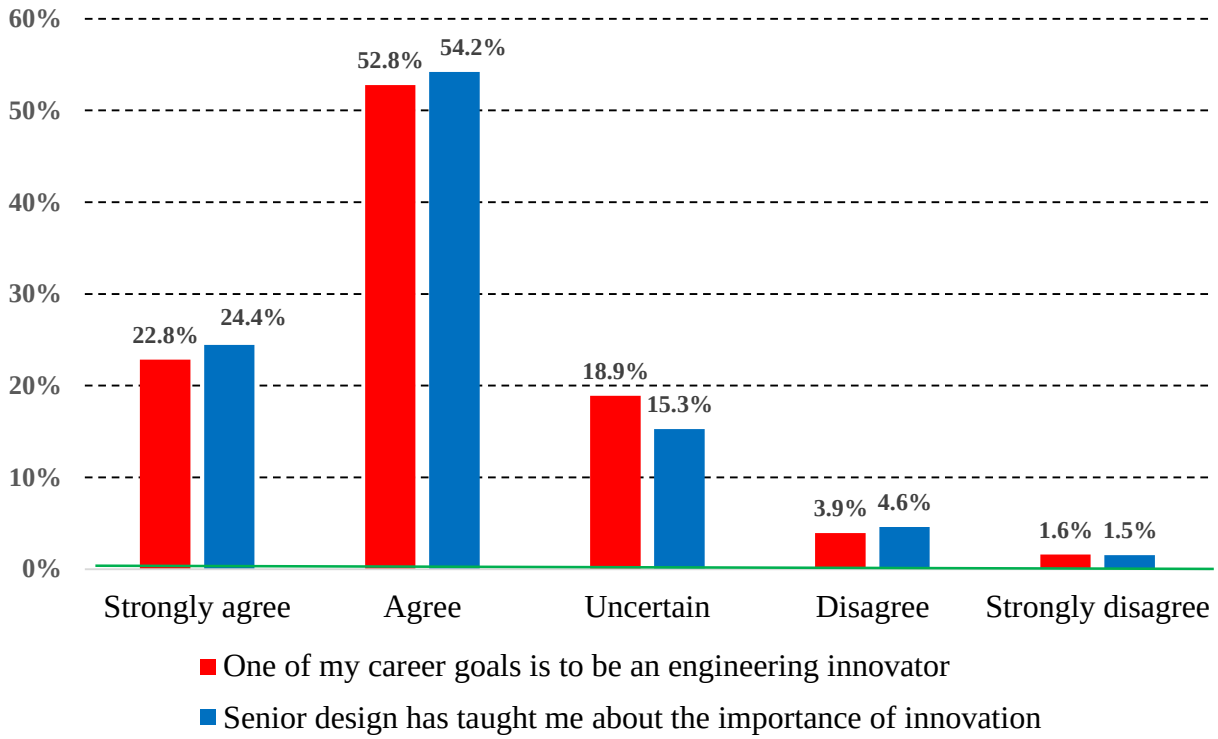
The survey responses for the entire cohort of 133 students were grouped according to question content: Career Goals, Innovation Goals, Entrepreneurship, Future Education Plans and Innovation and Entrepreneurship after Graduation. The grouping was essentially the same that was used for Pre-Senior Design I and was shown previously in Table 1.

Fig. 7 Likert Responses to Career Goals After Graduation for Post-Senior Design I students



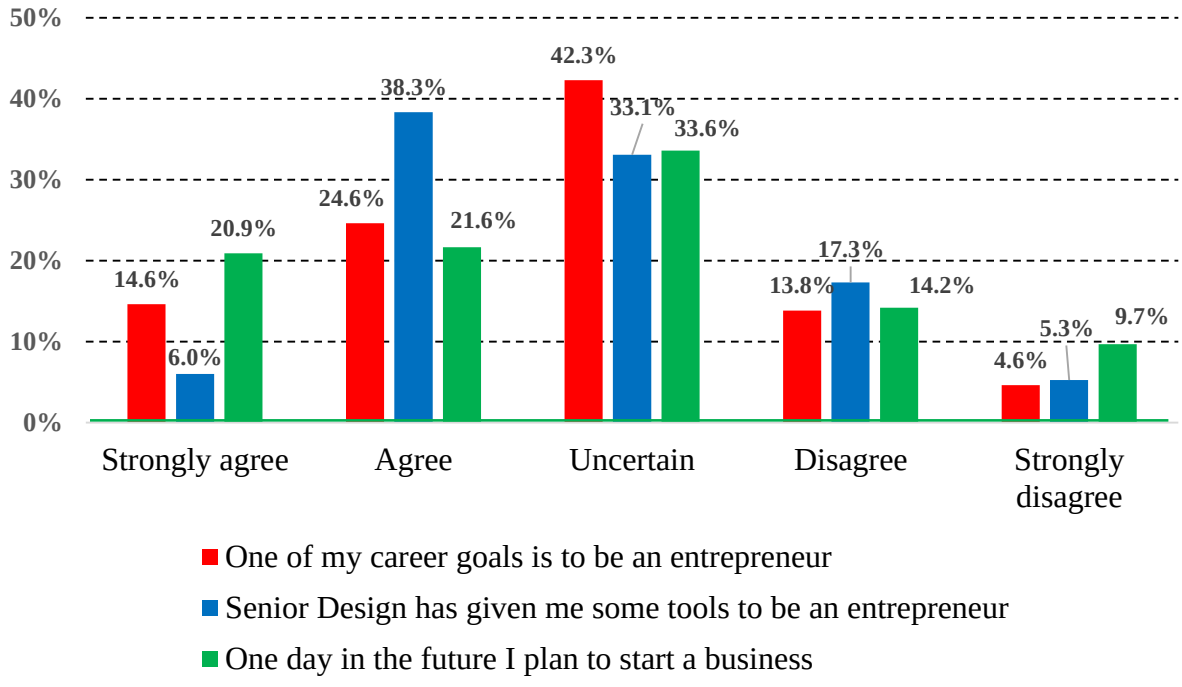
- When you were a freshman you knew what your career goals were – Likert Score: 2.9
- After taking Senior Design you now know what your career goals are – Likert Score: 3.7

Fig. 8 Likert Responses to Innovation Goals After Graduation for Post-Senior Design I students



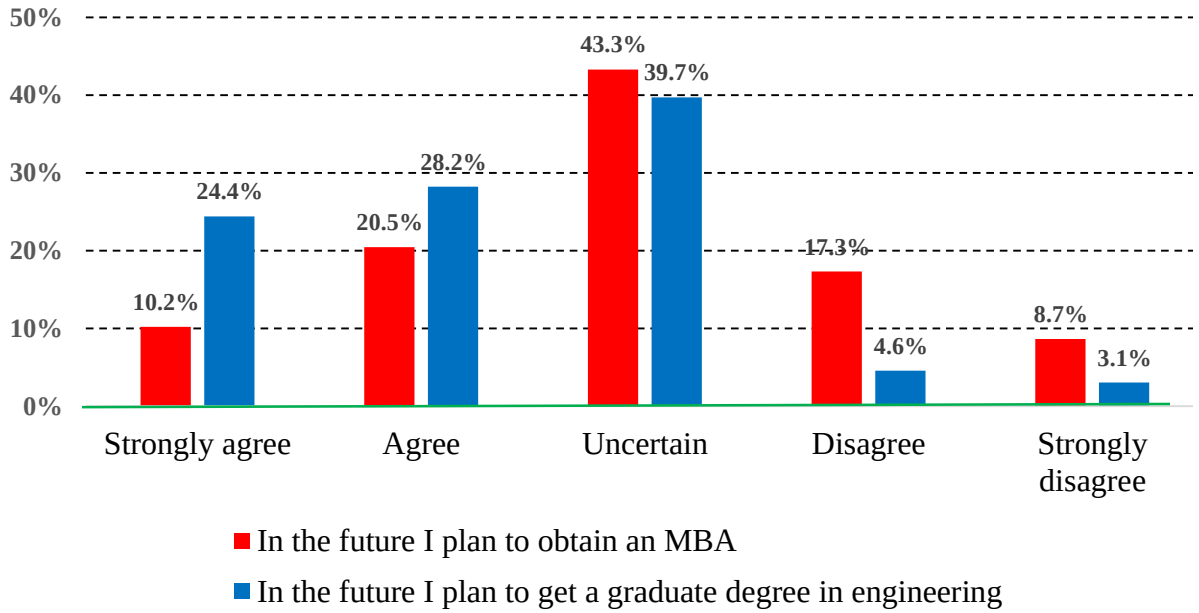
- One of my career goals is to be an engineering innovator – Likert Score: 3.9
- Senior Design has taught me about the importance of innovation – Likert Score: 4.0

Fig. 9 Likert Responses to Entrepreneurship Goals for Post-Senior Design I students



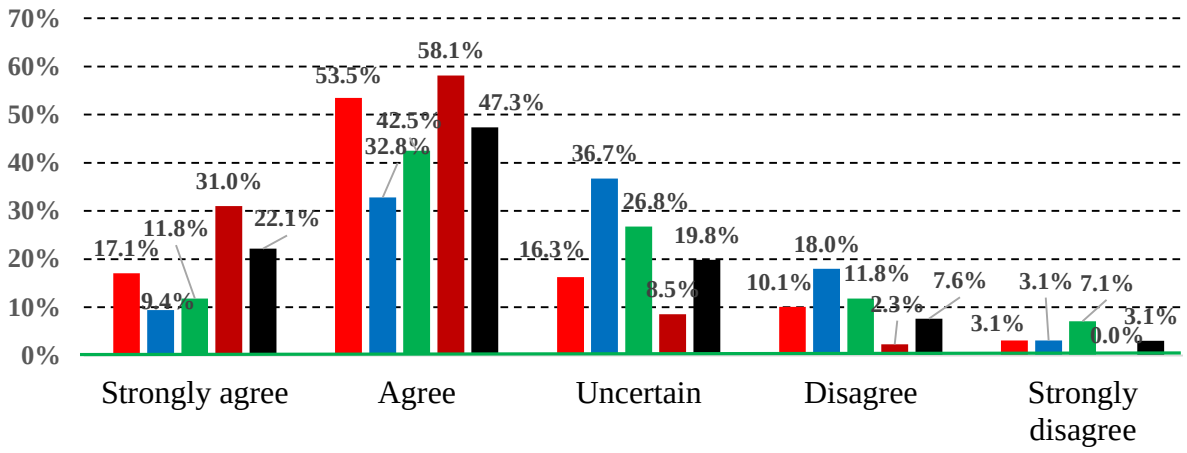
- One of my career goals is to be an entrepreneur – Likert Score: 3.3
- Senior Design has given me some tools to be an entrepreneur – Likert Score: 3.2
- One day in the future I plan to start a business – Likert Score: 3.3

Fig. 10 Likert Responses to Future Education Plans for Post-Senior Design I students



- In the future I plan to obtain an MBA – Likert Score: 3.1
- In the future I plan to get a graduate degree in engineering – Likert Score: 3.7

Fig. 11 Likert Responses to Innovation and Entrepreneurship Plans after Graduation for Post-Senior Design I students



- I learned in Senior Design that even if I work for a large company I will be expected to be an innovator
- I learned in Senior Design that even if I work for a large company I will be expected to be an entrepreneur
- Senior Design has improved my confidence in my ability to apply engineering to business
- When I graduate I will have a desire to apply technology in more creative ways
- Senior Design has enhanced my desire to apply technology in more creative ways

- I learned in Senior Design that even if I work for a large company I will be expected to be an innovator – Likert Score: 3.7
- I learned in Senior Design that even if I work for a large company I will be expected to be an entrepreneur – Likert Score: 3.3
- Senior Design has improved my confidence in my ability to apply engineering to business – Likert Score: 3.4
- When I graduate I will have a desire to apply technology in more creative ways – Likert Score: 4.2
- Senior Design has enhanced my desire to apply technology in more creative ways- Likert Score: 3.8

Below is a chart which shows the percentage responses for each question and are grouped by (1) Strongly Agree or Agree, (2) Uncertain, and (3) Disagree or Strongly Disagree.

	Survey Questions **# of respondents - 133**	**Strongly Agree or Agree**	**Uncertain**	**Disagree or Strongly Disagree**
1	When you were a freshman you knew what your career goals were	37.7%	21.5%	40.8%
2	After taking Senior Design I you now know what your career goals are	63.6%	24.2%	12.1%
3	One of my career goals is to be an engineering innovator	75.6%	18.9%	5.5%
4	Senior Design I has taught me about the importance of innovation	78.6%	15.3%	6.1%
5	One of my career goals is to be an entrepreneur	39.2%	42.3%	18.5%
6	Senior Design I has given me some tools to be an entrepreneur	44.4%	33.1%	22.6%
7	One day in the future I plan to start a business	42.5%	33.6%	23.9%
8	In the future I plan to obtain an MBA	30.7%	43.3%	26.0%
9	In the future I plan to get a graduate degree in engineering	52.7%	39.7%	7.6%
10	I learned in Senior Design I that even if I work for a large company I will be expected to be an innovator	70.5%	16.3%	13.2%
11	I learned in Senior Design I that even if I work for a large company I will be expected to be an entrepreneur	42.2%	36.7%	21.1%
12	Senior Design has improved my confidence in my ability to apply engineering to business	54.3%	26.8%	18.9%
13	When I graduate I will have a desire to apply technology in more creative ways	89.1%	8.5%	2.3%
14	Senior Design I has enhanced my desire to apply technology in more creative ways	69.5%	19.8%	10.7%

- 75.6% of students have a career goal to be an engineering innovator and 78.6% responded that Senior Design I taught them about the importance of innovation.
- 39.2% of students have a goal to be an entrepreneur and 44.4% responded that Senior Design I gave them some tools to be an entrepreneur.
- 42.5% % of students plan to start a business in the future.
- 54.3% of students responded that Senior Design I improved their confidence in their ability to apply engineering to business
- 69.5% of students responded that Senior Design I enhanced their desire to apply technology in more creative ways.

The responses to the 14 similar questions provided by the pre-SDI cohort and the post-SDI cohort were compared. **It is important to recognize that these were separate cohorts of students.** In future studies the pre-SDI cohort will be surveyed again at the completion of SDI and the completion of SDII (Senior Design II) and the current post-SDI students will be surveyed at the completion of SDII.

Aspirational Questions and Responses

	Survey Questions	Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
Pre-SD1	I expect Senior Design will teach me about the importance of innovation	77.6%	18.8%	3.5%
Post - SDI	Senior Design I has taught me about the importance of innovation	78.6%	15.3%	6.1%

- Over 75% of Senior Design students expected to be taught about the importance of innovation and their expectations were essentially met in Senior Design I.

	Survey Questions	Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
Pre-SD1	I hope Senior Design will give me some tools to be an entrepreneur	76.2%	17.9%	6.0%
Post - SDI	Senior Design I has given me some tools to be an entrepreneur	44.4%	33.1%	22.6%

- Over 75% of Senior Design I students expected to obtain tools enabling them to be entrepreneurial yet in Senior Design I less than 50% of the students agreed that they obtained those tools. Additional entrepreneurial tools are provided in Senior Design II and it is expected that when the Senior Design II students are surveyed at end of April 2016 more of their expectations will be met.

	Survey Questions	Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
Pre-SD1	If I work for a large company I will be expected to be an innovator	52.9%	31.8%	15.3%
Post - SDI	I learned in Senior Design I that even if I work for a large company I will be expected to be an innovator	70.5%	16.3%	13.2%

- Prior to starting Senior Design I slightly over 50% of students expected to be an innovator in a large company. After Senior Design I 17.6% more students realized they would be expected to be innovators.

	Survey Questions	Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
Pre-SD1	If I work for a large company I will be expected to be an entrepreneur	35.7%	40.5%	23.8%
Post - SDI	I learned in Senior Design I that even if I work for a large company I will be expected to be an entrepreneur	42.2%	36.7%	21.1%

- Prior to starting Senior Design I roughly a third of the students expected to be an entrepreneur in a large company. After Senior Design I 6.5% more students realized they would be expected to be an entrepreneur. More examples of entrepreneurship in engineering are included in Senior Design II and it is expected that when the Senior Design II students are surveyed at end of April 2016 more of the expectations will be met.

	Survey Questions	Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
Pre-SD1	I expect Senior Design to improve my confidence in my ability to apply engineering to business	79.8%	14.3%	6.0%
Post - SDI	Senior Design I has improved my confidence in my ability to apply engineering to business	54.3%	26.8%	18.9%

- Approximately 80% of students starting Senior Design I expected to improve their confidence in their ability to apply engineering to business yet only about 55% indicated that Senior Design I accomplished that. Senior Design II has additional examples of applying engineering to business and it is expected that when the Senior Design II students are surveyed at end of April 2016 more of the expectations will be met.

	Survey Questions	Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
Pre-SD1	I expect Senior Design to enhance my desire to apply technology in more creative ways	84.7%	8.2%	7.1%
Post - SDI	Senior Design I has enhanced my desire to apply technology in more creative ways	69.5%	19.8%	10.7%

- Senior Design II has additional examples of applying technology in creative ways and it is expected that when the Senior Design II students are surveyed at end of April 2016 more of the expectations will be met.

Common Questions and Responses

Survey Questions		Strongly Agree or Agree	Uncertain	Disagree or Strongly Disagree
When you were a freshman you knew what your career goals were	Pre-SDI	54.1%	23.5%	22.4%
	Post SDI	37.7%	21.5%	40.8%
One of my career goals is to be an engineering innovator	Pre- SDI	69.0%	26.2%	4.8%
	Post SDI	75.6%	18.9%	5.5%
One of my career goals is to be an entrepreneur	Pre- SDI	50.0%	39.3%	10.7%
	Post SDI	39.2%	42.3%	18.5%
One day in the future I plan to start a business	Pre- SDI	53.7%	35.4%	11.0%
	Post SDI	42.5%	33.6%	23.9%
In the future I plan to obtain an MBA	Pre- SDI	42.9%	39.3%	17.9%
	Post SDI	30.7%	43.3%	26.0%
In the future I plan to get a graduate degree in engineering	Pre- SDI	57.0%	29.1%	14.0%
	Post SDI	52.7%	39.7%	7.6%
When I graduate I will have a desire to apply technology in more creative ways	Pre- SDI	85.5%	14.5%	0.0%
	Post SDI	89.1%	8.5%	2.3%

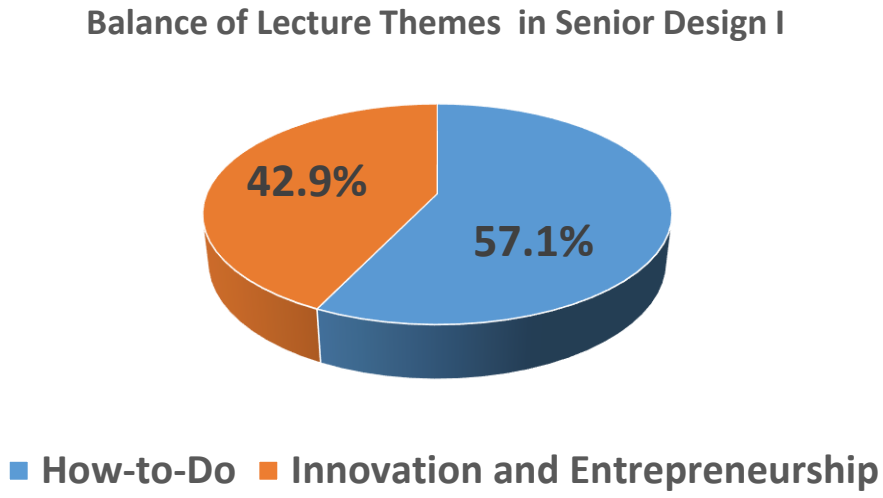
Summary

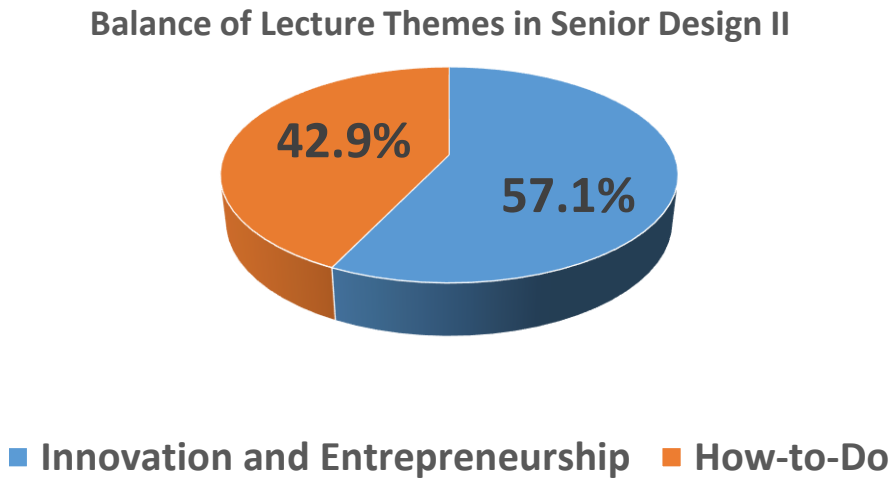
As noted earlier, it is important to recognize that the two cohorts surveyed, (Pre-Senior Design I and Post-Senior Design I), were not the same groups of students and that in future studies the pre-SDI cohort will be surveyed again at the completion of SDI and at the completion of SDII (Senior Design II) and the current post-SDI students will be surveyed at the completion of SDII. Nonetheless, the current study gave us a baseline for continuous improvement in Senior Design I and Senior Design II.

- 69% of pre-Senior Design I students have a career goal to be an engineering innovator and this increases to 75.6% post-Senior Design I.
- 77.6% of students expect Senior Design I to teach them about the importance of innovation and this increases to 78.6% post-Senior Design I.
- 50% of pre-Senior Design I students have a goal to be an entrepreneur and drops to 39.2% post-Senior Design I. It will be interesting to see if that % increases after taking Senior Design II.
- 76.2% of pre-Senior Design I students expect Senior Design to give them some tools to be an entrepreneur yet only 44.4% of post-Senior Design I students thought that Senior Design I gave them some tools to be an entrepreneur. It is anticipated that this % will increase after students take Senior Design II since there is a substantial amount of entrepreneurship education in Senior Design II.
- 79.8% of pre-Senior Design I students expect Senior Design to improve their confidence in their ability to apply engineering to business yet 54.3% of post-Senior Design I student indicate that their confidence is improved. Again, we expect that % to increase after taking Senior Design II.

In view of the student survey responses we rebalanced both Senior Design I and Senior Design II weekly lecture topics in the Spring of 2016 from what was once a 100% focus on "how-to-do" a senior design project to a mixture of "how-to-do" lectures and lectures focused on innovation and entrepreneurship. The new balances of lecture themes are shown below.

Fig. 12 Balance of Lecture Themes in Senior Design





As stated earlier, we will survey the post-Senior Design II students at the end of the Spring 2016 semester to see if the new balance of lecture themes are now more aligned with their expectations with regard to innovation and entrepreneurship. This will be the focus of a further research study.