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Preparing the Engineering Student for Success with IDEAS: A Second Year Experiential Learning Activity for Large-size Classes

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Dr. Zaurin obtained his Bachelor Degree in Civil Engineering from 'Universidad de Oriente' in Venezuela in 1985. In 1990 he earned a MSc in Information Technology. He has been civil engineering professor with teaching experience at his Alma Mater (Universidad de Oriente) from 1986 until 2002. Dr. Zaurin moves to USA and completes another MSc, this time Structural and Geotechnical Engineering. Upon completing multidisciplinary PhD on Structural Health Monitoring Using Computer Vision, he joined UCF in 2010 as a Lecturer at the Civil, Environmental and Construction Engineering (CECE) Department. He has published computer vision related research work in prominent journals and still mentors graduate students in this particular area. Dr. Zaurin has been very active in the STEM area as he is one of the selected faculty members for the NSF funded EXCEL and NSF funded COMPASS programs at UCF. Dr. Zaurin received College Excellence in Undergraduate Teaching Award in 2015, TIP Award in 2016, and also received 4 Golden Apple Awards for Undergraduate Teaching for a record four years in a row. During Fall 2013 he created IDEAS (Interdisciplinary Display for Engineering Analysis Statics) which is a project based learning activity designed specifically for promoting creativity, team-work, and presentation skills for undergraduate sophomore and junior students, as well as by exposing the students to the fascinating world of scientific/technological research based engineering. IDEAS is becoming the cornerstone event for the sophomore engineering students at UCF: from fall 2013 to fall 2017 approximately 2000 students have created, designed, presented, and defended around 600 projects and papers.

Preparing the Engineering Student for Success with IDEAS: A Second Year Experiential Learning Activity for Large-size Classes

Abstract

This study describes and summarizes the effects of introducing a semester long experiential learning project named IDEAS on class effectiveness, second and third year retention, graduation rates, class engagement, and students' perception of instruction. The investigation was conducted at the University of Central Florida (UCF) on the Engineering Analysis - Statics course, which is commonly taken by a large number of second year students from nearly all of the engineering disciplines. The research presented herein took place in two stages: an initial study on twelve sections during Fall 2013 and Spring 2014 and a replication during Fall 2014, Spring 2015, and Fall 2015 (nineteen sections). Some of the students participated in the IDEAS project and others did not (control). To certify the research's legitimacy, demographic data consisting of gender, ethnicity, average GPA, grade distribution, and classification were collected and compared for both the initial study and the replication. The same type of comparison was performed between the groups of participants and non-participants as well. The statistical analysis showed no significant difference regarding the initial characteristics of the participants and non-participants however, results from the study indicated that the students belonging to the IDEAS participants group performed better in the class. In addition, statistics regarding the retention (persistence) rates for two consecutive years after the intervention showed a positive difference of more than ten percent positive points for the IDEAS participants over the non-participants. Graduation rates for IDEAS participants were also higher. Students' perception of instruction and opinions of the project are summarized and discussed.

Introduction

The purpose of this research was to investigate if the introduction of an active learning experience (IDEAS) into a large-size engineering class improved the class effectiveness, second and third year retention, graduation rates, and student engagement/perception of instruction.

Attrition and Retention are issues that have been object of ample studies [1], [2], [3], [4].For engineering, student retention rates fall anywhere in the range of 40% - 60%, and even some students capable of completing an engineering degree switch to a different one. Teaching strategies and lack of identification with the major are some of the fundamentals reasons for students withdrawing from engineering programs, especially during the first years [1].

Education research has shown that when students are engaged in meaningful and relevant learning experiences, their motivation to learn is increased, as well as the retention and graduation in their disciplines [5].

Other research shows that experiential learning activities provides the tools necessary to develop a skilled STEM workforce, and that students who participate in any type of undergraduate research are more prone to continue a post Baccalaureate Education [6].

The university where this research was conducted has large enrollment of STEM Students (~8,600 in total for 2016) and most them are from the College of Engineering and Computer Science (~5,800 students, ~67.4% of all STEM students). Recent data for the same institution, show that retention of STEM engineering students is approximately 81% at the end of Year 1, 73% at the end of Year 2, and 51% at the end of Year 3. National studies also consistently show that after junior year (after Year 3), the amount of students either switching to non-STEM majors or dropping-out from college is around 56%, negatively impacting college retention and graduation rates as well as causing lasting negative consequences for the drop-out students, such as student loan debts [3], [7], [8].
In another study, the President's Council of Advisors on Science and Technology Nationwide presented statistics showing that 6-yr degree-completion rates in STEM majors are less than 40% [9]. This has raised flags about the capability of United States to keep competitiveness in science and technology fields [10]. Due to the well-documented success of first-year experience initiatives all around the country, there have been a good amount of efforts to study and create programs specifically designed for these students [7], [11], [12], [13], [14]. However, less research has been dedicated to increasing the retention in engineering majors during the second and third years.

Methodology

Based on previous studies and preliminary data, three research questions were formulated to assess the impact of incorporating an Experiential Learning Project as a part of a second-year course on class effectiveness, retention (persistence) and graduation rates, and students' engagement/perception of instruction:

Research Questions

1) To what extent does the introduction of IDEAS Active Learning Project improve student's success in Engineering Analysis Statics?
2) To what extent Active Learning Projects introduced early in the curriculum improve student retention and graduation rates?
3) Do Active Learning Projects improve Engagement, Class Participation, and Students' Perception of Instruction?

Research Design and Control

To answer these questions, an experiential learning project –IDEAS- was introduced to several sections of the Engineering Analysis-Statics course. This class was selected for several reasons: 1) It is a large-size class (around 150-250 students per class; 1,700 students per year), 2) It is required for several engineering majors and it is part of the critical path for graduation (It was required for all engineering majors during the duration of the research), 3) It has a high fail/pass ratio close to 50% which means that approximately 850 students fail the class every year, drastically affecting their budget and jeopardizing their graduation.

This research was conducted in two stages: An initial study with a span of two semesters (12 sections) and a replication study spanning over three semesters (19 sections).

Description of the Experiential Learning Project: IDEAS

The Interdisciplinary Display for Engineering Analysis Statics (IDEAS) was developed and organized with the objective of providing a second-year active learning experience by promoting creativity, team-work, and presentation skills for undergraduate sophomore and junior students, as well as exposing them to the fascinating world of scientific/technological research-based engineering. This effort was designed to close the gap between the theory and applied engineering at the early stages of the 4-year college education. It is also expected to promote Science Technology Engineering and Mathematics (STEM), and spark more interest in students to pursue a graduate degree in STEM disciplines.

a) b)

Figure 1: a) IDEAS Showcase at the End of a Semester (There have been 8 events, with a participation of approximately 2000 students in total with more than 600 projects so far), b) IDEAS Showcase Awardees at the end of a Semester (Top 10% of the Projects are Awarded First Place)

For IDEAS students are asked to form groups and work on a final project. They select a topic, preferably related to their majors, and conduct research involving some of the concepts learned in the Engineering Analysis-Statics course. The projects involve creation of physical models, designing experiments, testing, measurements, and comparison of the experimental data with the theoretical calculations. The students are also required to write papers and prepare posters, which are presented on the day of the showcase Professors and graduate students judge these projects. First places are awarded with medals and all students receive a certificate of participation upon completion and presentation of their projects (Figure 1). Online copies of the proceedings with all the abstracts are made available to the community. While possible project topics are recommended, students have the freedom to choose their own, if they present their proposal and abstracts for their professor’s approval. Over the course of IDEAS, there have been several remarkable projects that surprised the judges, professors, as well as visitors in terms of the depth of their content and the creativity. Some examples of project topics are presented in TABLE 1.

TABLE 1: LIST OF SOME REPRESENTATIVE IDEAS PROJECTS

• Tuned Mass Dampers: A Skyscraper's Defense Against Mother Nature • In-Depth Analysis of the Arrigoni Bridge: Exemplary Model of a Through Arch Truss and Suspension Combination • Proportional–Integral–Derivative (PID) Controllers and Static Equilibrium	• Planet Hollywood: An Investigation of Structural Integrity • Suspended Statics and Tire Camber • Donut Space Station • One Stressful Catapult • Analysis of Actuator Weight Distribution in Robotic Arms	• Restoring Roman Architecture • Give Me Liberty or Give me “Strength” • Getting to the Roots of It: A Structural Analysis of the Tree of Life • Comparative Macro-Scale Modeling of Deformation on Carbon Nanotube Structure • Statics in the Sky: Analysis of a Tower Crane

Steps for the Execution of IDEAS project

The first day of class the students are provided with the tasks’ schedule for the execution of IDEAS, which contain several milestones as shown in Figure 2

Fifth Interdisciplinary Display For Engineering Analysis-Statics
IDEAS Showcase

Fifth IDEAS Showcase Tasks' Schedule

			September				October				November				Dec
		Week	1	2	3	4	1	2	3	4	1	2	3	4	1
1	Group sign-up	9/11/2015		X											
2	Idea APPROVED by Dr. Zaurin in the appropriate format (in person)	9/24/2015				X									
3	Abstract Submission	10/8/2015					X								
4	Laboratory testing/Model ready before	11/6/2015-11/20/2015													
5	First Submission	11/6/2015-11/20/2015													
6	Final paper	11/23/2015											X		
7	Presentation	12/3/2015													X

Figure 2. Task's Schedule for IDEAS

The students’ first task is to sign up for groups. Students self-enroll online in groups of up to 4 members. This must happen during the first two weeks of class.

After the groups are formed, the students research project topics they would like to work on. Due to the fact that the class is required for nearly all engineering majors, many of the groups are multidisciplinary, which increases the diversity in the projects since every member looks at a problem from a different perspective. Once the group agrees on one (or several) ideas, they must discuss and obtain approval from the IDEAS Showcase Coordinator (the class professor in this case) by presenting a proposal which briefly describes the topic of study and how they plan to achieve it (Figure 3 a). A template for the proposal and several examples are provided to the students.

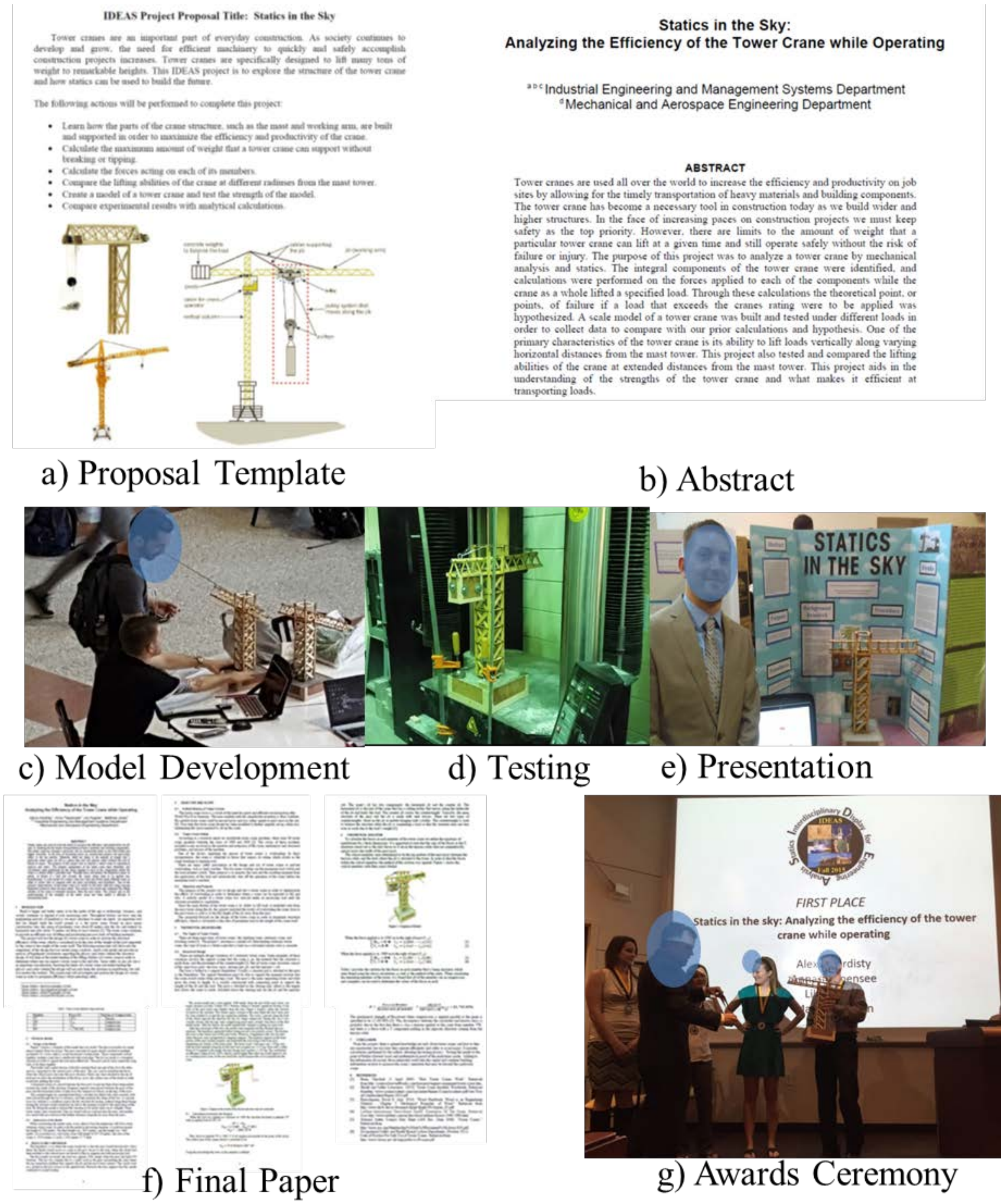


Figure 3. IDEAS Stages

After the proposal is approved, the groups start working in a literature review to develop a better understanding about their research topic. The students then produce an abstract (Figure 3 b), which is submitted online by the deadline, to be peer reviewed by the course's teaching assistants. The groups prepare their physical model(s) and experimental set-up (Figure 3 c) to be tested according to their experiment design (Figure 3d). Once the laboratory results, hand calculations, and simulations are completed, the groups write and submit a paper according to the provided template and guidelines (Figure 3f). The students also create a poster (examples are provided) which is presented at the showcase along with the model(s), video(s), and paper to be presented and defended (Figure 3e). Groups of judges (at least 2) evaluate several projects according to a provided rubric. The rubric contains several sections including: originality, relation to Statics, real life applications, quality of poster, paper, oral presentation, answer to questions. After the showcase is over, al the rubrics from the judges are compiled and the top 10% of the projects are awarded first place (Figure 3g).

Instruments and Assessments

To answer the research questions, two studies were conducted: An initial study and then a replication.

Initial Study

The students included in the initial study were all First Time in College (FTIC) classified as sophomore, junior, or senior when they enrolled in Statics during Fall 2013 or Spring 2014. Of the twelve sections of Statics taught during this period, four of them offered participation in IDEAS. Students were classified into three main groups: students who were enrolled in a section which offered Statics and participated, students enrolled in a section which offered IDEAS but did not participate, and students who were enrolled in a section which did not offer IDEAS (The last two groups were ultimately combined as “non-participants”. The courses were taught by professors and lecturers from the Civil, Environmental, and Construction Department (three lecturers, two associate professors, and two visiting scholars).

Replication

To ensure the relevance and validity of the research the study was replicated. The Replication study included all FTIC students that were enrolled in Statics during Fall 2014, Spring 2015, and Fall 2015. Of the nineteen sections of Statics taught during this period, seven of them offered IDEAS to students. The pool of professors teaching the sections was nearly the same, with the exception that one of the vising scholars was substituted by an adjunct professor who was provided with the same syllabus.

Students

Students selected their own groups and decided whether to participate in IDEAS or not. For this reason, the data from both studies were analyzed to determine the differences and similarities between the two groups. These analyses used data housed by Institutional Knowledge

Management (IKM) of the University, which includes student's demographics such as gender, classification (sophomore, junior, senior), ethnicity, enrollment, cumulative GPA (

TABLE 2). Although continuous data have been collected for students participating after Fall 2015, it should be noted that the results are not presented here, since graduation rates cannot be determined for those cohorts due to the fact that it usually takes more than two years after completing the Statics course for the students to obtain their degree.

TABLE 2. SUMMARY TABLES OF PARTICIPANTS.

INITIAL STUDY (FALL2013, SPRING 2014)							
Classification	Gender	IDEAS Participant		Non-Participant		TOTAL	
		Count	%	Count	%	Count	%
Sophomore	Female	9	12.16%	29	14.87%	38	14.13%
	Male	65	87.84%	166	85.13%	231	85.87%
Junior	Female	23	26.14%	35	17.50%	58	20.14%
	Male	65	73.86%	165	82.50%	230	79.86%
Senior	Female	10	37.04%	10	13.70%	20	20.00%
	Male	17	62.96%	63	86.30%	80	80.00%
All	Female	42	22.22%	74	15.81%	116	17.66%
	Male	147	77.78%	394	84.19%	541	82.34%
	ALL	189	100.00%	468	100.00%	657	100.00%
Classification	**Ethnicity**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Sophomore	Asian	5	6.76%	13	6.67%	18	6.69%
	Afr.Amer./Black	3	4.05%	13	6.67%	16	5.95%
	Hispanic/Latino	12	16.22%	24	12.31%	36	13.38%
	Other	3	4.05%	14	7.18%	17	6.32%
	White	51	68.92%	131	67.18%	182	67.66%
Junior	Asian	9	10.23%	11	5.50%	20	6.94%
	Afr.Amer./Black	3	3.41%	12	6.00%	15	5.21%
	Hispanic/Latino	17	19.32%	53	26.50%	70	24.31%
	Other	2	2.27%	9	4.50%	11	3.82%
	White	57	64.77%	115	57.50%	172	59.72%
Senior	Asian	3	11.11%	3	4.11%	6	6.00%
	Afr.Amer./Black	1	3.70%	7	9.59%	8	8.00%
	Hispanic/Latino	8	29.63%	18	24.66%	26	26.00%
	Other	1	3.70%	7	9.59%	8	8.00%
	White	14	51.85%	38	52.05%	52	52.00%
All	Asian	17	8.99%	27	5.77%	44	6.70%
	Afr.Amer./Black	7	3.70%	32	6.84%	39	5.94%
	Hispanic/Latino	37	19.58%	95	20.30%	132	20.09%
	Other	6	3.17%	30	6.41%	36	5.48%
	White	122	64.55%	284	60.68%	406	61.80%
	ALL	189	100.00%	468	100.00%	657	100.00%
Classification	**GPA**	**IDEAS Participant**		**Non-Participants**		**TOTAL**	
Sophomore	count	74		195		269	
	Min	0.82		1.67		0.82	
	25th Percentile	2.81		2.62		2.68	
	Mean	3.11		2.94		2.99	
	Median	3.10		2.91		2.98	
	75th Percentile	3.41		3.26		3.34	
	Max	3.98		4.00		4.00	
Junior	count	88		200		288	
	Min	2.13		0.43		0.43	
	25th Percentile	2.81		2.65		2.70	
	Mean	3.18		2.97		3.04	
	Median	3.16		2.96		3.02	
	75th Percentile	3.60		3.37		3.42	
	Max	4.00		4.00		4.00	
Senior	count	27		73		100	
	Min	2.19		1.99		1.99	
	25th Percentile	2.88		2.71		2.77	
	Mean	3.21		2.98		3.06	
	Median	3.27		2.97		3.08	
	75th Percentile	3.55		3.22		3.39	
	Max	4.00		3.94		4.00	
All	count	189		468		657	
	Min	0.82		0.43		0.43	
	25th Percentile	2.82		2.65		2.71	
	Mean	3.15		2.96		3.02	
	Median	3.15		2.96		3.02	
	75th Percentile	3.53		3.36		3.38	
	Max	4.00		4.00		4.00	

REPLICATION STUDY (FALL2014, SPRING 2015,FALL 2015)							
Classification	Gender	IDEAS Participant		Non-Participant		TOTAL	
		Count	%	Count	%	Count	%
Sophomore	Female	26	16.67%	24	15.79%	50	16.23%
	Male	130	83.33%	128	84.21%	258	83.77%
Junior	Female	46	20.63%	47	14.33%	93	16.88%
	Male	177	79.37%	281	85.67%	458	83.12%
Senior	Female	11	27.50%	30	28.30%	41	28.08%
	Male	29	72.50%	76	71.70%	105	71.92%
All	Female	83	19.81%	101	17.24%	184	18.31%
	Male	336	80.19%	485	82.76%	821	81.69%
	ALL	419	100.00%	586	100.00%	1005	100.00%
Classification	**Ethnicity**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Sophomore	Asian	6	3.85%	5	3.29%	11	3.57%
	Afr.Amer./Black	6	3.85%	13	8.55%	19	6.17%
	Hispanic/Latino	40	25.64%	36	23.68%	76	24.68%
	Other	6	3.85%	9	5.92%	15	4.87%
	White	98	62.82%	89	58.55%	187	60.71%
Junior	Asian	19	8.52%	28	8.54%	47	8.53%
	Afr.Amer./Black	14	6.28%	22	6.71%	36	6.53%
	Hispanic/Latino	55	24.66%	71	21.65%	126	22.87%
	Other	8	3.59%	15	4.57%	23	4.17%
	White	127	56.95%	192	58.54%	319	57.89%
Senior	Asian	4	10.00%	9	8.49%	13	8.90%
	Afr.Amer./Black	3	7.50%	9	8.49%	12	8.22%
	Hispanic/Latino	16	40.00%	22	20.75%	38	26.03%
	Other	3	7.50%	10	9.43%	13	8.90%
	White	14	35.00%	56	52.83%	70	47.95%
All	Asian	29	6.92%	42	7.17%	71	7.06%
	Afr.Amer./Black	23	5.49%	44	7.51%	67	6.67%
	Hispanic/Latino	111	26.49%	129	22.01%	240	23.88%
	Other	17	4.06%	34	5.80%	51	5.07%
	White	239	57.04%	337	57.51%	576	57.31%
	ALL	419	100.00%	586	100.00%	1005	100.00%
Classification	**GPA**	**IDEAS Participant**		**Non-Participants**		**TOTAL**	
Sophomore	count	156		152		308	
	Min	1.74		1.85		1.74	
	25th Percentile	2.86		2.63		2.76	
	Mean	3.18		3.01		3.10	
	Median	3.19		3.00		3.10	
	75th Percentile	3.51		3.40		3.49	
	Max	4.00		4.00		4.00	
Junior	count	223		328		551	
	Min	1.92		1.95		1.92	
	25th Percentile	2.91		2.72		2.80	
	Mean	3.20		3.10		3.14	
	Median	3.19		3.10		3.14	
	75th Percentile	3.55		3.52		3.52	
	Max	4.00		4.00		4.00	
Senior	count	40		106		146	
	Min	2.22		1.76		1.76	
	25th Percentile	3.03		2.80		2.84	
	Mean	3.27		3.16		3.19	
	Median	3.33		3.16		3.22	
	75th Percentile	3.64		3.56		3.59	
	Max	3.98		4.00		4.00	
All	count	419		586		1005	
	Min	1.74		1.76		1.74	
	25th Percentile	2.91		2.71		2.80	
	Mean	3.20		3.09		3.13	
	Median	3.20		3.09		3.14	
	75th Percentile	3.54		3.50		3.52	
	Max	4.00		4.00		4.00	

A chi-square statistical comparison analysis test was performed to verify the similarities between the groups corresponding to the initial study and the replication for each demographic category, for participants and non-participants. The test showed that there was not any significant difference between any of the distributions for the IDEAS participants and non-participants in both the initial study and the replication. In addition, a T-test was conducted to compare the grade distribution of the IDEAS participants and the non-participants for the initial study and replication. This comparison showed that for the cohorts corresponding to Fall 2013, Fall 2014, and Fall 2015 there was no initial significant difference between the IDEAS participants and non-participants group with $p<0.05$. Only for the cohorts Spring 2014 and Spring 2015 did the t-test show significant difference between the grade distribution of both groups, with $p>0.05$.

These results suggest that even though the study was quasi-experimental, the groups of participants and non-participants didn't exhibit any significant differences except for the cases previously reported.

Results

Several metrics were obtained from the data provided by the IKM department of the University: students' success in the class, students' retention (persistence) for 4 semesters after completing Statics, and students' graduation rates.

Students' Success in the Class:

To answer the first research question: "To what extent does the introduction of the IDEAS Active Learning Project improve student's success in Engineering Analysis Statics?" the percentages of students passing the class were determined for both groups (IDEAS participants and non-participants). Passing the class refers to those students that obtained a "C" or better in their final grade. All withdrawals are considered as failed attempts. Figure 4 shows the results in terms of percentage of students succeeding on their attempt to pass the class per semester and per group. The sizes of the samples are different since not all students decided to be part of the project. The results clearly show a better performance from the IDEAS participants compared with the non-participants (83.09% vs 48.7% for Fall 2013, 76.09% vs 44.15% for Spring 2014) for the initial study. Results of the students' success for the replication were very similar to those shown by the initial study (63.67% vs 44.15 for Fall 2014, 79.05% vs 43.56% for Spring 2015, and 78.76% vs 51.46% for Fall 2015). For every case, the success of IDEAS participants (passing the class) was significantly higher than the students not participating in IDEAS.

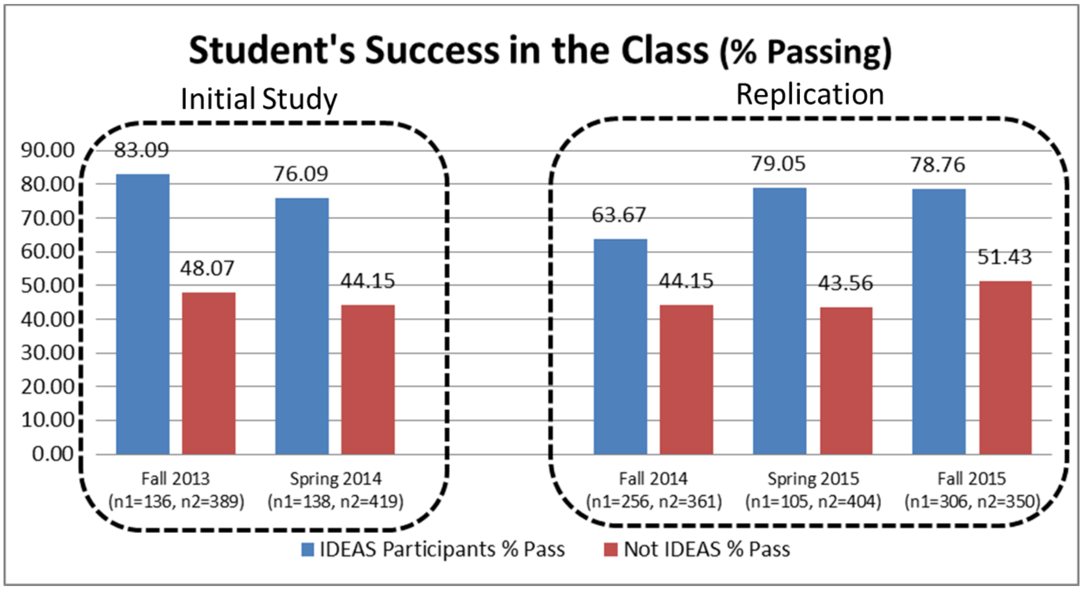


Figure 4. Students' Success in the Class.

In addition to the previous study, one-tail t-test analyses were performed to validate the data. A series of t-test analyses, with α=5%, show that not only the passing rates for the IDEAS participants were different (better in this case) than those who did not participate, but that the final grade distributions were significantly different as well. Results of these statistical analyses are shown in TABLE 3 and TABLE 4.

TABLE 3. T-TEST FOR INITIAL STUDY

Fall 2013 α=0.05	*IDEAS Participant*	*NOT Participant*
Mean	2.7868	1.5841
Variance	1.4875	2.1029
Observations	136	389
Pooled Variance	1.9440	
Hypothesized Mean Difference	0.0000	
df	523	
t Stat	8.6590	
P(T<=t) one-tail	<0.0001	
t Critical one-tail	1.6478	
P(T<=t) two-tail	0.0000	
t Critical two-tail	1.9645	

Spring 2014 α=0.05	*IDEAS Participant*	*NOT Participant*
Mean	2.3551	1.3842
Variance	1.6175	1.9262
Observations	138	419
Pooled Variance	1.8500	
Hypothesized Mean Difference	0.0000	
df	555	
t Stat	7.2724	
P(T<=t) one-tail	<0.0001	
t Critical one-tail	1.6476	
P(T<=t) two-tail	0.0000	
t Critical two-tail	1.9642	

TABLE 4. T-TEST FOR REPLICATION STUDY

Fall 2014 α=0.05	*IDEAS Participant*	*NOT Participant*
Mean	2.0871	1.6374
Variance	1.6378	1.7633
Observations	256	361
Pooled Variance	1.7113	
Hypothesized Mean Difference	0.0000	
df	615	
t Stat	4.2073	
P(T<=t) one-tail	0.00001	
t Critical one-tail	1.6473	
P(T<=t) two-tail	0.0000	
t Critical two-tail	1.9638	

Spring 2015 α=0.05	*IDEAS Participant*	*NOT Participant*
Mean	2.3048	1.3317
Variance	1.3870	1.8599
Observations	105	404
Pooled Variance	1.7629	
Hypothesized Mean Difference	0.0000	
df	507	
t Stat	6.6905	
P(T<=t) one-tail	<0.0001	
t Critical one-tail	1.6479	
P(T<=t) two-tail	0.0000	
t Critical two-tail	1.9647	

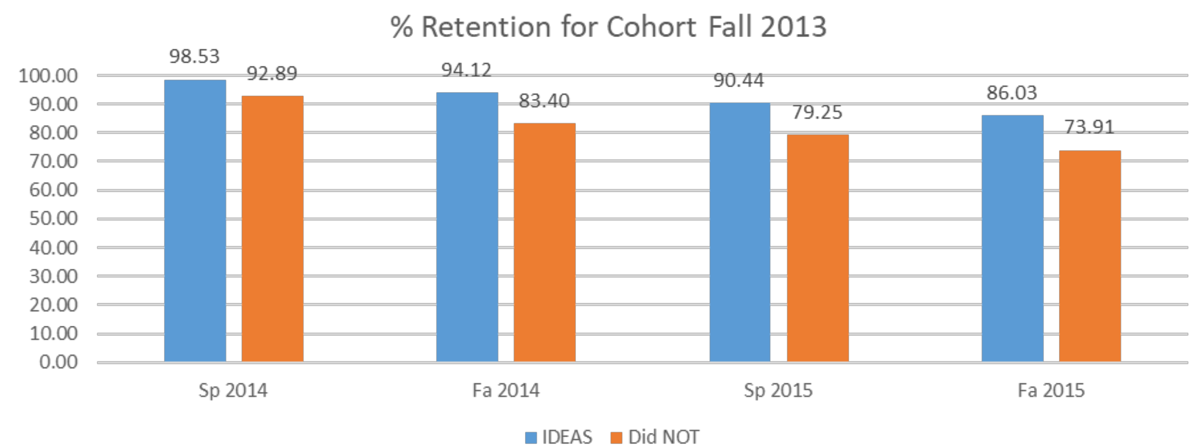
Fall 2015 α=0.05	*IDEAS Participant*	*NOT Participant*
Mean	2.5611	2.3556
Variance	1.4746	1.4486
Observations	306	239
Pooled Variance	1.4632	
Hypothesized Mean Difference	0.0000	
df	543	
t Stat	1.9676	
P(T<=t) one-tail	0.0248	
t Critical one-tail	1.6477	
P(T<=t) two-tail	0.0496	
t Critical two-tail	1.9643	

Students Retention and Graduation Rates

To answer the second research question: “To what extent Active Learning Projects introduced early in the curriculum improve student retention and graduation rates?”, a very large data set was provided by the university’s IKM. This set included all students that had taken a Statics course from Fall 2013 to Fall 2015 at the University of Central Florida, and their performance throughout Fall 2017. This data set enabled tracking of students’ performance for up to at least four semesters following their participation (or not) in the IDEAS experiential project.

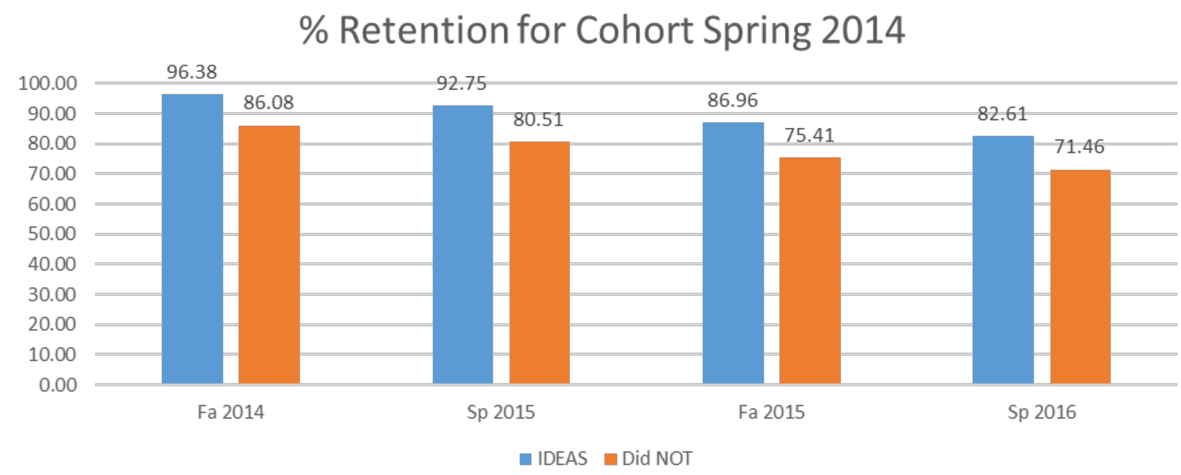
Students Retention

Results for the initial study are presented in figures 5 and 6. Figure 5 shows the results of retention corresponding to the Fall 2013 cohort. It can be observed that for Fall 2014 (one year after the intervention for this cohort) the % of IDEAS participants retained was 94.12% compared with 83.4% for the non-participants. By the end of the second year, the difference was even bigger (86.03% vs 73.91%). Figure 6 summarizes the four consecutive semesters (two years) retention corresponding to the cohort of Spring 2014. 92.75% of IDEAS participants were retained by the end of the year following the intervention (Spring 2015) compared with 80.51% of the non-participants. For the second year (Spring 2016), 82.61% IDEAS participants remained in the university/college vs 71.46% for the non-participants.



	Semester Taking EGN3310			First Year After Taking EGN3310						Second Year After Taking EGN3310					
	Fa 2013			Sp 2014			Fa 2014			Sp 2015			Fa 2015		
	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT
# of Students	642	136	506	604	134	470	550	128	422	524	123	401	491	117	374
Retention(%)					**98.53**	**92.89**		**94.12**	**83.40**		**90.44**	**79.25**		**86.03**	**73.91**

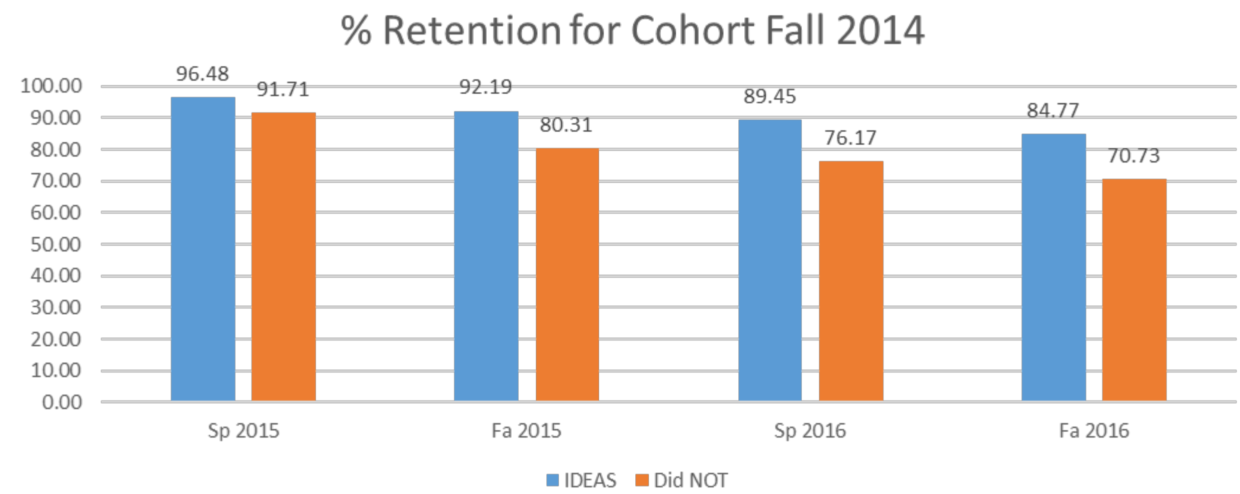
Figure 5 . Retention (Persistence) for Cohort Fall 2013



	Semester Taking EGN3310			First Year After Taking EGN3310						Second Year After Taking EGN3310					
	Sp 2014			Fa 2014			Sp 2015			Fa 2015			Sp 2016		
	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT
# of Students	569	138	431	504	133	371	475	128	347	445	120	325	422	114	308
Retention(%)				88.57645	**96.38**	**86.08**		**92.75**	**80.51**		**86.96**	**75.41**		**82.61**	**71.46**

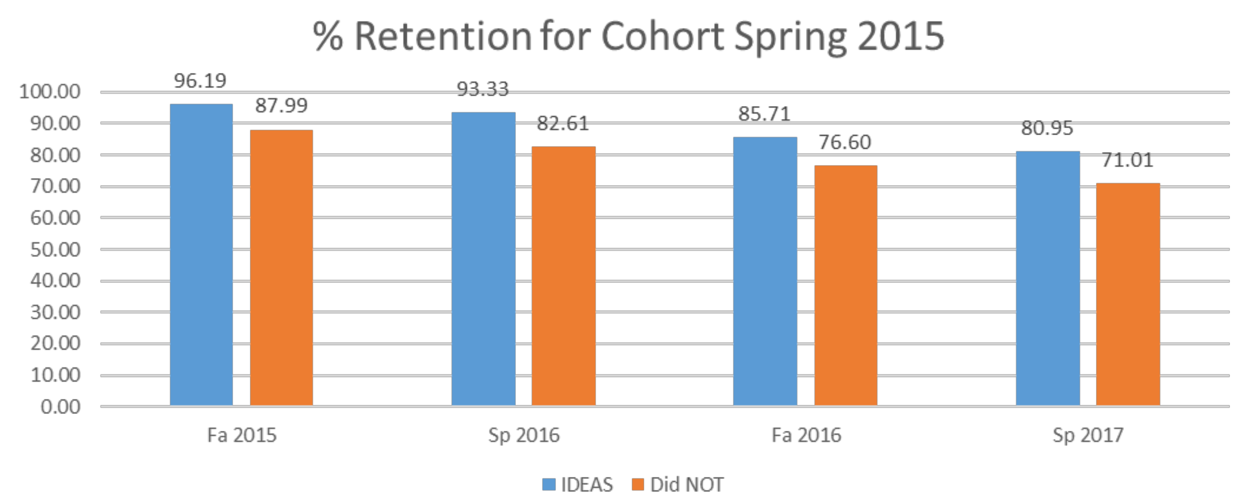
Figure 6. Retention (Persistence) for Cohort Spring 2014

Results for the replication study were very similar and are presented in figures 7 - 9. In Figure 7 (Cohort Fall 2014) can be seen that by Fall 2015, 92.19% of the IDEAS participants were still enrolled in classes compared with 80.31% for the non-participants. Fall 2016, shows a retention of 84.77% for participants and 70.73% for non-participants. Figure 8 (Cohort Spring 2015) summarizes that by Spring 2016, 93.33% were retained for participants and 82.61% (non-participants). By the end of the second year (Spring 2017), a retention of 80.95% was shown for the participants vs 71.01% for those students that didn't participate. Finally, retention for the last cohort of the replication study (Fall 2015) is presented in Figure 9: 92.48% (IDEAS) vs 83.45%(non-participants) by Fall 2016 and 83.99% vs 69.34% by Fall 2017. All the analyses from both the initial and replication study suggest that IDEAS had a positive impact on retaining the students within the university and the college of engineering.



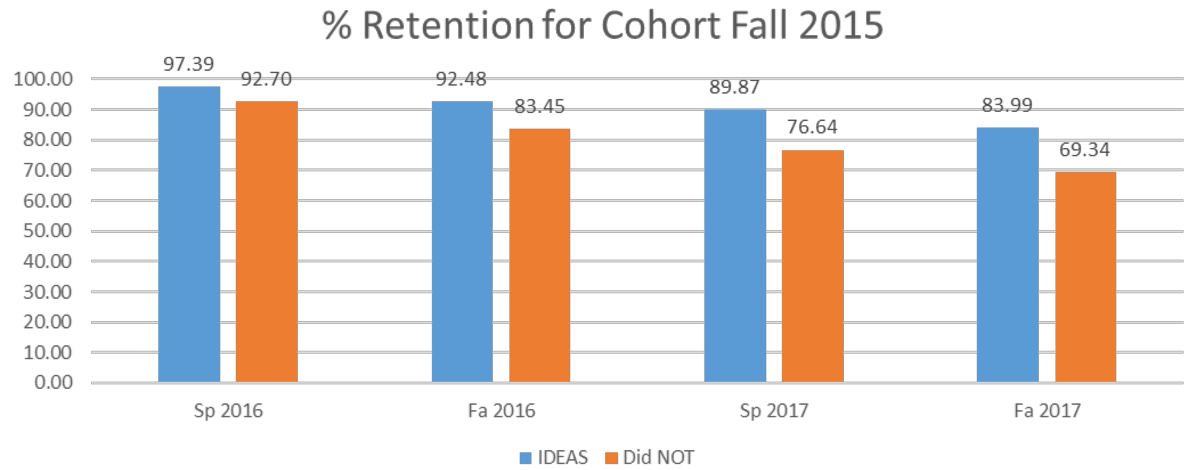
	Semester Taking EGN3310			First Year After Taking EGN3310						Second Year After Taking EGN3310					
	Fa 2014			Sp 2015			Fa 2015			Sp 2016			Fa 2016		
	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT
# of Students	642	256	386	601	247	354	546	236	310	523	229	294	490	217	273
Retention(%)					**96.48**	**91.71**		**92.19**	**80.31**		**89.45**	**76.17**		**84.77**	**70.73**

Figure 7. Retention (Persistence) for Cohort Fall 2014



	Semester Taking EGN3310			First Year After Taking EGN3310						Second Year After Taking EGN3310					
	Sp 2015			Fa 2015			Sp 2016			Fa 2016			Sp 2017		
	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT
# of Students	588	105	483	526	101	425	497	98	399	460	90	370	428	85	343
Retention(%)					**96.19**	**87.99**		**93.33**	**82.61**		**85.71**	**76.60**		**80.95**	**71.01**

Figure 8. Retention (Persistence) for Cohort Spring 2015



	Semester Taking EGN3310			First Year After Taking EGN3310						Second Year After Taking EGN3310					
	Fa 2015			Sp 2016			Fa 2016			Sp 2017			Fa 2017		
	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT	Total	IDEAS	Did NOT
# of Students	717	306	411	679	298	381	626	283	343	590	275	315	542	257	285
Retention(%)					**97.39**	**92.70**		**92.48**	**83.45**		**89.87**	**76.64**		**83.99**	**69.34**

Figure 9. Retention (Persistence) for Cohort Fall 2015

Student Graduation Rates

The other important aspect of the second research question addressed the possible effect of the IDEAS experiential learning project on increasing graduation rates. The data provided by the IKM did not contain information regarding Fall 2017 graduation. However, all the results were tabulated until Summer 2017. For the Initial study, TABLE 5, the data clearly shows a higher graduation rate for the IDEAS participants compared with the non-participants, regardless of their rank. For Sophomores, 51.40% (IDEAS) graduated by Fall 2016 in contrast with a 31.93% non-participants' graduation rate. For Juniors the difference was 54.50% vs 50.08% and for Seniors (74.10% vs 56.21%) the overall graduation rate was 56.1% for IDEAS participants and 43.39% for the non-participants.

TABLE 5 . GRADUATION DATA FOR THE INITIAL STUDY

Initial Study (Fall 2013, Spring 2014)							
		IDEAS Participants		DID NOT Participate		TOTAL	
Data sumarized by Fall 2016		count	%	count	%	count	%
Sophomore	Graduated	38	51.40%	62	31.93%	100	37.20%
	Not Graduated	36	48.60%	133	68.27%	169	62.80%
Junior	Graduated	48	54.50%	100	50.08%	148	51.40%
	Not Graduated	40	45.50%	100	50.11%	140	48.60%
Senior	Graduated	20	74.10%	41	56.21%	61	61.00%
	Not Graduated	7	25.90%	32	43.93%	39	39.00%
All	Graduated	106	56.10%	203	43.39%	309	47.00%
	Not Graduated	83	43.90%	265	56.66%	348	53.00%
		189	100.00%	468		657	100.00%

The data for the Replication study is shown in TABLE 6. This analysis also shows that IDEAS project seems to have a very positive impact in the graduation rate of the participants. For the replication study it was expected that the difference in graduation rate for the students at sophomore level wouldn't be significant (25.60% vs 23.06%) since the data was collected and summarized only until summer 2017 (less than two years since Spring 2015 and Fall 2015). The biggest difference is shown for the students at the Junior level (48.90% for IDEAS participants and 38.40% for non-participants).

TABLE 6. GRADUATION DATA FOR THE REPLICATION STUDY

Replication Study (Fall 2014, Spring 2015, Fall 2015)							
		IDEAS Participants		DID NOT Participate		TOTAL	
Data sumarized by Summer 2017		count	%	count	%	count	%
Sophomore	Graduated	40	25.60%	34	23.05%	74	24.00%
	Not Graduated	116	74.40%	118	77.78%	234	76.00%
Junior	Graduated	109	48.90%	126	38.45%	235	42.60%
	Not Graduated	114	51.10%	202	61.68%	316	57.40%
Senior	Graduated	25	62.50%	53	50.01%	78	53.40%
	Not Graduated	15	37.50%	53	50.07%	68	46.60%
All	Graduated	174	41.50%	213	36.60%	387	38.50%
	Not Graduated	245	58.50%	373	63.84%	618	61.50%
		419	100.00%	586		1,005	100.00%

Engagement, Class Participation and Students Perception of Instruction

To answer the third research question "Do Active Learning Projects improve Engagement, Class Participation, and students' perception of instruction?" an anonymous 5-point Likert scale exit survey was to the IDEAS participants. During the initial study, the author didn't provide this type of survey. Only after listening to the advice of other researchers were the surveys included for the replication study and beyond. The responses have been very consistent during all the IDEAS events. The total number of IDEAS participants during the replication was 419, however, 386 responses were collected (33 students did not answer). Only one of the questions addressed directly the interest in the class and engagement (Figure 10.a) 84.72% of the 386 students agreed that their interest and engagement in the class increased because of IDEAS, 11.66% were neutral, and 3.63% either disagree or strongly disagree.

Other responses collected are also very important to show the students' perception of the instruction. 82.90% of the sample agreed on IDEAS helping to improve their creativity (Figure 10. b), 78.78% expressed that IDEAS helped to better understand the class concepts (Figure 10. c), 86.53% replied favorable saying that their experience working with groups was improved (Figure 10. d). Regarding their capacity of creating models representing real-life problems, a total of 78.76% positive answers was achieved (Figure 10. e). For another question, 80.05%

stated that IDEAS improved their capacity of designing laboratory tests for engineering physical models (Figure 10.f)

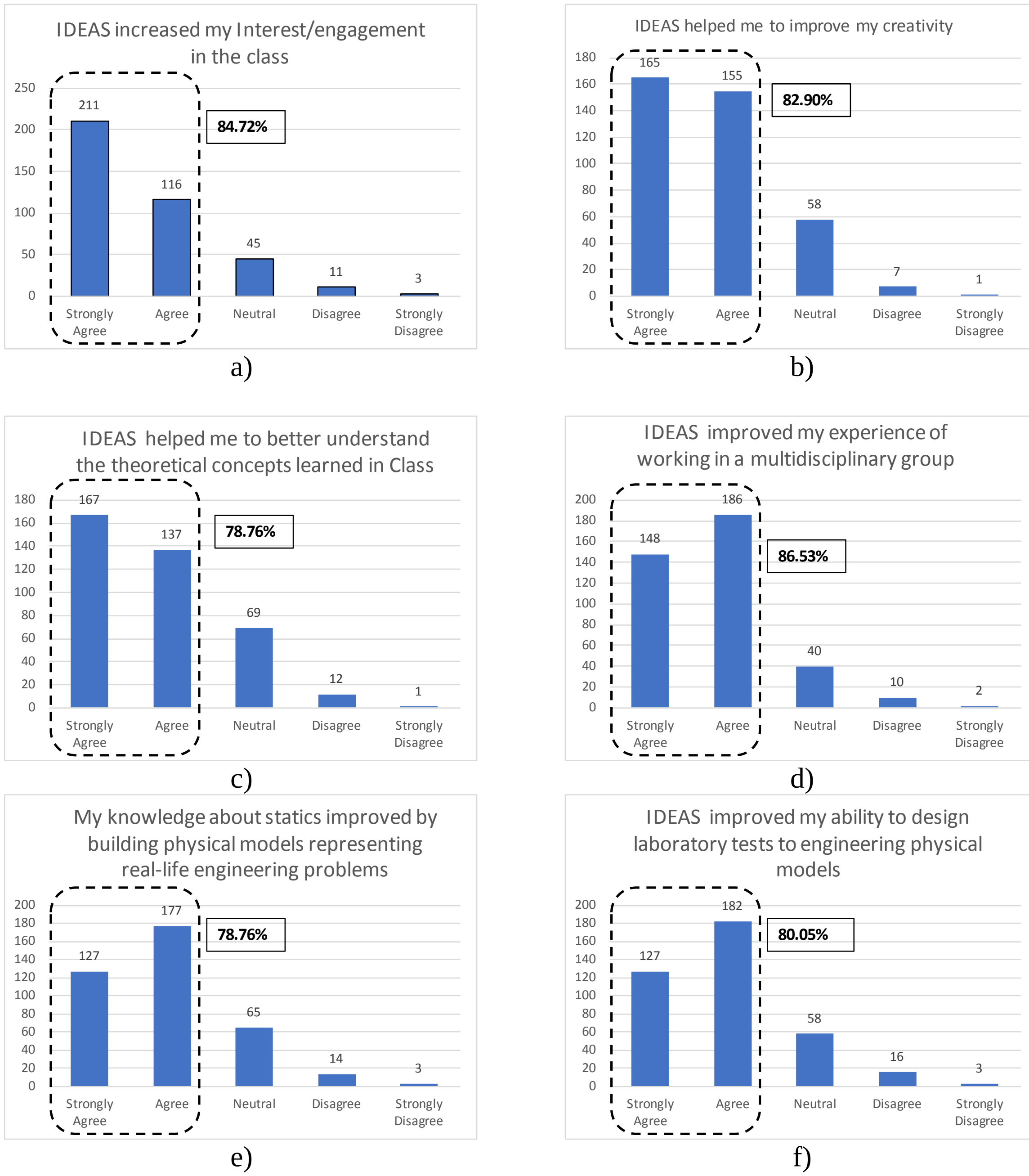


Figure 10. Responses from Surveys Applied to Replication Study (part 1)

Figure 11 presents other responses from the IDEAS participants. Improvement on presentation skills 81.61% positive feedback (Figure 11.a); 83.94% perceived that they improved their ability of writing formal engineering papers and reports (Figure 11.b); 88.34% said they have a better understanding of the presence, role, and importance of engineering in society (Figure 11.c); 60.88% of the IDEAS participants replied that their interest in pursuing graduate research education increased as a result of participating in IDEAS (Figure 11.d). Students were also asked if they would want similar projects in future courses, to which 82.90% of the survey agreed or strongly agreed (Figure 11.e). Finally, 91.9% of the participants considered that the experiential project IDEAS was a positive learning experience (Figure 11.f).

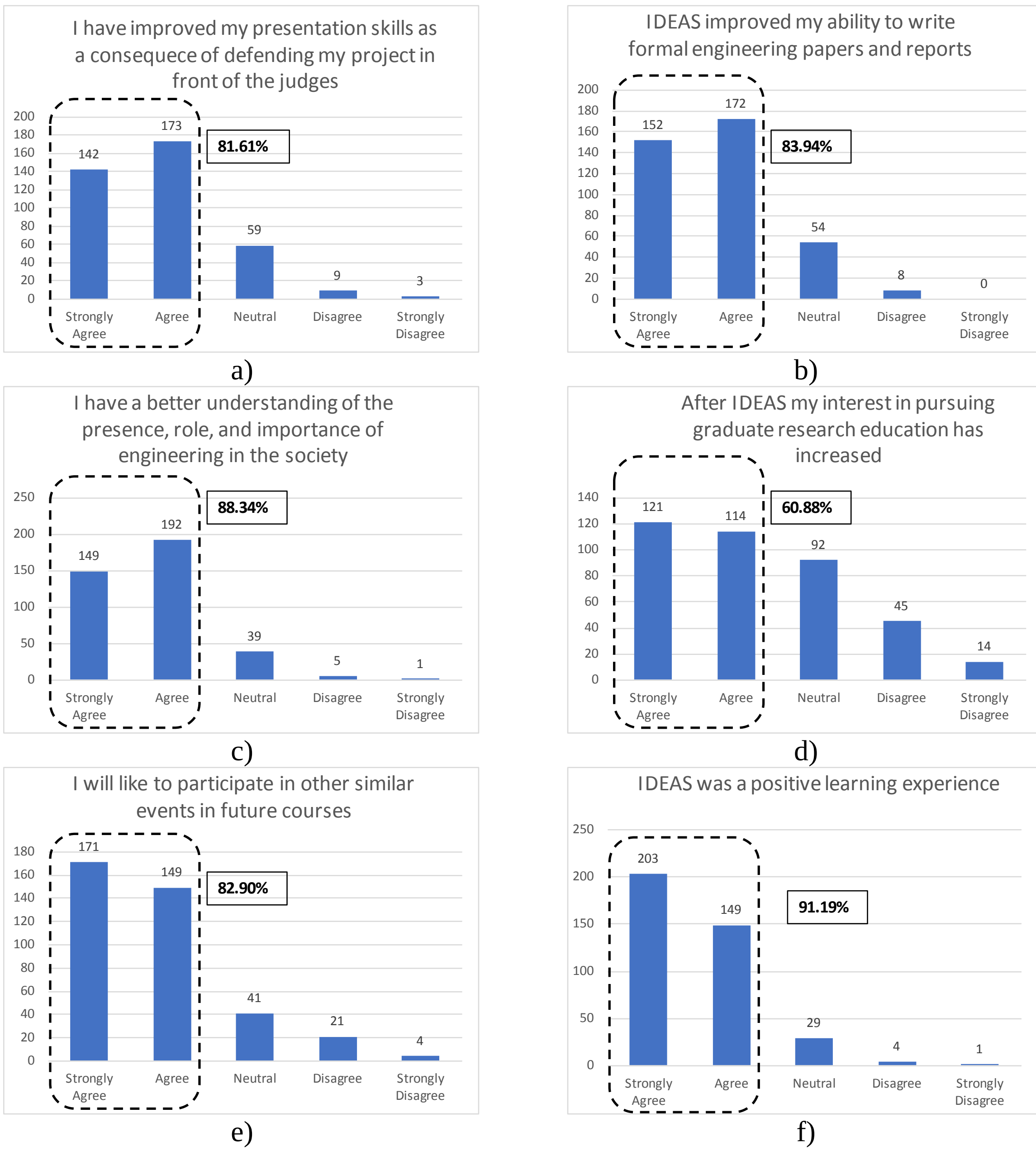


Figure 11. Responses from Surveys Applied to Replication Study (part 2)

Sustainability of IDEAS

Given the successful results of IDEAS, creating a path towards becoming a permanent part of the curriculum is one of the author’s goals. However, before this can be achieved, continuous, consistent, and improved results must be demonstrated. This paper presented the results of the first 5 IDEAS showcases. Currently, preparation of the Tenth IDEAS showcase is underway.

Until now, IDEAS has been developed, organized and implemented by the author (who is also teaching three courses per semester) and one teaching assistant provided by UCF’s department of Civil, Environmental, and Construction Engineering (CECE). CECE has also provided the funding for buying medals and certificates for the event winners.

The University of Central Florida has several laboratory facilities that provide free services and tools to students, such as access to 3D-printers, laser cutters, work stations, benches, electric saws, various hand tools, computers, and a machine shop.

In addition, IDEAS has been the center of an IUSE proposal (~US$ 600k) submitted to the National Science Foundation (currently in review for resubmission).

Based on IDEAS, a technology grant was awarded to the author (~US$ 60K) destined for the purchase of equipment such as Engineering Truss Kits, Data Acquisition Systems (DAQ), additional 3D-Printers, computers, and sensors. These are made available to the students at no cost. Other small grants (~US$ 10k) have been awarded internally providing funding to hire additional students’ assistants.

Due to the success of IDEAS, CECE is committed to continuing this event which has provided very important examples of students’ accomplishments. Some of them have been used as part of the documentation submitted to apply for ABET reaccreditation.. IDEAS also produce projects which are presented in other showcases of undergraduate research, locally and national level.

Findings, Conclusions, Limitations, and Future Work

This research investigated the effect of introducing an experiential learning activity called IDEAS in a large-size engineering class called Engineering Analysis-Statics. Statics was selected for several reasons such as being in the graduation critical path as a required common prerequisite and corequisite for more advanced engineering courses, having a large enrollment (around 1,700 per year), and presenting a high fail to pass ratio of about 50%. Four main aspects were studied: students’ success in the class, students’ retention (persistence) especially for the first 2 years after taking statics, improvement in graduation rates and students’ engagement and perception of instruction.

The first finding refers to students’ success in the class: those students who were involved in the experiential learning activity IDEAS performed better in the class. The percentage of IDEAS students successfully completing Statics and advancing to other courses was substantially higher than th non-participants. The percentage of success was between 44% and 81% higher for the IDEAS participants. Very similar results were obtained for the initial study and for the replication.

Regarding the students' retention (persistence), the study also showed that for the four semesters following the intervention (IDEAS in statics) the college retention rates for the IDEAS participants was significantly higher than the non-participants (ranging from ~11 and ~13 percent points higher for the participants). The same type of results was observed in the replication study.

The investigation of the effect of IDEAS experiential learning project in increasing the graduation rate also showed very compelling results. The data provided by the IKM clearly displays a higher graduation rate for the IDEAS participants compared with the non-participants, regardless of their rank and for both the initial study and the replication. The overall graduation rate reached up to 13 percent points higher for the IDEAS participants.

In addition, the students' perception of instruction is that IDEAS kept them more engaged, promoted their participation, increased their creativity, helped them to better understand the class concepts, improved coordination within multidisciplinary groups, and improved their capacity to create models representing real-life problems and designing laboratory tests for engineering physical models. The students also recognized improvements in their presentation skills, their ability to write formal engineering papers and reports, and their understanding of the presence, role, and importance of engineering in society.

A very important added finding (not part of the original study) is that by working on IDEAS their interest in pursuing a graduate research education increased considerably (by 61%). Overall the students expressed that IDEAS was a positive learning experience and they would like to participate in similar projects for future courses.

Despite the very promising results described in this paper, as with any research project, there is more work to be done. Since students had the opportunity to decide whether to participate in IDEAS or not, the past IDEAS participants could have consisted of students who were already motivated and would have performed better than non-participants, regardless of the project. For this reason, the demographics of both groups (participants and non-participants) were compared, and it was found that there were significance differences in only two of the five studied cohorts. Additionally, the pool of professors teaching the class could have introduced errors in the results. After Fall 2015, all the sections taught by the author included IDEAS as a mandatory part of the curriculum; it is not a voluntary project anymore. As of now, the new results are very consistent with the ones presented in this paper.

Due to the success evidenced by the results of IDEAS, professors from other courses (physics, chemistry, dynamics, and mechanics of materials), departments, and even universities have expressed their interest in either collaborating with the Statics students and becoming part of IDEAS or starting their own projects.

The researcher is currently analyzing more data and studying the performance of the several cohorts of IDEAS on more advanced courses such as Engineering Analysis-Dynamics and Mechanics of Materials.

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