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Status of a Summer Faculty Immersion Program After Four Years in Development

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Abstract

The Summer Faculty Immersion Program (SFIP) concludes its fourth year in strong form. The hypothesis of the study is summarized as follows: Systemic and sustainable change toward creating a classroom environment that engages students with authentic engineering real-world problems may be ignited by an intense one-month summer faculty immersion program in which faculty innovate two courses with inductive and active learning methodologies. The innovative methodologies addressed in SFIP are gaining more acceptance from the faculty as the program matures and the faculty gain more experience in their use. This is demonstrated by the fact that an average of 60% of the class sessions led by SFIP-trained faculty are now being conducted with the inductive methodology. Furthermore, faculty are transforming an average of 44% of the class sessions of courses other than those transformed during the summer. This is a measure of lasting change due to SFIP. The students are also expressing satisfaction with the innovation. Previous to SFIP, 16% - 20% of the senior students regularly complained of courses with “too much theory without real-world context”. After four years of implementation, the comments have been eliminated. SFIP is a five-year, externally-funded faculty development program that aims to train the entire engineering faculty as well as the science faculty that teach Physics I and II. Both new and experienced faculty are invited to participate in SFIP which trains a maximum of seven faculty members per summer session. The program also provides training to generate learning outcomes that are clear, relevant and observable. Diffusion of innovations in engineering education is a challenge that has defied a satisfactory solution for decades. SFIP is proving to be a potential solution for promoting diffusion and for creating lasting change in the faculty in this institution.

Introduction

The Summer Faculty Immersion Program (SFIP) was created as a response to the following issues:

1. The recognition that teaching methods in engineering are not often aligned with the goal of providing relevant learning experiences that lead to deep levels of conceptual knowledge, as noted by Litzinger, et al, in Ref. [1].

2. The affirmation by the National Research Council of the National Academies that innovative teaching in STEM courses requires time that exceeds normal course development, as well as additional funding [2]. Borrego [3] also mentions these same issues, among others, in stating that diffusion of educational innovations in engineering is a challenge that has defied a satisfactory solution for decades.

3. The desire of both new and experienced faculty at the Universidad del Turabo School of Engineering to improve their teaching. A survey performed in 2009 showed that 96% of the engineering faculty members at this this institution (across all the engineering disciplines) were receptive to learning and adopting transformative teaching strategies that were based on engineering education research results [4].

4. The results of exit surveys of graduating students from mechanical engineering in which approximately 20% of the students regularly commented that there was "too much theory without context" in the engineering courses [5]. Assessment results at the course level echoed the same issue.

The hypothesis of the study is stated as follows: Systemic and sustainable change toward creating a classroom environment that engages students with authentic engineering real-world problems may be ignited by an intense one-month summer faculty immersion program in which faculty innovate two courses with inductive and active learning methodologies (with the commitment of implementing them) at a cost of approximately $10,000 per faculty member, which includes a summer stipend plus funds to purchase educational materials. If the transformation occurs, then the faculty should be able to sustain it by using the regular course-preparation time during the semester to gradually polish the real-world examples used in class, to optimize the delivery of the inductive teaching/learning methodology, and to transform other courses.

After four years of implementation, the results of SFIP are encouraging, as demonstrated by the following:

1. The seven faculty slots that are available every summer, fill quickly on a first-come, first-served basis. Buy-in has been as predicted by the 2009 survey which revealed that 96% of the faculty were receptive to learning and adopting transformative teaching strategies.

2. Assessment results show that the faculty members have enjoyed the summer experience, they are implementing the innovations in their classrooms (average of 60% of the class sessions), and they have started innovating courses in addition to those that they innovated during the summer (average of 44% of the class sessions). This last item is a measure of the lasting impact that the program was expected to accomplish.

3. Mechanical engineering graduates are no longer complaining of "too much theory without context" in the exit survey. The comments have disappeared. A few students (5%) are still making related comments but the nature of the comments has shifted; for example, "use <u>more</u> practical real-world problems in class" and "faculty should have <u>more</u> real-world experience with the practical problems that they bring into class".

4. The SFIP experience in the School of Engineering has inspired a similar effort that will expand to the entire faculty community of Universidad del Turabo. The US Department of Education has granted external funding to conduct this effort for the next five years.

5. The SFIP experience inspired another variation that is being conducted in all the engineering schools in Puerto Rico. It promotes mobile, hands-on learning in courses with an instrumentation component using the Analog Discovery Board (portable circuits lab). NSF provided two years of funding to the SFIP researchers to experiment with this diffusion mechanism [6, 7].

This paper provides an overview of SFIP and its most recent performance results. It also includes an analysis to determine if there was a statistically significant difference in the results between the most recent group of SFIP participants (2015) and the previous groups (2012, 2013, 2014). There are several factors, most of which are uncontrollable, that could affect the SFIP results from year to year; for example, changes in program content from one summer to the next; the effect of different personalities and teaching philosophies of each faculty member; the degree of resistance to change of each faculty member; external factors affecting each faculty member as well as the program director; and the structure and content of each particular course in that some are more suitable than others to carry out the innovations addressed in SFIP. This statistical analysis is relevant because if it could be proven that these factors do not have statistical significance (after they have been averaged), then the survey results would suggest that faculty variation might be less of an influence on outcomes than some people might think.

Overview of the Summer Faculty Immersion Program

This section restates some material from previous SFIP papers [8, 9, 10, 5] to provide context for discussing the fourth year status of the SFIP program. Reference [8] includes additional details of the proposal that led to the SFIP program. Reference [9] provides a full description of SFIP as well as its implementation and results obtained during its first year. Reference [10] discusses the enhancements to the SFIP program during its second year of implementation. Reference [5] summarizes the third year SFIP results and includes full details of the faculty survey that was used in the third year. The same survey was repeated for the fourth year participants.

The spark that led to SFIP can be traced to the outcomes assessment process that was started in 1999 at the School of Engineering to meet the requirements of ABET 2000 criteria (refer to [4] for a full description of this assessment process). The first assessment instrument that uncovered teaching issues was the exit survey of graduating students. Between 16% - 20% of the mechanical engineering graduates regularly commented that there was “too much theory without real-world context” presented in classes. Assessment at the course level echoed the same issue. The desire to satisfy what seems like a reasonable student expectation led to the creation of this faculty development program in the School of Engineering.

The SFIP, as implied by its name, focuses its faculty development effort during the summer (the entire month of June), while faculty members are free from the regular duties of a typical semester. Funding is provided by a grant from the US Department of Education which provides to each participating faculty member a $7,500 summer stipend, a $2,500 budget to purchase educational materials, and a $2,000 travel budget to be used for additional professional development. The stipend provides an incentive to ensure that the faculty will concentrate their efforts only on course innovations during the month of June (no summer teaching or research), and that the faculty will commit to the implementation of the innovations in subsequent semesters. Funding runs through 2016 and the budget includes all the faculty members from the School of Engineering (Computer, Electrical, Industrial, Civil, and Mechanical engineering programs). It also includes the science faculty that are responsible for the Physics I and II courses that are required for all engineering students. A total of 35 faculty members will participate by 2016 at a rate of seven faculty members per summer session.

The time distribution during the SFIP in June is provided in Figure 1.

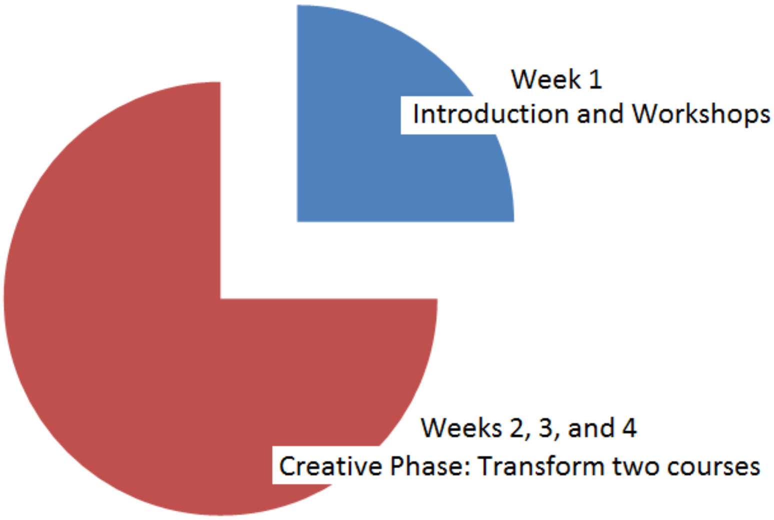


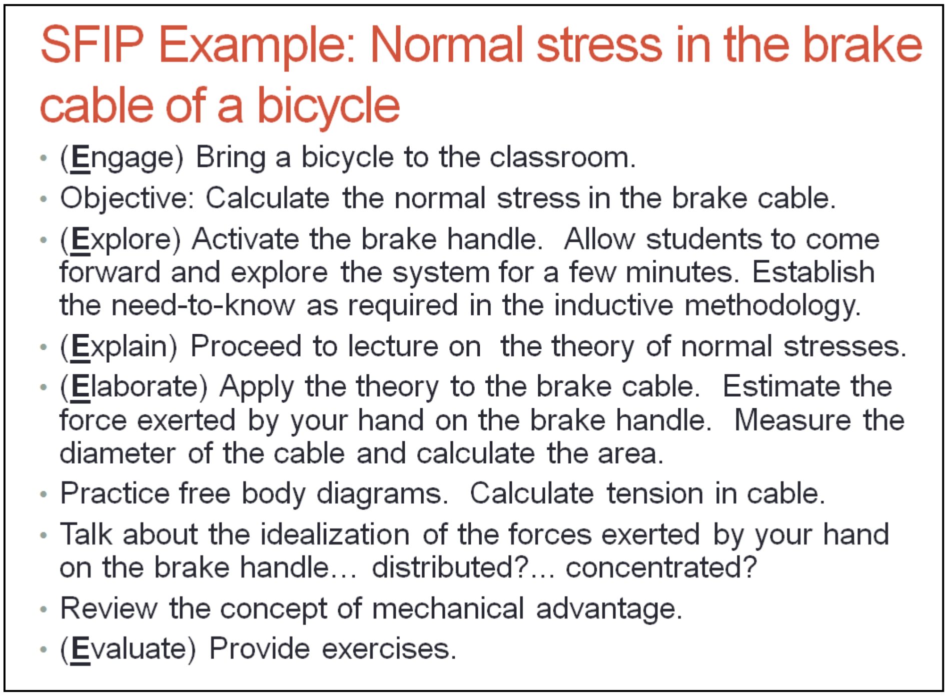
Figure 1: Time distribution during the summer program (month of June)

The first week starts with an on-site visit by the second author to provide workshops on the following topics: writing effective learning outcomes that are clear, relevant and observable; active teaching and learning techniques (including several types of inductive teaching and learning methodologies); and assessment techniques. Some of the material that is covered is included in references [11, 12]. This workshop may be rescheduled to an earlier point during the Spring semester, if necessary.

The first week concludes with additional workshops by the first author which include the following themes: a discussion of the difference between expert knowledge and pedagogical content knowledge [13]; several examples of work created by faculty members from previous SFIP sessions to calibrate the participants' expectations on deliverables; examples from Eann Patterson's use of *Everyday Engineering Examples in the classroom* and the use of the *Five E's: Engage, Explore, Explain, Elaborate, Evaluate* [14, 15]; presentation of new textbooks and workbooks that take into account innovative teaching techniques, for example, references [16] and [17]; innovation of grade distributions in engineering courses to include the "comprehension" cognitive level in Bloom's taxonomy; discussion on how to prepare exams and how to assist students in preparing for them; the use of innovative Massive Open Online Courses (MOOCs) as a potential complement to the class; gamification techniques to maintain the classroom motivated and engaged [18] – [23].

The last three weeks are dedicated to the transformation of two courses by each faculty member, as shown in Figure 1. This three-week period is a primary element in the diffusion hypothesis that underlies this study; i.e., it provides the time required for the faculty to work on the course development that will lead to adoption of innovative classroom techniques.

Figure 2 shows a real-world example that was developed by the first author using the inductive teaching and learning method. This example has been used in class with a real bicycle and with a hand dynamometer to measure the grip force.



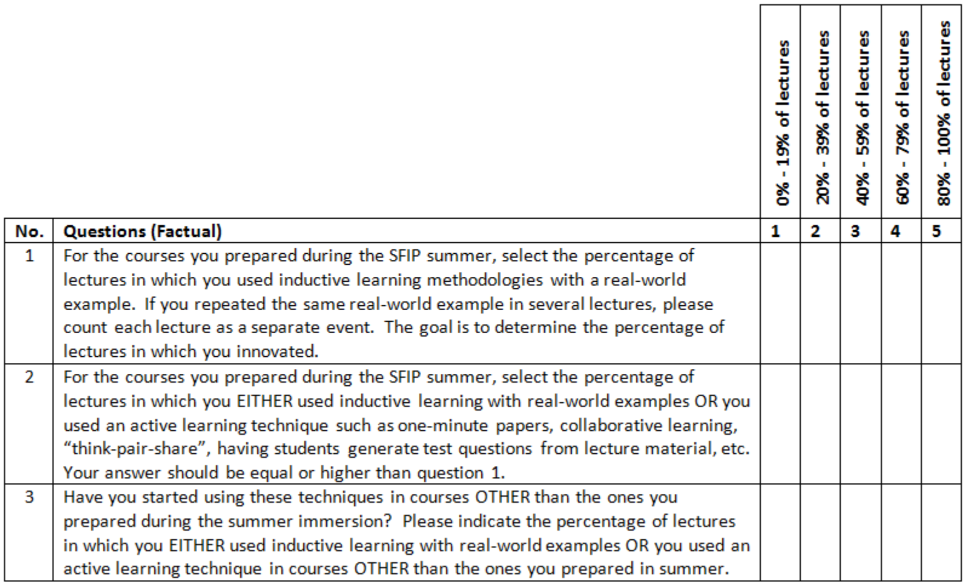
SFIP Example: Normal stress in the brake cable of a bicycle

- (**E**ngage) Bring a bicycle to the classroom.
- Objective: Calculate the normal stress in the brake cable.
- (**E**xplore) Activate the brake handle. Allow students to come forward and explore the system for a few minutes. Establish the need-to-know as required in the inductive methodology.
- (**E**xplain) Proceed to lecture on the theory of normal stresses.
- (**E**laborate) Apply the theory to the brake cable. Estimate the force exerted by your hand on the brake handle. Measure the diameter of the cable and calculate the area.
- Practice free body diagrams. Calculate tension in cable.
- Talk about the idealization of the forces exerted by your hand on the brake handle… distributed?… concentrated?
- Review the concept of mechanical advantage.
- (**E**valuate) Provide exercises.

Figure 2: A typical real-world example developed in SFIP taught inductively

A faculty survey was prepared in 2014 to determine the state of SFIP. The survey was validated by a group of three engineering faculty members who read the instrument and provided comments to expand it, clarify it, and improve it. The survey has been conducted twice. The first time was at the end of the 2014 Fall semester and included participants from the 2012, 2013, and 2014 SFIP sessions. The second time the survey was conducted was at the end of the 2015 Fall semester and only included the participants from the 2015 session.

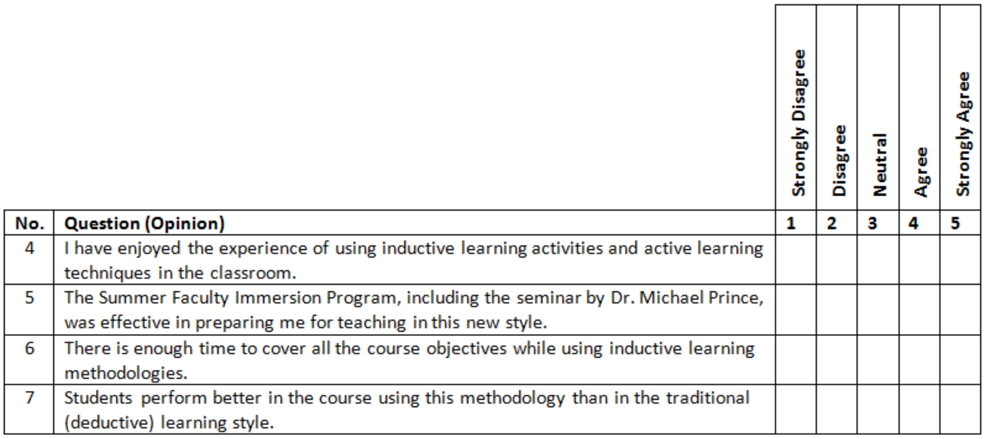
The first part of the survey contained three factual questions to determine a measure of adoption rates. The answers were framed on the basis of the percentage of lectures in which the innovative techniques were used. Please refer to Figure 3 for an image of this part of the survey.



		0% - 19% of lectures	20% - 39% of lectures	40% - 59% of lectures	60% - 79% of lectures	80% - 100% of lectures
No.	**Questions (Factual)**	**1**	**2**	**3**	**4**	**5**
1	For the courses you prepared during the SFIP summer, select the percentage of lectures in which you used inductive learning methodologies with a real-world example. If you repeated the same real-world example in several lectures, please count each lecture as a separate event. The goal is to determine the percentage of lectures in which you innovated.					
2	For the courses you prepared during the SFIP summer, select the percentage of lectures in which you EITHER used inductive learning with real-world examples OR you used an active learning technique such as one-minute papers, collaborative learning, “think-pair-share”, having students generate test questions from lecture material, etc. Your answer should be equal or higher than question 1.					
3	Have you started using these techniques in courses OTHER than the ones you prepared during the summer immersion? Please indicate the percentage of lectures in which you EITHER used inductive learning with real-world examples OR you used an active learning technique in courses OTHER than the ones you prepared in summer.					

Figure 3: First three questions (factual) of the faculty survey

The second part of the faculty survey contained four questions that asked for the opinion of the faculty participants. The answers were provided on the basis of a modified Likert scale with a scale from 1 (Strongly Disagree) to 5 (Strongly Agree). Please refer to Figure 4 for an image of this part of the survey.



		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
No.	**Question (Opinion)**	**1**	**2**	**3**	**4**	**5**
4	I have enjoyed the experience of using inductive learning activities and active learning techniques in the classroom.					
5	The Summer Faculty Immersion Program, including the seminar by Dr. Michael Prince, was effective in preparing me for teaching in this new style.					
6	There is enough time to cover all the course objectives while using inductive learning methodologies.					
7	Students perform better in the course using this methodology than in the traditional (deductive) learning style.					

Figure 4: Second part of the faculty survey: Questions 4-7 (opinion)

The last part of the survey asked the participants to comment on their experience. This section was divided into three questions. The first question asked “What did you like BEST about the SFIP experience”; the second question asked “What did you like LEAST about the SFIP experience; and the third question stated “Please make ADDITIONAL comments that could help the program improve and achieve its goals”.

Faculty Survey Results

Table 1 includes the 2014 survey results while Table 2 includes the 2015 survey results. The results are very similar.

Table 1. Results of the 2014 Survey
Includes participants from the 2012, 2013 and 2014 SFIP sessions (n=15)

Paraphrased question	Mean (n=15)	Sample Standard Deviation (n=15)
1.) % of lectures using a real-world example and inductive learning.	2.87	1.41
2.) % of lectures using a real-world example and inductive learning OR using active learning techniques.	3.60	1.35
3.) % of lectures innovated in courses OTHER than SFIP courses.	2.18	1.25
4.) Enjoyed using the SFIP techniques in the classroom.	4.73	0.46
5.) SFIP was effective in preparing me in this new style of teaching.	4.40	0.63
6.) There is enough time to cover all the course objectives.	3.20	1.26
7.) Students perform better using this teaching methodology.	3.50	0.65

Table 2. Results of the 2015 Survey
Only includes participants from the 2015 SFIP session (n=6)

Paraphrased question	Mean (n=6)	Sample Standard Deviation (n=6)
1.) % of lectures using a real-world example and inductive learning.	3.00	1.26
2.) % of lectures using a real-world example and inductive learning OR using active learning techniques.	3.67	1.03
3.) % of lectures innovated in courses OTHER than SFIP courses.	2.17	1.17
4.) Enjoyed using the SFIP techniques in the classroom.	4.67	0.52
5.) SFIP was effective in preparing me in this new style of teaching.	4.50	0.55
6.) There is enough time to cover all the course objectives.	3.33	1.21
7.) Students perform better using this teaching methodology.	3.83	0.75

Statistical Analysis

A statistical analysis was conducted due to the similarity of the results in Tables 1 and 2. The objective of the analysis was to determine if there was a statistically significant difference in the results between the most recent group of SFIP participants (2015) and the previous SFIP participants (2012, 2013, 2014). There are several factors, most of which are uncontrollable, that could affect the SFIP results from year to year; for example, changes in program content from one summer to the next; the effect of different personalities and teaching philosophies of each faculty member; the degree of resistance to change of each faculty member; external factors affecting each faculty member as well as the program director; and the structure and content of each particular course in that some are more suitable than others to carry out the innovations addressed in SFIP. This statistical analysis is relevant because if it could be proven that these factors do not have statistical significance (after they have been averaged), then the survey results would suggest that faculty variation might be less of an influence on outcomes than some people might think.

The statistical analysis was set up as a "Hypothesis test on means of normal distribution – variance unknown" using Student's t-test [24]. The test was performed on the means of all seven questions in the survey. The results of the 2012, 2013 and 2014 SFIP groups were categorized as the "population mean (μ_0)" while the results of the 2015 SFIP group were categorized as "sample mean (X)" and "sample standard deviation (S)". The number of samples used in the statistical analysis corresponded to the number of participants in the 2015 group (n=6). The selection of the participants was assumed to be a random process.

The two hypothesis were established as follows:

- Null Hypothesis: (H_0: $X = \mu_0$) There is no statistical difference between the sample and the population means.

- Alternate Hypothesis: (H_1: $X \neq \mu_0$, two-tailed test) There is a statistical difference between the sample and the population means. This is a two-tailed test since the difference in the sample mean may be greater than, or less than, the population mean.

The significance level (alpha) is set to the typical value of $\alpha = 0.05$. Given that the test is a two-tailed test, the value of alpha used in the analysis was divided in half ($\alpha/2 = 0.025$). If the null hypothesis is rejected and the alternate accepted (p-value $< \alpha/2$), it may be concluded that the results of the experiment are unlikely to happen by mere chance. The more likely explanation would be that the results are occurring because of the effect being studied, which in this case is any possible variation that may occur between the different groups of SFIP participants, as mentioned previously. On the other hand, if the null hypothesis cannot be rejected (because the p-value is large, that is, p-value $> \alpha/2$), then it is likely that the variation between participants has no effect (on average). Therefore, the survey results could be used to predict the performance of future implementations of a summer faculty immersion program in any given year.

Excel was used to compute the t-statistic (t) and the p-value for the results of each of the seven questions of the survey. The t-statistic was calculated by substituting values (see Table 3) into the following formula for "t" [24]:

$$t = \frac{X - \mu_0}{S/\sqrt{n}}$$

The following Excel functions were used in the analysis:

- "AVG" was used to calculate the mean.
- "STDEV.S" was used to calculate the standard deviation of the sample (n=6).
- "TDIST" was used to calculate the p-value. The arguments for this function are the t-statistic, the number of degrees of freedom (n-1), and whether it is a one-tailed or two-tailed test. Although the test is two-tailed, the function was set for a one-tailed calculation of the p-value, which is then compared to α/2 to correct it.

The results are summarized in Table 3.

Table 3. Results of the t-statistic and p-value calculations

Ques.	**μ_0 Population Mean (2012, 2013, 2014)**	**X Sample Mean (2015, n=6)**	**S Sample Standard Deviation (2015, n=6)**	**t-statistic**	**p-value**
1	2.87	3.00	1.26	0.258	0.40
2	3.60	3.67	1.03	0.158	0.44
3	2.18	2.17	1.17	0.032	0.49
4	4.73	4.67	0.52	0.316	0.38
5	4.40	4.50	0.55	0.447	0.34
6	3.20	3.33	1.21	0.270	0.40
7	3.50	3.83	0.75	1.085	0.16

The hypothesis test was conducted by using the p-values of Table 3. As can be observed, the p-values were much higher than the significance level of α/2 = 0.025. Therefore, the null hypothesis is accepted in all seven cases. These results have been summarized in Table 4.

Table 4. Acceptance or Rejection of the Null Hypothesis.

Question	p-value	α/2	Accept Null Hypothesis (if p-value > α/2) or Reject Null Hypothesis (if p-value < α/2)
1	0.40	0.025	Accept Null Hypothesis
2	0.44	0.025	Accept Null Hypothesis
3	0.49	0.025	Accept Null Hypothesis
4	0.38	0.025	Accept Null Hypothesis
5	0.34	0.025	Accept Null Hypothesis
6	0.40	0.025	Accept Null Hypothesis
7	0.16	0.025	Accept Null Hypothesis

Conclusions

These following conclusions can be drawn from this study:

1. The statistical analysis showed that there is not a statistically significant difference in the results between the most recent group of SFIP participants (2015) and the previous SFIP participants (2012, 2013, 2014). The several factors that could affect the SFIP results from year to year average out. Some of these factors , most of which are uncontrollable, are: the effect of different personalities and teaching philosophies of each faculty member; the degree of resistance to change of each faculty member; external factors affecting each faculty member as well as the program director; and the structure and content of each particular course in that some are more suitable than others to carry out the innovations addressed in SFIP. Therefore, the survey results suggest that faculty variation might be less of an influence on outcomes than some people might think.

2. The Summer Faculty Immersion Program continues to be very well received by the engineering and physics faculty at this institution. They are participating and implementing the techniques as was predicted by the survey carried out in 2009 which indicated that 96% of the engineering faculty members at this this institution were receptive to learning and adopting transformative teaching strategies that were based on engineering education research results.

3. The faculty members are enjoying the experience of using innovative teaching methodologies in the classroom as indicated by the average score of 4.7 out of a maximum of 5.0. In addition, 80% of the faculty commented on the improved engagement with students by using these techniques in the classroom.

4. The underlying hypothesis of this study – that SFIP is a suitable mechanism to diffuse engineering education innovations in the classroom – is taking place. The faculty are using real-world examples in the classroom at an average of almost 60% of the lectures. If active learning techniques are added, the average climbs to just above 70% of the lectures.

5. Another measure of diffusion can be measured by the fact that faculty members are beginning to use these techniques at the rate of approximately 44% of the lectures in courses other than those they innovated during the SFIP summer session. They are transforming these courses on their own time. This is a measure of lasting change due to SFIP.

6. There is potential for this diffusion mechanism to be transferred; however, there is no evidence that the same outcomes listed above can be reproduced in another institution. There are other factors involved that may contribute to these results; for example, this institution has particularly accepting faculty and an administration that supports this program. In addition, the leadership of the program is provided by a person who knows all the faculty by virtue of having worked with them to develop, implement, and adjust the School's outcomes assessment plan required by ABET. Also, there is the factor of the external consultant that is selected and how well the person communicates and relates with the faculty.

7. The issue of "time to cover the syllabus" continues to be the toughest challenge faced by the faculty while implementing these innovative techniques. As mentioned earlier, diffusion of educational innovations in engineering is a challenge that has defied a satisfactory solution for decades [3]. A satisfactory solution to these "time issues" could be the key to achieving very high diffusion rates.

8. Although there is no doubt that students are more engaged when using these classroom innovations, the faculty are not obtaining clear and consistent evidence that they result in improved student performance and better grades.

These conclusions, after four years of SFIP development, are very similar to the conclusions from the third year. It remains to be seen if the same conclusions hold after the fifth and final year of the program.

Acknowledgments

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