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Third-Year Status of a Summer Faculty Immersion Program

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Abstract

This paper discusses the status of a Summer Faculty Immersion Program (SFIP) after three years of implementation in the School of Engineering at Universidad del Turabo in Gurabo, Puerto Rico. The SFIP is a five-year, externally funded, faculty development program that began in the summer of 2012 and runs until the summer of 2016. The intention of the program is to diffuse the use of innovative and effective teaching practices in a manner that will promote lasting change in the entire engineering and physics faculty of Universidad del Turabo. The program targets new as well as experienced faculty members. The SFIP takes place during the month of June and provides a stipend to participants. It is divided into an intensive one-week training workshop that is followed by a three-week immersion where each faculty member transforms two courses. An expected transformation is the selection and adaptation of real-world examples that are presented at the beginning of class to establish the need for learning the course material (inductive approach). The problems are subsequently solved using the principles and theory taught in class. The results of a faculty survey show that the inductive methodology is being used in approximately 60% of the lectures; that the faculty enjoy this teaching methodology; and that the faculty think that SFIP was effective in preparing them for teaching in this new style. The results also show that the faculty is beginning to transform other courses on their own time (44% of lectures). Diffusion of innovations in engineering education is a challenge that has defied a satisfactory solution for decades so this result is a positive sign that SFIP is promoting diffusion and creating lasting change in the faculty. On the other hand, there is concern with the time required to cover all the expected material in the syllabus. A satisfactory solution to the issue of time could be the key to achieving very high diffusion rates. It has also been recognized that while this methodology creates an engaging classroom environment and leads to better understanding of underlying concepts, there is no clear and consistent evidence of improvement in the math skills required to solve exam problems that are similar to typical textbook problems.

Introduction

The origin of the faculty development program discussed in this paper, the Summer Faculty Immersion Program (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 accreditation (refer to [1] for a full description of this assessment process). The first assessment instrument that uncovered teaching issues was the exit survey of graduating students. The students regularly commented that there was "too much theory without 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.

The proposal to obtain funding for SFIP was based on the following five main elements:

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. [2].

2. The work spearheaded by Eann Patterson using Everyday Engineering Examples (E^3) in the classroom to provide context to the theory [3], as well as the use of the *Principles of the 5E's: Engage, Explore, Explain, Elaborate, and Evaluate*, to provide a template for the flow of the teaching and learning process in the classroom [4].

3. The work done by Prince and Felder on inductive teaching and learning methods [5], as well as the work by Prince on active learning [6], which provided a framework for the strategies designed into the SFIP faculty development program.

4. 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 [7]. Borrego [8] 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.

5. The desire of both new and experienced faculty at this school of engineering to improve their teaching. A survey performed in 2009 showed that 96% of the engineering faculty members at this this institution were receptive to learning and adopting transformative teaching strategies that are based on engineering education research results [1].

Overview of the Summer Faculty Immersion Program

Reference [9] includes additional details of the proposal that led to the SFIP program. Reference [10] provides a full description of SFIP as well as its implementation and results obtained during its first year. Reference [11] discusses the enhancements to the SFIP program during its second year of implementation. This section restates some of the material from these three references to provide context for discussing the third year status of the SFIP program.

The SFIP, as implied by its name, focuses its faculty development effort during the summer (the entire month of June), while the faculty members are free from the regular duties of a typical semester. Funding is addressed through 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 physics 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.

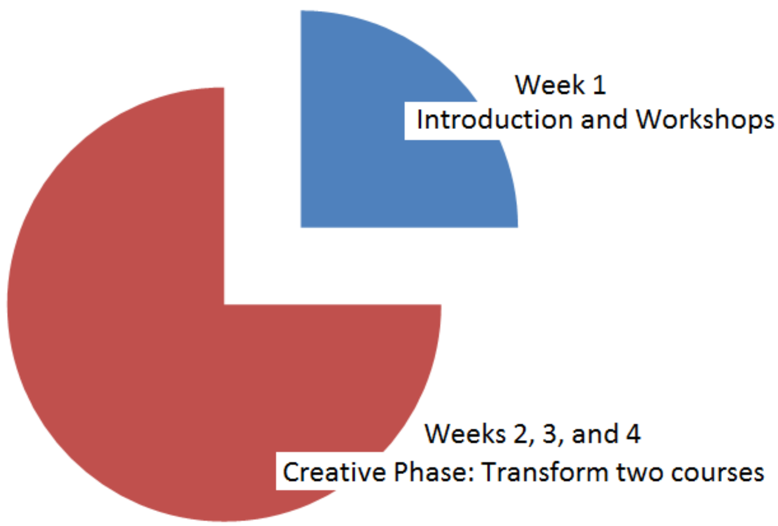

Figure 1: Time distribution during the summer program (month of June)

The first week starts with an on-site visit by the second author to provide workshops on the following topics: writing effective learning outcomes; active teaching and learning techniques (including several types of inductive teaching and learning methodologies); and assessment techniques. 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 [14]; 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* [3, 4]; presentation of new textbooks and workbooks that take into account innovative teaching techniques, for example, references [12] and [13]; 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 [15] – [20];.

The last three weeks are dedicated to the transformation of two courses by each faculty member. 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.

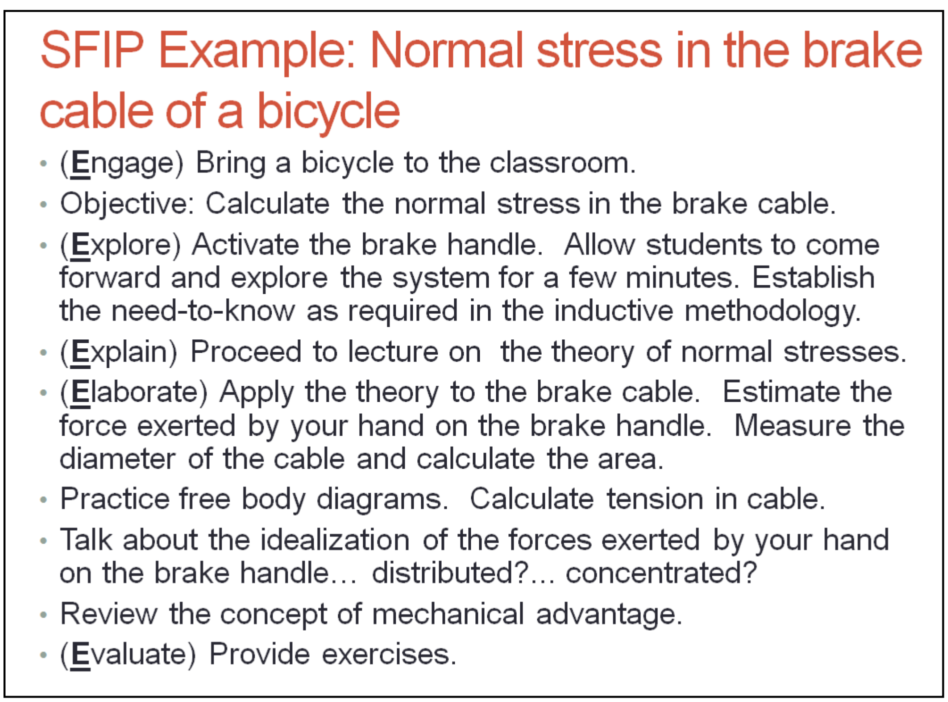

Figure 2: A typical real-world example developed in SFIP taught inductively

Faculty Survey

A faculty survey was used to determine the state of SFIP. The survey was administered at the end of the 2014 Fall semester. Therefore, the SFIP participants from the summer of 2014 had one semester of experience in teaching their transformed courses. The 2013 SFIP participants had three semesters, and the 2012 SFIP participants had five semesters, of teaching in this new style.

The survey was validated by a group of three engineering faculty members who read the instrument and provided comments to improve it. As a result of this process a third "factual" question was added to measure diffusion on courses other than those transformed during the summer. Also, the wording on some of the statements was edited to improve clarity.

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

A total of 21 faculty participants should have participated in the first three years of SFIP (7 trainees per year); however, the actual number of trainees was reduced to 18 as a result of three last-minute withdrawals, all for valid reasons. These individuals could not be replaced in time due to the full commitment required by SFIP during the month of June (most faculty members establish their summer plans several months in advance). Furthermore, one of them has since retired and two resigned from the university for personal reasons. Due to the unavailability of these three faculty members they were not included in the survey. Results are provided for the remaining 15 SFIP participants (n=15).

The results of questions 1-7 are summarized in Table 1. This table includes the average and standard deviation for the totality of the 15 members. It also includes the averages by program: Mechanical Engineering (ME) faculty, Electrical Engineering (EE) faculty, Industrial and Management Engineering (IE) faculty, Computer Engineering (CpE), and Physics faculty. The questions have been paraphrased in the last column of the table to facilitate the interpretation of the results. A legend, and the scales used, are provided for convenience.

Table 1: Faculty survey results: Questions 1-7

Question Num.	ME AVERAGE	PHYSICS AVERAGE	EE AVERAGE	IE AVERAGE	CpE AVERAGE	**TOTAL AVERAGE**	**TOTAL STD. DEVIATION**	
	n=5	n=2	n=3	n=2	n=3	**n=15**	**n=15**	Paraphrased question
1	2.2	4.0	1.7	3.5	4.0	**2.9**	**1.4**	1.) % of lectures using real-world example and inductive learning.
2	4.2	4.0	2.0	4.0	3.7	**3.6**	**1.3**	2.) % of lectures as in (1) OR used active learning techniques.
3	1.8	NA	1.0	3.0	3.0	**2.2**	**1.2**	3.) % of lectures innovated in courses OTHER than SFIP courses.
4	4.8	4.5	4.7	5.0	4.7	**4.7**	**0.4**	4.) Enjoyed using SFIP techniques in the classroom.
5	4.2	5.0	4.7	3.5	4.7	**4.4**	**0.6**	5.) SFIP was effective in preparing me in this new style.
6	2.8	3.0	3.7	3.5	3.3	**3.2**	**1.2**	6.) There is enough time to cover all the course objectives.
7	3.2	4.0	3.7	3.0	3.7	**3.5**	**0.6**	7.) Students perform better using this teaching methodology.

Legend:
n= number of faculty members
ME = Mechanical Engineering
EE = Electrical Engineering
IE = Industrial and Management Engineering
CpE = Computer Engineering
NA = Not Applicable

Scale: Questions 1-3
1 = 0%-19% lectures, **2** = 20%-39%, **3** = 40%-59%, **4** = 60%-79%, **5** = 80%-100%

Scale: Questions 4-7
1 = Strongly Disagree, **2** = Disagree, **3** = Neutral, **4** = Agree, **5** = Strongly Agree

Table 2 and Table 3 rank the programs for questions 1-3 and 4-7, respectively. Rank is based on the score and is sorted from highest to lowest. For cases in which the score is equal for two or more programs, equal rankings are assigned. The total average (n=15) for each question is also included. The ranking is provided not to determine which program is best, but rather, to present the data in a form that may shed light on particular issues that may affect the diffusion of teaching innovations in each of the different programs.

Table 2: Survey results ranked by program – Questions 1-3

Question 1		
Rank	Score	Program
1	4.0	CpE
1	4.0	Physics
3	3.5	IE
4	2.9	*AVERAGE*
5	2.2	ME
6	1.7	EE

Question 2		
Rank	Score	Program
1	4.2	ME
2	4.0	IE
2	4.0	Physics
4	3.7	CpE
5	3.6	*AVERAGE*
6	2.0	EE

Question 3		
Rank	Score	Program
1	3.0	CpE
1	3.0	IE
3	2.2	*AVERAGE*
4	1.8	ME
5	1.0	EE
NA	NA	Physics

Score Scale: Questions 1-3

1 = 0%-19% lectures, **2** = 20%-39%, **3** = 40%-59%, **4** = 60%-79%, **5** = 80%-100%

Paraphrased questions

1.) % of lectures using real-world example and inductive learning.
2.) % of lectures as in (1) OR used active learning techniques.
3.) % of lectures innovated in courses OTHER than SFIP courses.

Table 3: Survey results ranked by program – Questions 4-7

Question 4		
Rank	Score	Program
1	5.0	IE
2	4.8	ME
3	4.7	*AVERAGE*
3	4.7	CpE
3	4.7	EE
6	4.5	Physics

Question 5		
Rank	Score	Program
1	5.0	Physics
2	4.7	EE
2	4.7	CpE
4	4.4	*AVERAGE*
5	4.2	ME
6	3.5	IE

Question 6		
Rank	Score	Program
1	3.7	EE
2	3.5	IE
3	3.3	CpE
4	3.2	*AVERAGE*
5	3.0	Physics
6	2.8	ME

Question 7		
Rank	Score	Program
1	4.0	Physics
2	3.7	CpE
2	3.7	EE
4	3.5	*AVERAGE*
5	3.2	ME
6	3.0	IE

Score Scale: Questions 4-7

1 = Strongly Disagree, **2** = Disagree, **3** = Neutral, **4** = Agree, **5** = Strongly Agree

Paraphrased questions

4.) Enjoyed using SFIP techniques in the classroom.
5.) SFIP was effective in preparing me in this new style.
6.) There is enough time to cover all the course objectives.
7.) Students perform better using this teaching methodology.

The “Comments” section of surveys usually contains very valuable information; in fact, as was mentioned in the introduction, the origin of the SFIP program can be traced to student comments in some of the assessment instruments used at this institution (and not on the quantitative sections of the instruments). Issues that were mentioned by many participants were grouped into themes in order to obtain a measure of the tendency of the comments. The themes were not prescribed a priori; instead, they emerged and took form after the authors read and analyzed all of the comments. The strength of the themes was measured by the frequency that they were mentioned; for example, if 12 of the 15 participants mentioned a theme, a percentage was calculated: 12/15 = 80%. The percentages do not add up to 100% since not every participant mentions a particular theme, some participants may mention more than one theme in their comments, and some issues mentioned by some participants did not develop into a theme because they were very infrequent. These infrequent issues were not reported in this paper; however, all the comments were transcribed in their entirety and saved as part of the data archived by the authors.

Tables 4, 5 and 6 provide the percentages and the themes for the three sections of comments: “Liked BEST”, “Liked LEAST”, and “ADDITIONAL” comments, respectively. The particular wording used by the SFIP participants that led to the particular theme have been paraphrased.

Table 4: Themes based on “Liked BEST” comments

Frequency	Liked “BEST” Themes
12/15 = 80%	*Theme: The use of real-world examples*… more student interest; more student awareness; more participation in class; students are more engaged; students seem to understand better; easier to explain; students appreciate it; deeper understanding.
6/15 = 40%	*Theme: The benefit of writing specific learning outcomes at the topic level*… became more organized; was able to work more precisely with the learning outcomes; easier to develop study guides; able to prepare more balanced exams based on Bloom’s taxonomy.

Table 5: Themes based on "Liked LEAST" comments

Frequency	Liked "LEAST" Themes
10/15 = 67%	*Theme: Time concerns regarding coverage of syllabus while teaching inductively*… requires time to implement in the classroom; time consumed during class; difficult to cover the syllabus; there should be more time for lectures; requires better time management; more effort required by the instructor.
3/15 = 20%	*Theme: Difficulty dealing with physical objects in the classroom*… size of device makes it impossible to bring to classroom; difficult transporting objects to classroom; difficulty taking measurements in the classroom.
2/15 = 20%	*Theme: Student performance*… No evidence on improved student performance in exams; no evidence that the methodology improves students' knowledge and performance.

Table 6: Themes based on "ADDITIONAL" comments

Frequency	"ADDITIONAL Comments" Themes
8/15 = 53%	*Theme: Suggestions to improve the SFIP program*… include assessment methods as part of the workshops; integrate past experiences in new editions of SFIP; I would like to re-attend the workshops provided by Dr. Prince; should have more follow-up meetings during the semester; create a compilation of common misconceptions, possible ways of addressing them, and sharing results with all the faculty; invite former SFIP trainees to talk to the new trainees.
3/15 = 20%	*Theme: Students should study more*… there is still a problem with students' mentality regarding study and they just look for simple ways to pass the class; students should understand that engineering courses require dedication and that they are not going to pass by studying the day before the exam; root cause of poor academic performance stems mainly from shaky mathematical foundations that impede an intellectual leap.

Additional Results: Comments on Exit Survey

As mentioned in the Introduction, the “Liked Least” comments provided by the graduating students in the ME Exit Survey (“too much theory without a practical context”) inspired the grant that supports this program. This “theme” had a frequency of between 16% - 20% prior to the introduction of SFIP. In the exit surveys that were delivered on December 2013 and May 2014, the frequency of this comment dropped to 5%. Furthermore, for the first time, one ME student commented that what they “Liked Best” was the use of Everyday Engineering Examples in the classroom to provide context to the theory. This result is an additional indicator that students are enjoying the experience of their transformed courses.

Discussion of Faculty Survey Results

Question 1 *(% of lectures using a real-world example and inductive learning)*: Real-world examples provide context in an inductive manner prior to discussing the theoretical principles that will be used to solve it. Please refer to Tables 1 and 2. An average score of 2.9 translates to 58% of the lectures being impacted by using a real-world example to start the class. The values ranged from a low score of 1.7 (34% of lectures) for EE to a maximum score of 4.0 (80% of lectures) for both Computer Engineering and Physics.

Question 2 *(% of lectures with a real-world example or used active learning techniques)*: The active learning component refers to techniques that keep the class engaged in the learning process throughout the class period. Please refer to Tables 1 and 2. When active learning techniques are also included, the average score rises to 3.6 (72% of lectures). The values range from a low score of 2.0 (40% of lectures) for EE to a high score of 4.2 (84% of lectures) for ME.

Question 3 *(% of lectures innovated in courses OTHER than SFIP courses)*: The objective of this question was to determine if the faculty members have started innovating additional courses on their own time (courses different than the two courses that they transformed during the SFIP summer program). It is therefore a measure of diffusion of the teaching innovations. Please refer to Tables 1 and 2. The average score is 2.2 (44% of the lectures) thus indicating some diffusion of the innovations. The scores ranged from a low score of 1.0 (0% - 19% of lectures) for EE to a high score of 3.0 (60% of lectures) for both Computer Engineering and Industrial & Management Engineering. The fact that both CpE and IE achieved the highest scores may be due to the fact that the real-world examples that they use are, for the most part, case-studies that do not involve bringing physical objects to the classroom (typical in ME and physics). The “Liked LEAST” section of the comments in Table 5 addressed some of the difficulties in handling physical objects in the classroom. The physics faculty answered NA (not applicable) since they are dedicated 100% to the Physics I and II courses taught to engineering students; therefore, they have had no need to extend the innovations beyond these two courses.

Question 4 *(enjoyed using the SFIP techniques in the classroom)*: Please refer to Tables 1 and 3. The average score of 4.7 out of a maximum of 5.0 leaves no doubt that, in general, the faculty members are enjoying the educational innovations in the classroom. This result is confirmed by comments in the "Liked BEST" section in Table 4. It shows that 80% of the faculty commented on improvements such as "more student interest; more student awareness; more participation in class; students are more engaged; students seem to understand better; easier to explain; students appreciate it; deeper understanding".

Question 5 *(SFIP was effective in preparing me in this new style)*: Please refer to Tables 1 and 3. The average score of 4.2 out of a maximum of 5.0 is very good. The "ADDITIONAL Comments" section in Table 6 provides improvement ideas to the SFIP program as follows: "include assessment methods as part of the workshops; integrate past experiences in new editions of SFIP; I would like to re-attend the workshops provided by Dr. Prince; should have more follow-up meetings during the semester; create a compilation of common misconceptions, possible ways of addressing them, and sharing results with all the faculty; invite former SFIP trainees to talk to the new trainees." Assessment methods will be included by Dr. Prince in his SFIP 2015 workshops.

Question 6 *(There is enough time to cover all the course objectives)* : The issue of time is the most difficult challenge encountered while experimenting with inductive learning in the classroom. Please refer to Tables 1 and 3. The average score was 3.2 out of a maximum of 5.0 which may be considered "marginal". Furthermore, the issue of time was mentioned by 67% of the faculty in the "Liked LEAST" section of the comments (see Table 5). Returning to Table 3, the scores ranged from a low score of 2.8 for Mechanical Engineering to a high score of 3.7 for Electrical Engineering. It is not surprising to see ME and Physics obtain the lowest scores since the physical objects brought to class take time to set up, operate, and measure (see Table 5, second theme). But even programs that use case studies and not physical objects, like Computer Engineering and Industrial & Management Engineering, although they scored above-average, they still scored below 4.0 out of 5.0, thus indicating that there is an issue with respect to time to cover all the course objectives.

Question 7 *(Students perform better using this teaching methodology)*: Please refer to Table 1 and 3. The average score of 3.5 out of a maximum of 5.0 should be considered marginal. The values range from a low score of 3.0 in Industrial & Management Engineering to a high score of 4.0 in Physics. Furthermore, 20% of the faculty mentioned that they had no evidence that showed an improvement in student grades (see Table 5, third theme). An additional 20% of the faculty mentioned that students had to “study more” (see Table 6, second theme).

As a final point of discussion, Table 4 (third theme) shows that 40% of the faculty mentioned the benefit of writing learning outcomes at the topic level. This has been one of the greatest benefits of the SFIP.

Conclusions

The Summer Faculty Immersion Program is delivering promising results. It is achieving systematic diffusion of innovative teaching methodologies as had been hypothesized. Still, there are some issues that need to be addressed.

Specifically, the following can be concluded:

1. The Summer Faculty Immersion Program has been very well received by the 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 are based on engineering education research results.

2. 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.

3. Diffusion of these innovative classroom methodologies is taking place. The faculty are using real-world examples in the classroom in an average of almost 60% of the lectures. If active learning techniques are added, the average climbs to just above 70% of the lectures.

4. Diffusion is also taking place, and can be measured by the fact that faculty members are beginning to use these techniques at the rate of 44% of the lectures in courses other than those they transformed during the SFIP summer session. They are transforming these courses on their own time. This is a very positive development and was an expectation of the program when it was proposed, i.e., that once the faculty members underwent the training, and started experiencing the value added by teaching in a more engaging manner, that they would begin to transform other courses on their own time. Transformation of the faculty is taking place.

5. The issue of "time to cover the syllabus" continues to be the toughest challenge faced by the faculty while implementing these innovative techniques. It is a critical issue that needs to be resolved; however, the solution is not yet clear nor is it an easy endeavor. As mentioned earlier, diffusion of educational innovations in engineering is a challenge that has defied a satisfactory solution for decades. A satisfactory solution to these "time issues" could be the key to achieving very high diffusion rates.

6. 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. One area that will continue to be monitored and addressed is the grading distribution. Traditionally, the grading distribution in engineering courses at this institution is heavily weighted toward exams that primarily test the application of math skills in the solution of textbook-type problems. SFIP promotes a balanced assessment distribution between the different cognitive levels of Bloom's taxonomy. The use of the inductive methodology with real-world examples is better suited for the "Comprehension" level of Bloom's taxonomy. It leads to better and deeper understanding of the underlying concepts and not necessarily to improved math skills in solving textbook-type problems. The comprehension of conceptual knowledge should also be assessed and graded, in addition to the skill of solving textbook-type problems. For example, in a heat transfer course, students could be asked to identify heat transfer modes in real-world cases and explain them in the context of the case. Also, different types of problems are beginning to emerge in the literature; for example, *Ranking Tasks for Mechanics of Materials*, authored by Brown and Poor [12]. This book is marketed and sold as a supplement to any Mechanics of Materials textbook. The problems, all of which involve ranking (from highest to lowest) a set of similar cases, are excellent pedagogical tools to progressively build conceptual understanding and learn the basic equations of mechanics of materials. The progression is achieved by isolating a variable and figuring out the effect of changing it while the other variables are held constant. Once the student has grasped the individual effect of each variable, the set of tasks concludes with a ranking exercise in which all the variables are changed. A typical example is a bar under tension, and the variables that are progressively isolated are: force, length, area, and modulus of elasticity. Another interesting feature of these ranking tasks is that at the bottom of each problem there is a horizontal scale numbered from 1 to 10 where students indicate with a circle the level of confidence that they have in their answer (1 is low and 10 is high confidence). The students and the instructor can "see" the improvement in the level of confidence by working on a full set of exercises during class. These types of problems, and the numerical axis to indicate level of confidence, are very insightful in showing a path that can be followed by any student to progressively achieve deep conceptual learning.

Acknowledgments

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