Effectiveness of High-Impact Practices (HIPS) in an Engineering Course

Ms. Sharon S. Wu, California State University, Fullerton

Sharon Wu is currently a graduate student at California State University, Fullerton. She is conducting research in engineering design and STEM education research with focus on women and minorities,

Dr. Yong Seok Park, California State University, Fullerton

Yong Seok Park is an assistant professor in mechanical engineering at California State University Fullerton. He earned his Master's degree at George Washington University and his Doctorate at the Virginia Tech. Prior to joining California State Fullerton, Dr. Park was a postdoctoral research associate at Arizona State University. His research interests lie in undergraduate STEM education research and engineering design education.

The Effectiveness of HIPs in a Mechanical Engineering Class

Introduction

High-Impact Practices (HIPs) are innovative and transformational learning opportunities for students inside and outside of the classroom that provide a myriad of learning gains aimed at promoting the success of students in a higher education environment. In the 2007 report, *College Learning for the New Global Century*, the National Leadership Council for Liberal Education and America's Promise (LEAP) was able to identify many such HIPs that are gaining attention [1]. In a subsequent report, Kuh found that students who participated in these HIPs show that they were positively affected by these activities, as measured by the National Survey of Student Engagement (NSSE). It was found that these "deep approaches to learning are important because students who use these approaches tend to earn higher grades and retain, integrate, and transfer information at higher rates [2]." Thus, what we set out to do is to apply HIPs to a 300- level engineering course at a state college level and gather data regarding its effectiveness, student reflections, and possible future improvements for better learning outcomes.

HIPs in a Mechanical Engineering Class

The goal is to implement HIPs for mechanical engineering students who are still in their early part of the core mechanical engineering program. This course would be one of the first mechanical engineering courses required by the university that is not considered part of the general education curriculum. The purpose of this study is to track the effects of HIPs with carefully planned pedagogies that would provide numerous benefits for the students, such as overall increased learning gains and graduation rates. There are seven HIPs characteristics used to measure the results at the end of the semester: these are (1) interaction with faculty, (2) interaction with peers, (3) feedback from instructor, (4) quality time spent on the course, (5) engaging in reflection, (6) engaging in diversity, and (7) engaging in experiential learning. There are specific instructional methods implemented in each class time to maximize the effect of each characteristic.

To provide (1) meaningful interaction with faculty, (2) meaningful interaction with peers, and (4) time spent on the course, the instructor organized classroom time into 25 minutes of lecture with the remaining time for active problem-solving in groups for a hands-on project. For students to receive (3) feedback from instructor, be (5) engaging in reflection, and (6) engaging in diversity, Muddiest Points (MPs) were implemented to capture any misconceptions and issues that arose from new materials. Students were allowed time for questions during class and asked to submit any MPs to an online forum for every lecture with any questions or confusing concepts that would be reviewed by the instructor and addressed at the start of the following class. Asking students to write down what was least clear to them is a

potentially powerful integrative exercise because it requires students to identify any misconceptions or difficulties they may be having with the material, opening a dialogue with the instructor and allowing students to a more profound learning outcome. Finally, for (7) engaging in experiential learning, the lecture
materials offered heavy contextualization, such as emphasizing group work that related to real-world engineering problems.

Implementation

Surveys were used to measure self-reported data on how much each student engaged with each of the HIPs characteristics. A mobile app was also developed by the university to track students who participated in this engineering course and how much time they spent in each of the HIPs characteristics. This data was then analyzed by the university with an ordinal logistic regression, and the results were provided to the instructor.

Student Demographics

A total of 40 students participated in the HIPs survey on the very first and last day of class. University researchers collected the attendance data from the mobile app and measured the learning gains by comparing pre-test and post-test data. An ordinal logistic regression analysis was conducted to compare the demographic characteristics of each student to each of the seven HIPs characteristics. Interestingly, 48.6 percent of students self-reported as an Under- Represented Student (URS), defined as Black/African American, Hispanic/Latino/a, or Native American. 67.5 percent of the students fell under the Low-Income category (PELL), as defined by those receiving the Pell Grant, and 66.7 percent identified as a First Generation Student (FIRSTGEN). Only 7.5 percent of the students were female (GENDER), and the same percentage were 25 and older (AGE).

Table 1. Survey results showing URS, PELL, and FIRSTGEN responses

	URS		**PELL**		**FIRSTGEN**	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No	19	51.4	27	67.5	12	33.3
Yes	18	48.6	13	32.5	24	66.7
Total	37	100	40	100	36	100
Missing	3		0		4	
Total	40		40		40	

Table 2. Survey results showing age of students

	AGE	
	Frequency	Percent
24 and under	37	92.5
25 and older	3	7.5
Total	40	100
Missing	0	
Total	40	

Table 3. Survey results showing student gender

	GENDER	
	Frequency	Percent
Male	37	92.5
Female	3	7.5
Total	40	100
Missing	0	
Total	40	

Statistical Analysis

Statistical data was analyzed using an ordinal logistic regression method and the SPSS Statistics software. The impact of each demographics (URS, FIRSTGEN, AGE) on each of the twenty-one HIPs survey questions were analyzed using these tools, and results that showed no significance are not included in this study. Among all the characteristics and survey questions, we found three statically significant results worth sharing. First, did any particular demographic group report spending more time participating in HIPs? The following demographic characteristics had a statistically significant relationship with several of the survey questions (Sig. <0.05):

- Whether the student was a first-generation college student. If a student is a FIRSTGEN, they reported spending less time interacting with classmates, had less feedback from their instructor, and spent less time working with real-world problems as part of learning new material.
- A students' age category. If a student is under 25 years old, they spent less time interacting with classmates.

Second, did any particular demographic group feel the available opportunities to participate were adequate? If a student is a female, they reported that they did not feel they had to spend a lot of time and effort to be engaged in the program.

Third, did any particular demographic group feel that participating in HIPs was beneficial to them (personally, professionally, etc.)? Gender was again a statistically significant predictor (Sig. <0.05). If a student is a female, they agreed less that the course challenged them to reach high goals, academic or personal, than they thought they could.

Researchers looked at the data on student learning gains and their retention rate. Learning gain is calculated by the difference between the post-test score and the pre-test score, in percentage points. Retention is measured by whether the student is registered for the following semester. Although 39 of the 40 students were registered, researchers found that there was no statistically significant relationship between learning gain and retention for this course. There was, however, a demonstrated learning gain in this course ($p<0.5$). A T-test shows that students demonstrated an average learning gain of 4.53 percentage points.

Table 4. Change in assessment score

Change in Assessment Score (Percentage) N=40	
Min	-15.000
1st Quartile	-3.750
Median	3.500
3rd Quartile	11.500
Max	25.000
Mean	4.530
SD	10.280

Table 5. T Test information

T Test Information	
Statistic	2.790
df	39.000
p value	0.008
Mean	4.530

As for demographics and learning gains/retention, there is no statistically significant difference between demographic characteristics and learning gain, and demographic characteristics and retention rates.

Overall, the study found that there were a number of beneficial outcomes with the following having the highest statistically significant correlation to learning gains: (1) interaction with faculty, (2) interaction with peers, (3) feedback from the instructor, and (7) experiential learning. On the other hand, (4) time spent on the course, (5) engaging in reflection, and (6) engaging in diversity show a somewhat weak relationship to learning gains.

Interpretation

From the statistical analysis provided by the university, the demographic groups FIRSTGEN, GENDER, and AGE, show meaningful results that we hope to gain further insight and understanding by an attempt to interpret the findings. A few students were interviewed to attain a deeper perception of our results and form our own interpretations.

If a student is a FIRSTGEN, they spent less time interacting with classmates and felt they had less feedback from the instructor. A plausible interpretation may be that students have gone from high school to a higher education environment without the guidance from their parents and relatives. Students who have had family members attend college may have received advice to help them succeed in college, emphasizing the importance to network, make friends quickly, and seek to connect with their professor. Perhaps higher intellectual topics were discussed more frequently and openly; therefore, non-FIRSTGEN students could be more comfortable interacting with other classmates in group settings. Compared to these students, FIRSTGEN students may not have had this benefit.

As for GENDER, the sample size for the results is extremely small and should be carefully considered. Female students who go into engineering are usually highly interested in the topic, so less effort is needed to stay engaged and would naturally feel that they were not challenged enough in the class. Knowing female students in an engineering course tend to be in the minority, they most likely must be equipped with greater confidence in their abilities compared to other students. Perhaps more confidence equates to already understanding what must be done to perform well, and they were prepared with being more organized, more dedicated, etc. Because of this, it’s possible they did not feel the class was challenging enough nor the need to spend extra time or effort to be engaged.

Students who were under 25 years of age spent less time interacting with classmates, and there can be many reasons for this disparity. For one, older students may understand the importance of networking, put it as a higher priority, or already have friends in the class. Younger students, on the other hand, tend to be shyer and not be inclined to interact with classmates with whom they are already not friends. Students who are engineering majors are typically less likely to engage with others, and in general, tend to be more comfortable being

by themselves. Being stereotypically introverted, those under 25 years of age prefer to be "followers" in a social setting, allowing someone else to lead the discussion or group work. Also, compared to other majors, there is less room left for discussion for an engineering problem. In many cases, the methodology for approaching the answer is already included in the lecture and discussion frequently does not occur.

Limitations and Future Improvements

In this study, a source of potential bias is the limited sample size, especially in women and students over the age of 25. In order to obtain better comprehensive data for engineering courses, we can collaborate with instructors from other entry-level engineering classes. Not only would this provide a necessary larger sample needed for repeatability and reliability, this also allows for more in-depth analysis of minorities' and women's perspectives on the HIPs characteristics. Another possible adjustment can be having studies that span over a longer period, from multiple semesters to a few years over the duration of students' academic career. This would allow us to track student academic performances through a longer period, rather than just one semester.

In the future, a comparison against a non-HIPs course in the same level, or even the same course, could be helpful in acting as a control group. This course could provide a standard to compare against and understand how HIPs could create more of a gain than if it were not used.

Nonetheless, the outlook for implementing HIPs in an engineering course shows that students gain deeper learning opportunities and better attitude towards interacting with staff and fellow classmates. By adjusting for future studies, we can hopefully further improve upon this and achieve higher learning gains.

References

[1] J. E. Brownell and L. E. Swaner, "High-Impact Practices: Applying the Learning Outcomes Literature to the Development of Successful Campus Programs," Association of American Colleges & Universities, 02-Apr-2017. [Online]. Available: https://www.aacu.org/publications- research/periodicals/high-impact-practices-applying-learning-outcomes-literature. [Accessed: Aug. 29, 2018]

[2] Kuh, G.D. *High-impact educational practices: What they are, who has access to them, and why they matter.* Washington, DC: Association of American Colleges and Universities. 2008

CALIFORNIA STATE UNIVERSITY FULLERTON

California State University, Fullerton EGME 331

Activate contrast mode

1 2 3 4 5

1 HIP Student Experience Survey - HIP Course

1.1 CWID:

Please answer the following questions based on your experience in this course.

MEANINGFUL AND SUBSTANTIVE INTERACTIONS WITH INSTRUCTOR(S)

1.2 How much time, over the entirety of the course, have you spent in meaningful interactions (including class sessions) with the instructor(s)?

- 0-10 hour
- 11-20 hours
- 21-30 hours
- More than 30 hours

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.3 I have had adequate opportunities to interact (including class sessions) with the instructor(s).	○	○	○	○	○
1.4 My interactions with the instructor(s) was helpful for my academic or personal growth.	○	○	○	○	○

<< Previous Next >>


2012
-AA-
Access for All

CALIFORNIA STATE UNIVERSITY FULLERTON

California State University, Fullerton EGME 331

Activate contrast mode

1 2 3 4 5

1 HIP Student Experience Survey - HIP Course

MEANINGFUL AND SUBSTANTIVE INTERACTIONS WITH PEERS

1.5 How much time, over the entirety of the course, have you spent in meaningful interactions (including class sessions) with classmates?

- 0-10 hour
- 11-20 hours
- 21-30 hours
- More than 30 hours

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.6 I have had adequate opportunities to interact (including class sessions) with fellow student(s).	○	○	○	○	○
1.7 My interactions with fellow student(s) was helpful for my academic or personal growth.	○	○	○	○	○

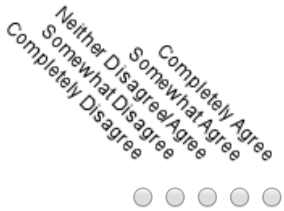
FREQUENT AND MEANINGFUL FEEDBACK

1.8 How many times, over the entirety of the course, have you received feedback (written or oral) from the instructor(s) on your work?

- Less than 5 times
- 6-10 times
- 11-20 times
- More than 20 times

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.9 I have had adequate opportunities to receive feedback from the instructor(s).	○	○	○	○	○



1.10 The feedback I received from the instructor(s) was helpful for my academic or personal growth.

<< Previous

Next >>

CALIFORNIA STATE UNIVERSITY FULLERTON

California State University, Fullerton EGME 331

Activate contrast mode

1 2 3 4 5

1 HIP Student Experience Survey - HIP Course

CONSIDERABLE TIME AND EFFORT

1.11 How many hours, in a typical 7-day week, do you spend preparing for this course?

- Less than 1 hour
- 1-5 hours
- 6-10 hours
- More than 10 hours

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.12 I had to spend a lot of time and effort in order to do well in this course.	○	○	○	○	○
1.13 This course challenged me to reach higher academic or personal goals than I thought I could.	○	○	○	○	○

REFLECTIVE AND INTEGRATED LEARNING

1.14 How many times, over the entirety of the course, have you worked on an assignment or project that required integrating ideas or information from various sources?

- Less than 5 times
- 6-10 times
- 11-20 times
- More than 20 times

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.15 I have had adequate opportunities to integrate ideas or information from various sources.	○	○	○	○	○

CALIFORNIA STATE UNIVERSITY FULLERTON

California State University, Fullerton EGME 331

Activate contrast mode

1 2 3 4 5

1 HIP Student Experience Survey - HIP Course

DIVERSITY, COMPLEXITY, AND CHANGE

1.17 How many times, over the entirety of the course, have you worked on a topic or issue that involved unfamiliar or different perspectives (political, social, religious, culture, etc.)?

- Less than 5 times
- 6-10 times
- 11-20 times
- More than 20 times

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.18 I have had adequate opportunities to grapple with unfamiliar or different perspectives (political, social, religious, culture, etc.).	○	○	○	○	○
1.19 This course helped me learn how to interact with people who have different views or come from different backgrounds.	○	○	○	○	○

EXPERIENTIAL LEARNING

1.20 How many times, over the entirety of the course, have you worked with real-world problems as part of learning new materials?

- Less than 5 times
- 6-10 times
- 11-20 times
- More than 20 times

To what extent do you agree with the following statements:

	Completely Disagree	Somewhat Disagree	Neither Disagree/Agree	Somewhat Agree	Completely Agree
1.21 I have had adequate opportunities to work with real-world problems as part of learning new materials.	○	○	○	○	○

CALIFORNIA STATE UNIVERSITY FULLERTON

California State University, Fullerton EGME 331

Activate contrast mode

1 2 3 4 5

1 HIP Student Experience Survey - HIP Course

iFullerton HIPs App

1.23 Please rate your experience using the iFullerton HIPs app.

1.24 Please share any suggestions on improving the iFullerton HIPs app.

Thank you very much!

<< Previous Submit