

Quantitative Analysis on Students Success and Class Satisfaction by Comparing Three Different Modalities of Assessments for a Large Engineering Gateway Course.

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Abstract

Statics is a large engineering gateway course with usually a very high Fail /Pass (C or better) ratio of around 40-60%. Students in general, do very well in their traditional on-line or pencil-and-paper homework assignments, but in many cases do not perform as well when given very similar problems in their proctored quizzes and tests. This paper summarizes a study conducted in three different class sections of Statics, each one of them with variations in the type and amount of assessments used. Results of class success are presented as well as students' opinions regarding engagement and learning.

Keywords

Statics, Assessment comparison, Project based homework, course redesign, gateway engineering courses.

Introduction

Statics is the first fundamental course faced by the majority of engineering students at the sophomore level and it is also a pre-requisite of other courses such as Dynamics and Mechanics of Materials (Solid Mechanics). At the University *omitted for blind review* Statics sections are usually large (150-300 students) and the fail/pass ratio is very high (40%-60%). As a result, a significant number of students have to retake it, delaying their expected graduation date, and in some cases, having to change majors to non-STEM disciplines because of the universities repeating policies. Due in part to the growth in the student population, on-line instructional delivery and assessment have been gaining popularity among institutions compared with the traditional face-to-face lecturing and pencil and paper class exams albeit the students overwhelming preference for the paper exams ¹.

It is no surprise that many engineering education researchers have been actively trying to improve the teaching and learning for Statics. Incorporation of active learning, experiential learning, manipulatives, and project based hands-on homework (PBH) have been documented to increase the class success, retention, and graduation rates ²⁻⁷. This study was conducted to test how the use of different types of assessment and strategies affected the students' class performance and satisfaction with the ultimate goal of producing a course redesign that includes the best tools and could be used for large size classes.

Methodology

Three different sections of Statics were taught by the same instructor during Fall 2018 (Sections 1, 4, and 5). All of them had 2 Mid-terms and a final exam. Students in section 1 have on-line homework (hw). Section 4 included 3 PBH in addition to the on-line hw. Students in section 5 were not required to complete any homework. Instead, they had to study and take bi-weekly proctored quizzes at the Engineering Proficiency Center (EPC). For all three sections, YouTube videos, study-sets, and practice exams were made available. Table 1 summarizes the assessments.

Table 1. Type of Assessment per Section

Sections	Type of Assessment				
	Mid-Term 1 (25%)	Mid-Term2 (25%)	Final Exam (30%)	Homework(20%)	Quizzes (20%)
Section 1	In-Class Paper Based Multiple Choice Possibility of Partial Credit (GTA)	In-Class Paper Based Multiple Choice Possibility of Partial Credit	In-Class Paper Based Full Response	Online (Mastering Engineering) and Multiple Attempts No-Timed	NO
Section 4	On-line Proctored (EPC) Multiple Choice Possibility of Partial Credit (Scratch Paper- GTA)	On-line Proctored (EPC) Multiple Choice Possibility of Partial Credit (Scratch Paper- GTA)	In-Class Paper Based Full Response	Online (Mastering Engineering) and Multiple Attempts No-Timed 3 Hands-On HW	NO
Section 5	On-line Proctored (EPC) Multiple Choice Possibility of Partial Credit (Scratch Paper- GTA)	On-line Proctored (EPC) Multiple Choice Possibility of Partial Credit (Scratch Paper- GTA)	In-Class Paper Based Full Response	NO-HW	Proctored (EPC) Multiple Choice Possibility of Partial Credit (Scratch Paper- GTA)

Students Demographics

For a better comparison between the three modalities, data regarding students' demographics was collected and presented in Table 2. The gender distribution looks very similar for all sections. The main difference is a reduced amount of Black/African American students in section 1. Students self-enrolled in the sections without knowing beforehand the type of assessment per class.

Table 2. Enrollment by Gender and Ethnicity per Section

Section #	Ethnicity	Total	%	Gender			
				Male	%	Female	%
Section 1	White	73	46.79	64	41.03	9	5.77
	Hispanic/Latino	57	36.54	44	28.21	13	8.33
	Black/African American	5	3.21	3	1.92	2	1.28
	Asian	11	7.05	7	4.49	4	2.56
	Other	10	6.41	9	5.77	1	0.64
	TOTAL	156	100.00	127	81.41	29	18.59
Section 4	White	47	42.34	39	35.14	8	7.21
	Hispanic/Latino	34	30.63	25	22.52	9	8.11
	Black/African American	13	11.71	12	10.81	1	0.90
	Asian	6	5.41	3	2.70	3	2.70
	Other	11	9.91	10	9.01	1	0.90
	TOTAL	111	100.00	89	80.18	22	19.82
Section 5	White	68	46.26	57	38.78	11	7.48
	Hispanic/Latino	44	29.93	34	23.13	10	6.80
	Black/African American	12	8.16	10	6.80	2	1.36
	Asian	10	6.80	7	4.76	3	2.04
	Other	13	8.84	8	5.44	5	3.40
	TOTAL	147	100.00	116	78.91	31	21.09

Academic background (Cumulative GPA) of the students when they enrolled in the course was also investigated. The three charts shown below (Figure 1) presented a very similar distribution as well as the mean and standard deviation showed in Table 3.

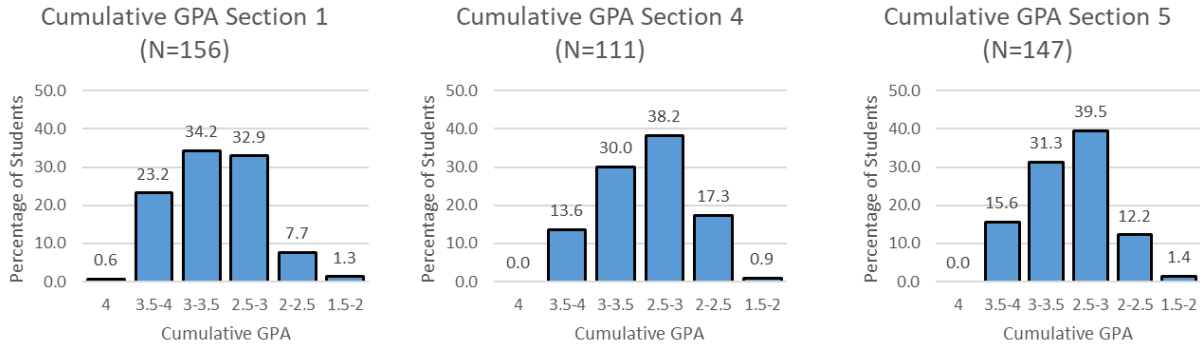


Figure 1. Cumulative GPA of the students (Three Studied Sections)

Table 3. Average and Standard Deviation of the Students for the three Studied Sections

Comparison of Cumulative GPA		
Section	Mean	Standard Deviation
Section 1	2.98	0.47
Section 4	3.13	0.49
Section 5	2.9	0.48

Students Performance Results per Section

Students’ results for the three sections were analyzed and summarized. The left part of Figure 2 shows that the passing rate of students in Section 1 is higher than 4 and 5. The right part of Figure 2, presents the passing rate by gender. It seems that for sections 1 and 4, the gap between male and female passing rate is not statistically important however, it increased greatly for section 5. It is important to remember that this was the only section with biweekly proctored quizzes and no homework. The presence of this increased gap was further investigated by looking at the amount of D’s, F’s, and W’s per section.

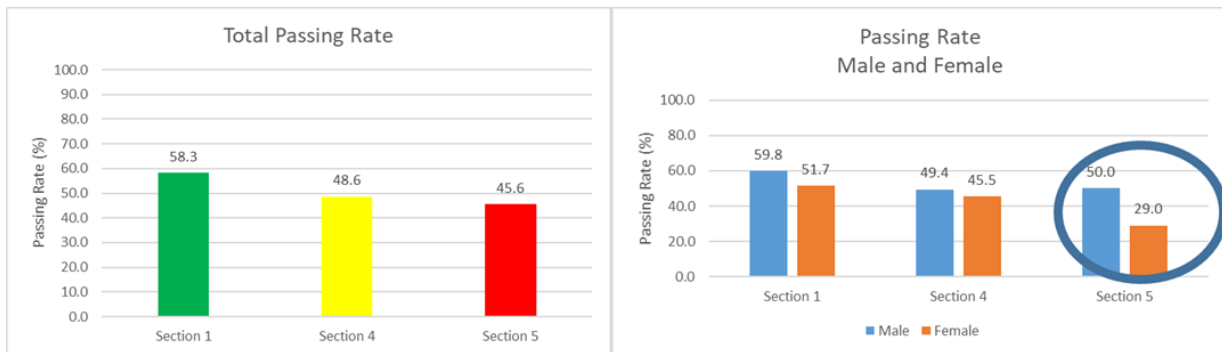


Figure 2. Passing Rate for the three sections. (Left: Total; Right: by Gender)

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Table 4 and Figure 3 show the main reason for the marked difference in failing rate between male and female students for section 5 was mainly due to the withdrawals and not for D's and F's. This is something that must be taken into account when designing the type and number of assessments.

Table 4. Passing Rates by Gender

Class	Gender	Attempted	Passed (ABC)	Passing Rate	Withdrawn	% W	Failed (D,F)	% DF
Section 1	Male	127	76	59.8%	21	16.5	30	23.6
	Female	29	15	51.7%	5	17.2	9	31.0
Section 4	Male	89	44	49.4%	13	14.6	32	36.0
	Female	22	10	45.5%	4	18.2	8	36.4
Section 5	Male	116	58	50.0%	19	16.4	39	33.6
	Female	31	9	29.0%	11	35.5	11	35.5
Total	Male	332	178	53.6%	53	16.0	101	30.4
	Female	82	34	41.5%	20	24.4	28	34.1

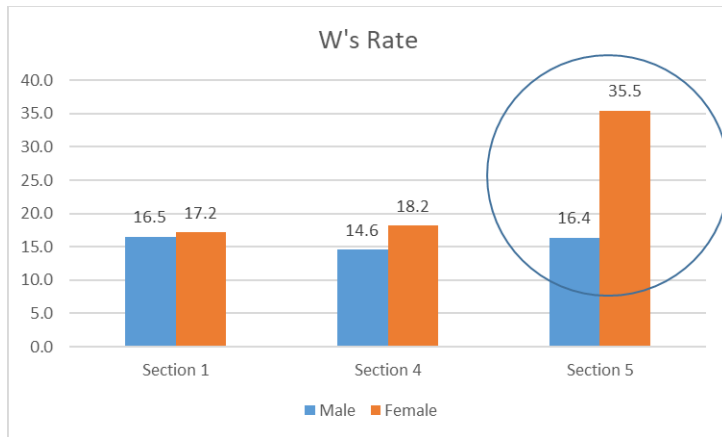


Figure 3. Percentage of Withdrawals (W) per Gender

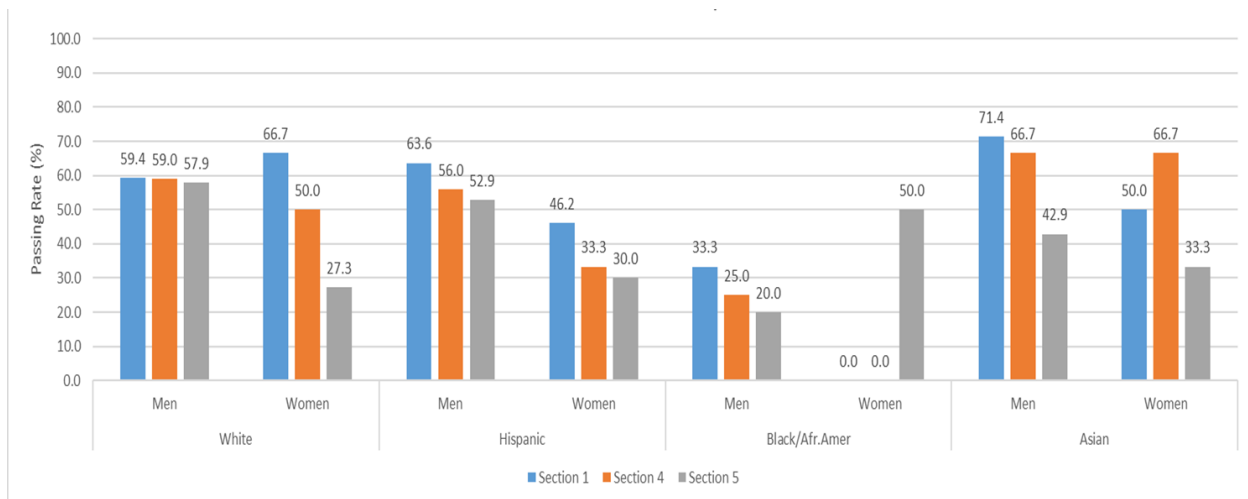


Figure 4. Passing Rate by Ethnicity and Gender

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By inspecting this aggregated data (Figure 4 and Table 5) it seems that several findings could be generalized. White men have almost identical passing rate while white women fared better in section 1, then 4, and lastly section 5. Hispanic men and women as well as African American and Asian men followed the same trend. There were insufficient data to discuss African American women. Asian women performed better in section 4.

As mentioned before, this is aggregated data which is not the best way of finding individual cause/effect relationships. One important component present in section 4 was the PBH assignments; however, only three topics were covered by a PBH (Non-perpendicular axis, 2D particle equilibrium, and 2D rigid body equilibrium). An evaluation of how the three sections performed in the exam topics addressed by the PBH was undertaken. Figure 5 tells a different story since now, students in section 4 (PBH) performed the best, followed by section 5 (quizzes) and then section 1.

Table 5. Passing Rate by Ethnicity and Gender

Class	Ethnicity	Gender	Attempted	Passed (A,B,C)	Passing Rate	Withdrew
Section 1	White	Male	64	38	59.4%	11
		Female	9	6	66.7%	2
	Hispanic/Latino	Male	44	28	63.6%	6
		Female	13	6	46.2%	2
	Asian	Male	7	5	71.4%	1
		Female	4	2	50.0%	1
	Afr. Amer./Black	Male	3	1	33.3%	1
		Female	2	0	0.0%	0
	Other	Male	9	4	44.4%	2
		Female	1	1	100.0%	0
Section 4	White	Male	39	23	59.0%	7
		Female	8	4	50.0%	1
	Hispanic/Latino	Male	25	14	56.0%	3
		Female	9	3	33.3%	2
	Asian	Male	3	2	66.7%	1
		Female	3	2	66.7%	1
	Afr. Amer./Black	Male	12	3	25.0%	1
		Female	1	0	0.0%	0
	Other	Male	10	2	20.0%	1
		Female	1	1	100.0%	0
Section 5	White	Male	57	33	57.9%	6
		Female	11	3	27.3%	4
	Hispanic/Latino	Male	34	18	52.9%	5
		Female	10	3	30.0%	4
	Asian	Male	7	3	42.9%	1
		Female	3	1	33.3%	1
	Afr. Amer./Black	Male	10	2	20.0%	3
		Female	2	1	50.0%	0
	Other	Male	8	2	25.0%	4
		Female	5	1	20.0%	2

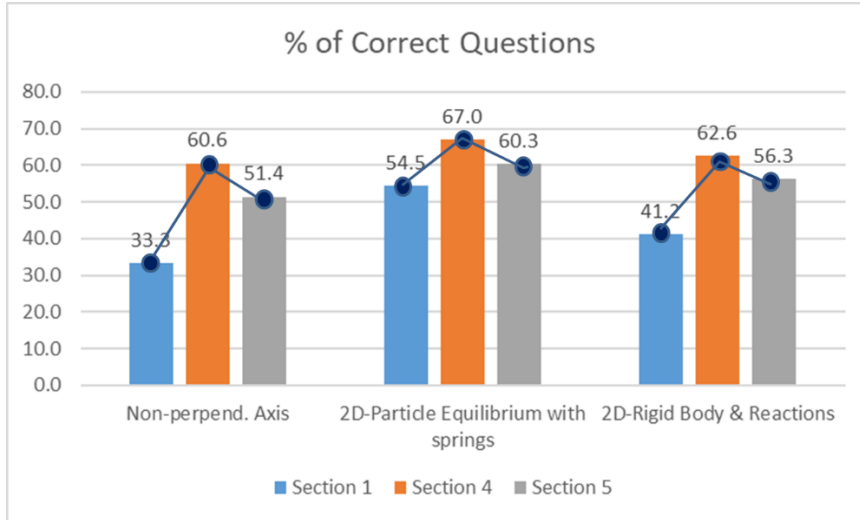


Figure 5. Percentage of Correct Answers in the Topics Addressed by PBH

In addition, when looking at the same results by genders, the gap between correct answers for male and female was reduced in section 4 as shown in Figure 6.

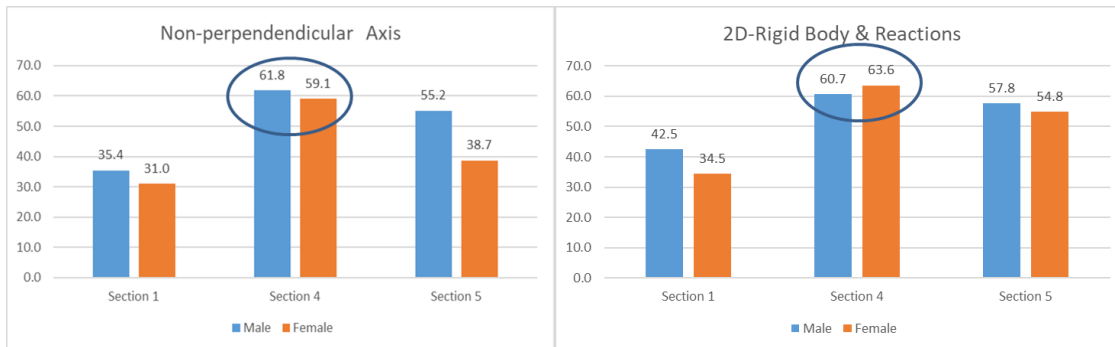


Figure 6. Percentage of Correct Answers by Gender (in the Topics Addressed by PBH)

Students Opinions

Anonymous 5-point Likert scale polls were distributed to the students in the three sections. Figure 7 shows some of the results. For section 1, a significant portion of the students found the YouTube videos (81.6%) and study sets (79.6%) very useful and effective for learning (a and b). A great majority of the students in section 4 expressed that PBH helped them (c and d) to better understand the concepts (82.3%) and that PBH was a better tool than regular homework (79.3%). Finally, for section 5, even though 52.6% considered the exams and quizzes were fair, only 31.6% expressed they were better than homework for learning purposes (e and f).

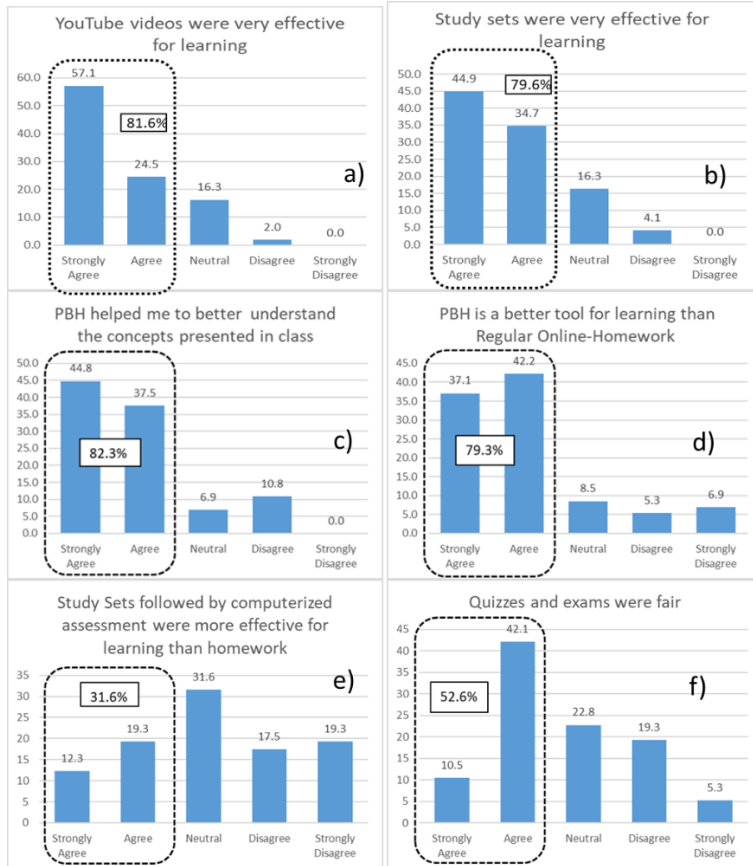


Figure 7. Results of Students' Surveys

Furthermore, students from Section 1(S1), Section 4(S4) and Section 5 (S5) were asked 1) “What did you like about this class?” and 2) “What would you change?” Some of their responses are copied below.

What did you like about this class?

- “I liked having the information in multiple ways. The videos helped with understanding, the PowerPoints are good for quick reference. You Tube Videos and Study Sets” (S1, S4, S5).
- “I liked the pre-tests”(S1,S4,S5).
- “On-line homework” (S1,S4)
- “The videos and study sets helped me an immense amount” (S1, S4, S5).
- “I liked the projects the most because I learned better while working with my hands and seeing real-life issues being solved” (S4).

What would you change?

- “Include more hands-on homework” (S4).
- “I don’t understand why we didn’t do projects. I would like to have them in our section” (S1, S5).
- “Homework should have been mandatory” (S5).

- “Implement quizzes. I feel that weekly quizzes would have led to stronger retention of the material “(S1, S4).
- “Maybe add more assignments to boost our grades so we are not so stressed all the time.” (S5)
- “I feel like the weight of tests in the class need to be adjusted, one failing grade on a single exam, allows you very slim chances to catch up” (S1, S4, S5).

Discussion and Future Work

After analyzing the all the data, it seems that the students were more successful in the section with regular on-line homework and exams (no quizzes). However, when data is disaggregated and exam questions were analyzed in detail, the students in the section with PBH (Section 4) had more correct answers related to the topics addressed by them. Also, it appears the PBH helped to close the gap between male and female correct answers in the exams. Based on the results discussed before, and the students’ suggestions, the statics course was redesigned to include the best tools from all the sections. This new redesign project is also presented at the ASEE SE 2020. The new Statics class now includes video lectures, study-sets, on-line homework, PBH for each main concept, practice tests with questions more challenging than the actual exam, by-weekly on-line proctored quizzes, 2 Mid-term exams (on-line), and a final examination.

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2020 ASEE Southeastern Section Conference

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