Statics and Dynamics: A Case Study of Supplementing Traditional Lectures with High Impact Practices such as Multiple-Attempt-Testing and Project-Based-Homew

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Statics and Dynamics: A Case Study of Supplementing Traditional Lectures with High Impact Practices such as Multiple-Attempt-Testing and Project-Based-Homework

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Statics and Dynamics are two essential core fundamental gateway courses for Mechanical and Aerospace engineering majors, whose fail rates are one of the highest observed in engineering courses. By introducing different pedagogical high-impact practices, such as Multiple-Attempt Testing (MAT) and hands-on Project Based Homework (PBH), we have attempted to improve these success rates. MAT was introduced for Dynamics since Spring 2021 and has proven to be successful over the past few years. PBH has been part of the Statics curriculum since 2016. However, we have yet to study the combined implementation and impact of using *both* High-Impact Practices (HIP) in these courses.

This paper presents the results of incorporating MAT and PBH into the Statics and Dynamics courses. A baseline was created by using the Spring 2019 semester that did not implement any practice, then PBH and MAT were inserted during Spring 2023 and Summer 2024. Classes were delivered either face-to-face or in a blended mixed mode where students watched videos and/or did adaptive learning assignments to acquire some understanding before coming to class to solve problems with their instructor. After class, they could do other assignments, such as take-home quizzes, problem-solving assignments, and tests with multiple attempts. These MAT were conducted in the high-integrity testing center of the College of Engineering. The tests were automatically graded in Canvas, the institution's Learning Management System (LMS), and students saw their scores instantly. With the help of the teaching assistants (TAs), students were permitted to see their tests and learn from mistakes before their subsequent attempt. Although based on the same concepts, the following attempts for the same test were different due to the large pool of question banks. In Statics, students completed PBH that had them create a physical model, measure results, solve it analytically, compare the results (analytical vs experimental), present a report, and create a small video of them explaining the case and discussing the results.

Students completed entry and exit survey questionnaires gauging their self-regulatory and motivational learning processes in these courses. In this paper, we present our experiences implementing, a detailed analysis of the learning outcome and student self-reported results, and discuss the lessons learned from this educational model. These surveys confirmed the students strong positive reactions to the methodology presented herein.

Key words: Project based homework, Multiple-attempt-testing, Mixed-mode, Gateway engineering courses, Self-reported motivation and Self-regulation.

Introduction

Prior studies have reported that interventions utilizing online resources could enhance students' learning gains in STEM education as in Arora et al.[1] and Van den Broeck et al.[2]. However, a rapid change in online landscape accelerated by COVID-19 pandemic has brought up serious academic misconduct issues, as evidenced by the students' frequent utilization of websites and AI tools such Chegg[3], Quizlet[4], and ChatGPT 4o[5]. The matter was compounded during COVID-19 when the isolated environments contributed to students' lack of motivation to study and learn, Y. Terada[6]. The academic misbehaviors are further described by P. Charlesworth et al.[7], M. M. Lanier[8] as well as by A. Fask et al.[9]. In effect, this creates grade inflation and possibly jeopardizes the academic integrity of the institution's program that could in turn dampen students' motivation.

One effective usage case of online learning is to provide multiple-attempt homework assignments where students are allowed to try their assignments multiple times while checking their answers as a method of learning[10,11], creating step-by-step scaffolds for the students to acquire knowledge and understanding[12]. The system provides a pathway to help students learn while they work their assignments out. Unfortunately, many students insincerely solve their assignments due to the availability of the websites mentioned above that provide quick solutions, such as Chegg[3] and others. Although this type of online learning modules developed by textbook publishers[10] can be very convenient in training students and helping them learn, they could also work against students' learning inadvertently as they rush through finishing and submitting their assignments on time, with the false hope to study later for the tests. This is exacerbated by the fact that some students lack the techniques to study effectively or prepare well for exams, as per Van den Broeck et al.[2].

This becomes more challenging for the instructor when faced with a *large class* with a wide spectrum of learners' backgrounds and capabilities, especially for fundamental courses such as Statics and Dynamics. It is already challenging to teach such a large, diverse class, and it is even more difficult to prepare a fair test to all levels of students, given this diversity. G. Herman[13] took the idea of MAT further to give students more than one chance per test, as opposed to the McGraw Hill assignments described above, and the results are promising. Nader et al.[14] have proven that MAT works effectively and successfully if done with the right conditions. One such condition is the use of the university testing center with cameras and proctors rather than remote testing to maintain academic integrity as done during COVID-19, discussed by Nader et al.[15]. In fact, such a testing center provokes the students to prepare better for their tests, knowing there is no tolerance for dishonest behavior[15]. MAT provides more options and opportunities to all levels of students in the same class. The method depends on the fact that each test, taken asynchronously, provides more than one attempt per test. In the case of Statics, two attempts were provided and in the case of Dynamics, three. Being conducted in the Evaluation and Proficiency Center (EPC)[16] via Canvas[17], each attempt is electronically and therefore, instantly graded. The students can then see their grades, after which they can physically meet their TA to verify their work and learn from mistakes before their subsequent attempt(s). Not all students require MAT, and those who do well do not need to do more attempts. Some are satisfied with only one attempt per test, or perhaps two for one of the tests during the semester. Nonetheless, those who need it continue working their grade up to as high as 100%, where possible. This ensures all students with their different academic standards and backgrounds can still do well in the fundamental courses under investigation, with better preparation before they are promoted to upper courses.

It is noteworthy to mention that the Dynamics course of Spring 2019, with 252 students, was not delivered with any MAT opportunities. However, to encourage all to do well, the students were made aware that their final grade was based on the best 2 out of 3 tests without the need of a final examination, i.e. any 2 tests the students pass out of 3 tests may get the students to pass the course. Yet, the Summer 2024 class of 177 students included MAT for all three tests and a final optional examination for those who wanted to improve their grades.

Along with MAT, Project-Based Homework (PBH) has been recently implemented in both Statics and Dynamics courses, with experimental engineering kits from PASCO Scientific[18], Arbor Scientific[19] and other products to support our students in their experiential learning. This type of PBH and class projects, have previously shown very encouraging results regarding class success, students' satisfaction, retention, and graduation rates as reported in[28,29,30]. The objective is to allow students to experience with their own eyes and hands the physical quantities of speed, acceleration, momentum, impact, internal forces, equilibrium, etc., given these products also come with computer software that allows the experimenter to see graphs of the just mentioned quantities and learn the natural behavior of things. Note also that these courses are delivered in a blended mixed-mode style, similar to Bishop & Verleger[20] and Scharlau et al.[21] where the students do some interactive assignments, such as Smart Book (SB), previously known as LearnSmart (LS) before they come to their weekly class lectures. There they clarify concepts with their instructor and solve more problems with him in class. After class the students become ready to solve harder and more challenging problems. Students are also be given some videos, based on the P.J. Cornwell et al.[22] textbook, created and provided by the instructor for the students to watch before the lectures. However, since this is a self-paced course, the students can still repeat watching these videos anytime they see convenient for them, as these videos are available 24/7.

The Testing Center

It must be emphasized that, had it not been for the Canvas digital examinations in combination with the EPC, MAT would not have worked out, at least not as well as it is conducted. Canvas facilitates the instantaneous examination corrections, while the EPC is equipped with 16 cameras and proctors that encourages students to study better and conduct themselves professionally. The EPC runs 12 hours per day from 9:00 am – 9:00 pm and during the final examinations period it operates extra hours on a Saturday from 9:00 am – 2:00 pm. It has over 120 stations with comfortable seats providing a less-stressful test ambiance. It has lockers where students leave their belongings behind before entering the examination hall. The EPC includes a small room attached to the examination hall with access to it, but it also has a separate door through which students can enter to meet their TAs and discuss their exams without disturbing other students who are taking their tests. Once a test attempt is over or a student finishes their test, scratch sheets are collected and scanned to be retrieved later by the TAs to pinpoint mistakes, where applicable, so that students can learn from them.

Course delivery

Engineering Dynamics

The Dynamics course is delivered in the blended mixed-mode similar to M. Nader & C.D. Dziuban[23] with pre-assignments such as video homework assignments for students to watch and interactive LS/SB assignments to be done before class. This is to ensure students are ready to ask conceptual questions and solve more rigorous problems in class with their instructor. For Summer 2024, the video homework assignments were converted to mini take-home quizzes with a 30-minute duration to ensure students watch the videos. In both Spring 2019 and Summer 2024, the lectures totaled 3.0 hours per week. Note in Spring 2019, students neither had the MAT nor PBH options, yet the better 2 out of 3 tests were considered.

As previously mentioned, the Summer 2024 MAT implementation was based on three attempts per test, and the students had two days to complete each attempt such that within six business days the test closed. Usually, the best attempt is considered as the test grade. Each attempt comes with variable types of questions, that include concepts, multiple drop-down, multiple-choice questions, T/F, and algorithmic problems, as per T. Tian & R. F. DeMara[24] and Marsh et al.[25] to create a fair and yet a thorough examination of the students. Problems are randomly pulled from large question banks, that have minimal chances to repeat, thus decreasing the chances of any grade inflation as in C.J. Lee[26]. These question banks are layered according to the difficulty level, i.e., each student gets a question or a problem from the same difficulty-level bank to ensure fairness to all. To clarify, different question banks have different difficulty levels such that each student gets the same amount of problems from that same questions pool of the same challenge level per attempt making the tests fair and acceptable by all students. Some banks are easy, others, have medium difficulty, and some are more challenging. Students are expected to do well in every attempt and as such a minimum threshold grade restriction is applied. If the student scores below that minimum grade on any attempt made for the first time, the average of all attempts will be used as the test grade, instead of selecting the best out of three attempts. With this strict rule, the students have been doing well. However, a mock test is provided as a review for each test such that the students could live the test experience at home. students are aware that these mock tests do not account for the course grade.

In the case a student is not satisfied with their grade for the first attempt, they can see their TA for clarification. This grants the students a better vision of their weaknesses and strengths, to enhance their knowledge and strengthen their weaknesses where necessary and devise a better learning strategy for a better grade. Students unsatisfied with their grade on all three tests can take a final exam that obliterates all three tests, provided that, they do better in it. Students see this as another option instead of withdrawing from the course, fully committed they end up taking this final resort to a successful pass. Thus, higher number of students are retained in the course. However, not all pass the final examination as it is cumulative that includes all the course material. Serious students take the opportunity to pass the three semestrial tests to concentrate on other courses during the final examinations period, thus reserving valuable time for those other courses. Another reason why a small percentage of the final examination participants pass it is because a few non-committed and having passed the course with the three semestrial tests take it non-seriously in the hope to perform better and improve their grade. However, the final examination is designed only

for those who prepare well to pass it. Realize that the final examination comes also with three attempts and the best attempt is kept as a final examination grade. No partial credit is given in any of the tests or the final examination, thus reducing complaints and negotiations to null. Other than the tangible benefits discussed above, MAT has many intangible benefits such as less students' anxiety, strong motivator instilling hope and achieving better grades, self-paced that provides a lot of opportunities for those who want to learn.

In Summer 2024 course, using the PASCO Scientific and Arbor Scientific products, a few PBH were created and given to the students to do, on average once every two weeks. Students were grouped, about four per team, and were given the instructions via Canvas. The day of the experiment, one TA has the students take the equipment out to an area within the university, where they assemble the parts together and conduct their experiments. These experiments take an average of an hour or two for each group to participate, to take pictures, create a 2-minute video, write a short report and submit their work via Canvas. As it is a large classroom, the university has much equipment to distribute to the students' groups, at the same time and the TAs roam about between groups while they conducts their experiments to direct them, and answer questions. Since the students seem to understand the concept well from experiential learning, more experiments will be implemented in the future. Although there is no statistics taken for this phenomenon, when asked in class most students agreed to have learned more and appreciated the experience.

Engineering Statics

For Spring 2023 two Statics courses incorporated PBH. One of the sections was delivered via face to face modality and the other was performed in a blended mixed-mode. Those 2 sections were compared with a Baseline created for Spring 2019.

Student Surveys

The authors prepared a student questionnaire survey to examine the students' perceptions of these high-impact practices, including the level of acceptability and appreciation at the beginning and end of the semesters. To investigate student perceptions, we conducted a survey in the Summer 2024 section of Dynamics focusing on perceptions of MAT and students' self-reported motivation, self-regulated learning (SRL), and test anxiety to further interpret the ways in which these HIPs might inform students holistically. The survey was administered at the beginning of the semester before the first test and towards the end of the semester around the test 3. After gaining IRB approval, students could choose to complete the survey for 1-point of extra credit. If students did not want to complete the survey, they could choose an alternative assignment that is equivalent to the same amount of time and effort. In doing so, we were able to include responses of those who chose to respond to the survey (Table 1). Questions regarding perceptions of multiple attempts were created by the professor on a scale from 1-5 (strongly disagree to strongly agree) to further develop best practices and identify the perceived efficacy of MAT in a course providing PBH (Table 1). Self-reported motivation was investigated through the lens of self-efficacy, or the belief that a student is able to accomplish the goals set before them as per Freeman[28], using the General Self-Efficacy (GSE) Scale ($.76 \leq \alpha \leq .90$) of Chen et al.[32], which provides a range of 1-4 [Not True at All (1), Hardly True (2), Moderately True (3), and Exactly True (4)] with a sum score for the

measure, and the total was divided by 40 to provide a continuous percentage score for GSE. A higher score indicates higher general self-efficacy.

SRL refers to the cyclical process in which an individual sets goals, plans, performs, and reflects on their own learning to adapt within a learning environment described by P.H. Winne & A. F. Hadwin[33]. MAT and PBH allow for students to engage with the material overtime and reflect on their own learning needs, providing opportunities for students to foster SRL, leading to improved learning outcomes as per P.H. Winne & R. Azevedo[34]. Additionally, we anticipate that providing MAT and PBH decreases test anxiety because students can engage with the material multiple times in these challenging courses. To investigate SRL and test anxiety, we utilize two distinct subscales of the Motivated Strategies for Learning Questionnaire (MSLQ) (Metacognitive Self-Regulation Scale: α=.79; Test Anxiety Scale: α=.80, as in Fang et al.[35]. The MSLQ is on a scale from 1-7 [Not true at all of me (1) to Very true of me (7)]. The higher scores indicate greater use of metacognitive self-regulated learning strategies and higher reported test anxiety for the metacognitive self-regulation scale and test anxiety scale, respectively. The scores for the MSLQ are then averaged.

To investigate student overall perceptions of MAT, we used 10 researcher-developed questions that asked them to respond to questions about the MAT on a scale from 1-5 [Strongly disagree (1) to Strongly agree (5). Therefore, a higher score indicates more positive perceptions of MAT. All survey questions can be found in Appendix A. It is important to note that they all use different scales because with the exception of the perceptions of MAT, that was developed by the researchers, these scales have previously been developed and validated (see reliability metrics above). Therefore, we decided not to change the scales so as not to compromise the reliability and validity of the measures. Additionally, when using different scales, this better ensures students are paying attention to the questions because the scales are different.

First, descriptive statistics were conducted to identify the overall perceptions of the practices and their self-reported motivation, SRL and test anxiety. Then, we wanted to identify whether these perceptions and self-reported responses changed over the course of the semester by conducting a paired *t*-test with the results to investigate the mean differences between entry and exit survey responses (see Results).

Measure		**Minimum Observed Score**	**Maximum Observed Score**	**Mean**	**SD**
Multiple Attempt Testing Perceptions (1-5 scale)	Entry	1	5	4.04	.602
	Exit	1	5	4.02	.749
General Self-Efficacy (GSE) (1-4 scale)	Entry	.50	1.0	.788	.106
	Exit	.45	1.0	.799	.122
Self-Regulated Learning (SRL) (MSLQ) (1-7 scale)	Entry	2.83	7.0	4.65	1.04
	Exit	2.25	6.58	4.54	1.03
Test Anxiety (MSLQ) (1-7 scale)	Entry	1.4	7.0	4.96	1.44
	Exit	1.83	7.0	4.56	1.31

Table 1. Descriptive statistics of perceptions of MAT, GSE, SRL, and test anxiety for entry and exit surveys. Please see Appendix A with all survey questions. Scales fot each survey are also described in the text above.

Results

Dynamics

We will keep our comparison simple between Spring 2019 and Summer 2024, as the courses approaches are different. Therefore, a fair and easy view or understanding on which approach produces better results is to consider the final successes in each course. As such, we will look at each approach separately, and *then* we will compare the results.

Table 2 illustrates the results for Dynamics of Spring 2019, Nader et al.[27]. These results are based on taking the best 2 out of 3 tests, which discouraged many students to do T3 when knowing they already passed the course with the first two tests, T1 and T2. This is confirmed with the low percentage participants of 38% from 95% in both of T1 and T2, based on the number of students in class. Note that the 95% is based on the total number of students in class as a basis for comparison between the number of participants in T1, T2 and T3 in the case for the Single Attempt Testing (SAT).

	T1	T2	T3
Class Average	61%	63%	53%
No. Student Success >70%	48%	50%	19%
Participants per class	95%	95%	38%

Table 2.: Class Average and Success Rates for Dynamics Spring 2019[27]

Let's close our eyes to the comparison of the overall success rate with Summer 2024, but instead focus our attention on the MAT and PBH results progressively. Table 3 shows the increasing progress for each attempt. For example, in the first attempt (A1) of the first test (T1), the class average is 48% which increases to 66% in A3 with an overall class average 71%, given the best attempt is retained. Similarly, the success rate increases from 16% in A1 to 43% by A3 with an overall success rate of 51% for T1. The participants included in Table 3 for MAT is based on the number of students attempting the test for the first time, A1, which is the same number of students in class for each of T1 and T2. Certainly, this comes with an adjustment in the attempts, i.e. when some students take A2 while attempting the test for the first time, that attempt counts as A1 for that student. This is a fair comparison as the student is attempting the test for the *first time* and *not* for the *second* or *third*. A similar adjustment is done when they do A3 when it should be A2 for them. The percentage participants shows that less and less students attempt the test for a third time. A fair comparison is then to use the number of participants of A1 as a basis for the amount of students doing the following attempts of that test by which we can assess how many less and less students participate in that test. This is not exactly the case for the SAT where we compare each test to the basis of the number of students in class. After all A1 often has the same number of students as the number of students in class, especially in the case of T1 and T2. For example, one can notice the decrease in the participants percentage from 100% down to 63% in A3 for T1, given the satisfied students do not continue with more attempts. This trend is obvious for all tests. Yet, again T3 has the lowest average and success rates similar to the Spring 2019 trend. Some students already passed the course by the first attempt of T3 so they are satisfied even with a lower, but passing grade, so they refrain from trying harder for a better grade in another attempt for the same T3. Others gave up on T3 altogether, knowing they failed the semestrial tests and decided to go for the final examination in compensation for all the tests in the hope to eventually pass the course.

	T1				T2				T3			
	A1	A2	A3	Best of 3 Attempts	A1	A2	A3	Best of 3 Attempts	A1	A2	A3	Best of 3 Attempts
Class Average	48%	60%	66%	71%	47%	58%	63%	68%	42%	50%	55%	53%
Student success >70%	16%	34%	43%	51%	16%	37%	44%	51%	8%	17%	26%	22%
Participants per A1	100%	90%	63%	100%	100%	80%	53%	100%	100%	61%	32%	100%

Table 3.: Percentage Class Average, Success Rates and Participants for Dynamics Summer 2024

The final examination results are presented in Table 4. There is always some students who need to take the final optional exam to improve their grades. We see the overall improvement that 17% of those who tried the final exam passed it, given there are not too many in the course who need to improve their grades, who also prepare well for the final exam.

	Final Examination			
	A1	A2	A3	Best of 3 Attempts
Class Average	37%	45%	50%	47%
Student success >70%	5%	13%	17%	17%
Participants per A1	100%	78%	52%	100%

Table 4.: Class Average, Success Rates, and Participants for Dynamics Summer 2024 Final Exam with 3 Attempts

It is important to note that in the case of Spring 2019, MAT and PBH were not implemented, but 2 out of 3 tests was a curving technique used to help the students and most students have ignored T3 which was about 3D dynamic. However, in Summer 2024 students completed the course material with MAT and PBH. This brings us to the stage where we want to look at the overall results of the course given the added intervention of PBH apart from MAT that was already implemented in Spring 2023[27] with 167 Students whose results are shown in Table 5. In comparison to that of Spring 2019, one notices the high improvement in the number of As and Bs, the overall success and the decrease in DFW. For example, the passing rate was 80% versus 67% between Spring 2023 vs Spring 2019, respectively leading to $\left(\frac{80-67}{67}\right)\% = 20\%$ improvement. However, when we look at Table 6 based on the results of implementing both MAT as well as PBH, we notice yet another increase in students' success by an extra 1% as calculated in Table 7, i.e., $\left(\frac{81-80}{80}\right)\% = 1\%$. There is also another increase which is in the percentage of As and Bs, i.e. from 66% (Spring 2023, Table 5) to 68% (Spring 2024, Table 6), or $\left(\frac{68-66}{66}\right)\% = 3.6\%$, within an approximation error. Table 7 summarizes the improvements between Spring 2019 to Spring 2023 with the intervention of MAT only and between Spring 2019 and Summer 2024 with both MAT and PBH. It also compares the success improvements with the added PBH to MAT, i.e. the results between Spring 2023 and Summer 2024. Retention between Spring 2019 and Spring 2023 is $\left(\frac{33-20}{33}\right)\% = 40\%$, and between Spring 2019 and Summer 2024 $\left(\frac{33-19}{33}\right)\% = 42\%$, as in Table 7. Note also the 4% increase in the course retention between the two semesters.

Dynamics Spring 2019 - 252 Students					Dynamics Spring 2023 -167 Students				
Grades	No. Of Students	Class Percentage			Grades	No. Of Students	Class Percentage		
A	45	18%			A	54	32%		
B	65	26%	**44%**	**As&Bs**	B	56	34%	**66%**	**As&Bs**
C	58	23%	**67%**	**Pass**	C	24	14%	**80%**	**Pass**
D	20	8%			D	10	6%		
F	48	19%			F	11	7%		
W/WM	16	6%	**33%**	**DFW**	W/WM	12	7%	**20%**	**DFW**

Table 5.: Overall Results Comparison between 2019 and 2023 Dynamics Courses[27]

Dynamics Summer 2024 -177 Students				
Grades	No. Of Students	Class Percentage		
A	66	37%		
B	55	31%	**68%**	**As&Bs**
C	22	12%	**81%**	**Pass**
D	12	7%		
F	8	5%		
W/WM	14	8%	**19%**	**DFW**

Table 6.: Overall Results for Summer 2024 Dynamics Course

	SP2023 vs SP2019	**SU2024 vs SP2019**	**SU2024 vs SP2023**
As&Bs Improvement	51%	57%	3.6%
Overall Pass Improvement	20%	21%	1.0%
Retention increase	**40%**	**42%**	**4.0%**

Table 7.: Overall Results Comparisons for three semesters: Spring 2019, Spring 2023 & Summer 2024 for Dynamics Course

Statics

For the semesters included in this study, MAT wasn't introduced yet to Statics. The results showed correspond only to the inclusion of PBH into the course.

Project- Based Homework:

A Baseline was created using all the Statics sections taught in Spring 2019, in which 340 students belonged to Mechanical and Aerospace engineering. The final grade scores for this baseline is as follows: 36 students obtained A (10.59%), 118 got B (34.71%), 96 C's (28.24%), 30 D's (8.82%), 27 F's (7.94%), and 33 W's (9.71%). The % of Success (Students with ABC) was 74% and the percentage of failure (DFW) was determined to be 26% as in Table 8.
In Spring 2023, 2 sections were taught including PBH, one face to face (F2F) and the other as blended mixed mode. For the Spring 2023 – F2F, 76 students belonged to Mechanical and

Aerospace engineering. The final grade scores for this baseline is as follows: 31 students obtained A (40.79%), 27 got B (35.53%), 13 C's (17.11%), 2 D's (2.63%), 1 F's (1.32%), and 2 W's (2.63%). The percentage students' success rates (Students with ABC) were 93% and the percentage failure (DFW) was determined to be 7% as in Table 8.

Statics Spring 2019 (Baseline)					Statics Spring 2023 (Face to Face)				
Grades	No. Of Students	Class Percentage			Grades	No. Of Students	Class Percentage		
A	36	10.59			A	31	40.79		
B	118	34.71	**45%**	**As&Bs**	B	27	35.53	**76%**	**As&Bs**
C	96	28.24	**74%**	**Pass**	C	13	17.11	**93%**	**Pass**
D	30	8.82			D	2	2.63		
F	27	7.94			F	1	1.32		
W	33	9.71	**26%**	**DFW**	W	2	2.63	**7%**	**DFW**

Table 8. Overall Results Comparison between Spring 2019 and Spring 2023 F2F Statics Course

In addition, the results for Spring 2023 - Blended mixed-mode, 79 students belonged to Mechanical and Aerospace engineering. The final grade scores for this baseline is as follows: 12 students obtained A (15.19%), 23 got B (29.11%), 31 C's (39.24%), 2 D's (2.53%), 5 F's (6.33%), and 6 W's (7.59%). The percentage students' success rates (Students with ABC) was 84% and the percentage failure (DFW) was 16% indicated in Table 9.

Statics Spring 2023 Blended M-Mode				
Grades	No. Of Students	Class Percentage		
A	12	15.19		
B	23	29.11	**44%**	**As&Bs**
C	31	39.24	**84%**	**Pass**
D	2	2.53		
F	5	6.33		
W	6	7.59	**16%**	**DFW**

Table 9. Overall Results Spring 2023 M-Mode Statics Course

As can be observed in Table 10 the percentage of A's and B's Increased from 45.3% to 76.3%. This represents an overall increase of 68.4% and for the section taught in Mixed mode was virtually the same as the baseline. However, the overall class success increased from 73.5% for Spring 2019 to 93.4% for the F2F Section of Spring 2023 which translates to 27.1% of pass improvement (Table 10) and to 83.5% for the mixed mode section on Spring 2023 corresponding to 13.6%.

	SP2023 F2F vs SP2019	SP2023 Mixed vs SP2019
As&Bs Improvement	68.4%	0%
Overall Pass Inprovement	27.1%	13.60%

Table 10. Overall Results Comparisons for Spring 2019 and Spring 2023

Survey Results

A self-report survey was administered at the beginning and towards the end of the Summer 2024 term for a Dynamics course utilizing MAT and PBH. Results from the descriptive statistics suggest that there was not much change throughout the semester, rather, MAT was perceived as being beneficial for student learning. Additionally, self-reported self-efficacy, SRL, and test anxiety seemed to be similar at the beginning and end of the semester. To investigate further, a paired *t*-test was conducted with 81 students (n=81) voluntarily deciding to respond to both the entry and exit surveys. Results of the paired *t*-test reveal no significant differences between the average perception of MAT at the beginning and end of the semester, consistent with students' expressions within the course and interviews describing their appreciation and benefits regarding MAT (Table 10). Rather, the paired samples correlations were statistically significant (r=.229, p<.05). The results according to Table 1 suggest, on average, students agree that multiple attempt testing is efficacious at both the beginning and end of the semester.

Self-efficacy, SRL, and test anxiety also did not change significantly over the semester, either, but they were also correlated in the paired samples (self-efficacy: r=.601, p<.001; SRL: r=.667, p<.001; test anxiety: r=.672, p<.001) (Table 11). The relationship between entry and exit directs us towards the descriptive statistics to identify how self-efficacy, SRL, and test anxiety might have been reported similarly throughout the semester. For self-efficacy, students reported an average of .78-.79 throughout the semester, suggesting a medium to strong belief that they would be able to accomplish the goals set before them. As many of these students are second and third years, these results are promising as students are reporting that they believe in their capacity to accomplish their academic goals. SRL was reported as an average of 4.6 at the beginning of the semester, and a 4.5 at the end out of 7 (Table 1). These data suggest that a single semester might not be able to increase self-reported SRL, but these practices impact their scores on tests in the short term, pointing us to investigate these results overtime in the future. Finally, test anxiety was similarly reported with an average of 4.5 out of 7 at the beginning and end of the semester (Table 1). We anticipated that test anxiety would statistically significantly decrease. However, as myriad variables can attribute to the presence of test anxiety, we hope that the implementation of these practices overtime can mitigate self-reported test anxiety in the future. As we have demonstrated the positive impacts of MAT and PBH on test scores, we hope to identify ways in which these practices impact self-efficacy, SRL, and test anxiety in the future by exploring these processes in different contexts and overtime.

Pairwise Comparisons				**Paired Samples *t*-test**		
Measure	***N***	***r***	***p***	***df***	***t***	***p***
Multiple attempt testing	81	.229	.04*	80	.185	.427
General self-efficacy	81	.601	<.001**	80	-1.026	.154
SRL	81	.667	<.001**	80	1.20	.117
Anxiety	79	.672	<.001**	78	.234	.408

Table 11. *t*-test of entry and exit responses

Discussion & Conclusion

It is obvious the concept of MAT supported by PBH methodology creates yet even more success and higher students' retention in the course on top of its laying out more motivational conditions that encourages the students to study, learn and do well. It is a self-paced step-by-step method that leads the students in the right direction by scaffolding and overcoming difficulties towards success. The success rates in dynamics increased by 21% not to mention it opens the door for more learning, more concepts as in Summer 2024 compared to the 2 out of 3 test curving that delaminated some students from T3. The hope that MAT strengthens the perseverance in students with a goal to finish the course till the end. Thus, minimizing the withdrawal rate by far and decreasing the overall unsuccessful rate, especially with the optional final examination. The intervention combined effect increased the As and Bs to 57%, with a 42% higher retention in the course.

The PBH added to the Statics courses studied, demonstrated very significant improvement in the class success of 27.1% and 13.8%. Additionally, PBH creates an enjoyable experiential learning atmosphere that permits the students to see, sense and better understand what they learn in class with a practical approach, rather than a simplistic conceptual lecture-based style. The active learning of touching and working on real world problems better prepares the learners to solve more complicated problems, given the knowledge gained by the experimental experience, especially before doing the tests. Other benefits of PBH are the communications between the students and the social interactions while working in groups that helps them to create a sense of belonging and develop them positively in their junior years instead of waiting till their final Senior Design course. These preparations and the different skills development is intangible, yet they impart positive critical thinking in the learners while they progress in their university years of education.

While all the above lead to students' success and students' retention in the courses, students also enjoyed the experience as per the students' questionnaire survey. Most students confirmed that this method is agreeable and hope to see it in other future courses. Future directions include specifically investigating the perceptions of PBH over the course of a semester in a class that offers MAT. Additionally, we will analyze interviews conducted to investigate how students describe their perceptions of MAT and PBH, as well as how they self-describe their study habits (e.g., SRL) and motivation. By utilizing interviewing for a qualitative lens, we anticipate uncovering a more nuanced understanding of how these HIPs impact students' holistically to further improve success rates.

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Appendix A: Survey Questions

I. Perceptions of Multiple Attempt Testing

Please rate the following questions about multiple test attempts on a scale from 1-5, where 1 means "Strongly disagree" and 5 means "Strongly agree."

1. Helped me take the test with less stress, knowing I have other chances.
2. Allowed me to go back to learn the material better before my next attempt.
3. Gave me the opportunity to know where I stand in the course before my next attempt.
4. Gave me the chance to recognize how much more I should study before my next attempt.
5. Gave me the chance to repeat just the test instead of repeating the entire course.
6. Allowed me to do better in the course.
7. Was not helpful because no matter how much I tried, I still got the same grade [reverse coded]
8. The fact that I could go back and ask about a problem I saw in the test to study it before my next attempt advanced my knowledge of the subject, even though I knew it might not show up in my next attempt.
9. I learned a great deal with this testing method, irrespective of my grade.
10. In the future, I hope to see more courses offered with 3-test attempts that allow a full week to complete.

II. General Self-Efficacy (Chen et al., 2001)

Indicate for each statement below how true it is for you. For each item, please answer using the following scale: 1-4, where 1 is "Not true of me at all" and 4 is "Exactly true."

1. I can always manage to solve difficult problems if I try hard enough.
2. If someone opposes me, I can find the means and ways to get what I want.
3. It is easy for me to stick to my aims and accomplish my goals.
4. I am confident that I could deal efficiently with unexpected events.
5. Thanks to my resourcefulness, I know how to handle unforeseen situations.
6. I can solve most problems if I invest the necessary effort.
7. I can remain calm when facing difficulties because I can rely on my coping abilities.
8. When I am confronted with a problem, I can usually find several solutions.
9. If I am in trouble, I can usually think of a solution
10. I can usually handle whatever comes my way.

I. Motivated Strategies for Learning Questionnaire – Metacognitive Self-Regulation Scale (Pintrich et al., 1991)

Please rate the following items based on your behavior in this class. Your rating should be on a 7-point scale where 1 = "not at all true of me" to 7 = "very true of me."

1. During class time I often miss important points because I'm thinking of other things.
2. When reading for this course, I make up questions to help focus my reading.
3. When reading for this course, I make up questions to help focus my reading.
4. If course materials are difficult to understand, I change the way I read the material.
5. If course materials are difficult to understand, I change the way I read the material.
6. If course materials are difficult to understand, I change the way I read the material.
7. If course materials are difficult to understand, I change the way I read the material.

8. I often find that I have been reading for class but don't know what it was all about.
9. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.
10. When studying for this course I try to determine which concepts I don't understand well.
11. When studying for this course I try to determine which concepts I don't understand well.
12. If I get confused taking notes in class, I make sure I sort it out afterwards.

II. Motivated Strategies for Learning Questionnaire – Test Anxiety Scale (Pintrich et al., 1991)

Please rate the following items based on your behavior in this class. Your rating should be on a 7-point scale where 1 = "not at all true of me" to 7 = "very true of me."

1. When I take a test, I think about how poorly I am doing compared with other students.
2. When I take a test, I think about items on other parts of the test I can't answer.
3. When I take tests, I think of the consequences of failing.
4. I have an uneasy, upset feeling when I take an exam.
5. I feel my heart beating fast when I take an exam.

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