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Improving Student Success, Retention, and Equity in Engineering Statics and Dynamics Using Experiential Learning Modules and Mastery Based Grading

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Improving Student Success and Equity in Engineering Statics and Using Experiential Learning Modules and Mastery Based Grading (Work in Progress)

Abstract

It is common knowledge that engineering mechanics courses in Statics and Dynamics often serve as “gatekeepers”, delaying or preventing many students from progressing towards an engineering degree. In Fall 2019, to address unfavorable DFW rates, the department implemented a one hour lab session in each course to provide additional practice on key concepts. Within the lab section, faculty lead directed problem solving to supplement the weekly lessons. Additionally, an upperclassman Student Instructor is assigned to the course to provide a second person in the classroom to assist during the problem solving assignments.

In Fall 2021, mastery based assessments were introduced in Statics to switch from using primarily exam assessments to using a series of weekly implemented mastery based assessments. Mastery based learning has seen growing adoption in higher education and is recognized as a culturally responsive pedagogical approach. Mastery based assessments were also used in Dynamics during the Spring 2023 and Fall 2023 semesters.

In Spring 2022, experiential learning modules were introduced to both Statics and Dynamics labs to provide hands-on experiments to aid students’ comprehension of select problems. The implementation builds upon previous work of using adaptive 3D coordinate models to facilitate hands-on experiential problem-solving in group laboratory sessions. In the first phase of the project, the authors sought to develop and construct the physical units to use in the modules and to identify the topics in the courses the modules should cover. In the second phase of the project, the authors have worked with other faculty teaching the courses to implement the experiential learning modules. These experiential learning modules have continued in the Statics course and have been used intermittently in Dynamics.

The following paper will document assessment results over the last 9 years from the beginning of the Statics course at the institution through the subsequent implementation of the (i) additional lab, (ii) mastery based assessments, and (iii) experiential learning modules. Departmental data from Statics will be reviewed for student success rates. Course equity data will be presented using a proportionality index to see if these changes have led to disproportionate improvements for underrepresented students, particularly for Latinx/é students at a Hispanic Serving Institution.

Background- DFW Data for Statics and Dynamics

Engineering mechanics courses are the fundamental courses for mechanical and civil engineering students that build the foundation to be able to analyze and design a system that is at rest (Statics) and in motion (Dynamics). Thus, these courses serve as a prerequisite for many upper-level engineering courses in most universities; however, high drop-out rates in Statics and Dynamics are widely reported [1], [2].

From 2016-2024, the David L. Hirschfeld Department of Engineering at Angelo State University has internally examined the DFW rate (percentage of total students receiving a grade of D or F or Withdrawing from a course), particularly in foundational courses typically taken in the students' first two years of the program. Table 1 summarizes the results.

Following the completion of Statics and Dynamics, anecdotal evidence suggests most students go on to successfully complete the Bachelor of Science degree requirements for the civil and mechanical engineering programs. Therefore, it is imperative for the continued success of the programs to increase success amongst students taking these courses, forming the impetus for the proposed changes documented within this paper.

Table 1: DFW Data for Engineering Mechanics- Statics Course at Angelo State University

ENGR 2301: DFW Data		
Semester	**Enrollment**	**DFW Rate**
Fall 2016	32	43.8%
Spring 2017	15	13.3%
Fall 2017	22	-
Spring 2018	23	21.7%
Fall 2018	27	48.1%
Spring 2019	31	45.2%
1 Hour Lab Session Added to Course		
Fall 2019	30	60.0%
Spring 2020	28	42.9%
Fall 2020	19	52.6%
Spring 2021	23	43.5%
Mastery Based Assessments Added to Course		
Fall 2021	26	15.4%
Experiential Learning Modules Added to Course		
Spring 2022	18	0.0%
Fall 2022	21	19.0%
Spring 2023	19	21.1%
Fall 2023	23	13.0%
Spring 2024	19	21.1%
Fall 2024	24	16.7%

Based on the data shown, it is observed the DFW rate before any interventions varied from 13.3% to 48.1%. Following the first intervention, improvement was not observed, with DFW rates increasing to 42.9% – 60.0%, which motivated the faculty to implement additional interventions to address the issues. After implementing mastery-based assessments and experiential learning modules, the DFW rate significantly decreased to an average of 15.2%, indicating that these combined interventions were effective in improving student success.

Course Equity Data by Proportionality Index

Moreover, as a Hispanic Serving Institution, it is a culturally responsive practice to review course outcomes and grades disaggregated by ethnicity to ensure that all demographics are achieving similarly [3], [4]. Using a proportionality method, the course equity index can be calculated for a course in a given semester. The mathematical model proposes that if 25% of students in the class obtain the grade of 'A', then 25% of any subcategory, such as Latinx students, will also achieve the grade of 'A'. If this is exactly the case, then the course equity index will be 1.0. Otherwise, the values will depart from 1.0, meaning that there are disproportionate outcomes occurring in the course and therefore, faculty should work to improve these inequities.

Course equity data is presented and discussed in the section titled "Proportionality Index for Hispanic Students".

Intervention- Lab Session for Problem Solving

Motivation

Like many universities, Angelo State University has found that Statics and Dynamics are bottleneck courses in our engineering curriculum. There are a number of reasons for this. They are the first really demanding engineering course students face. They are expected to demonstrate mastery of prerequisite topics in physics, trigonometry, and calculus. These courses also come at a point where students are not yet fully mature in their learning and academic skills. All of these characteristics contribute to the difficulty of these courses. Faced with the demands of these courses, there are two broad approaches a program can take. They can be treated as gatekeeper courses, where the focus is on weeding out those students who do not demonstrate the required learning outcomes, or they can be treated as gateway courses, where the focus is on supporting the students to gain competency in the required learning outcomes. Angelo State has adopted a gateway approach to these courses. The purpose of the lab sessions is twofold. First, to provide hands-on tactile learning experiences to complement the mathematical and analytical approach of lectures. Secondly, to model the out-of-class problem solving that we expect students to be able to do on their own.

Description

There are twelve to thirteen lab sessions each semester. The first session is a math review designed to evaluate and refresh students on essential math skills for Statics. Of the twelve to thirteen lab sessions, four are hands-on activity sessions focused on 2D particle equilibrium, distributed loads, friction, and 3D static equilibrium. These hands-on sessions allow students to connect theory with application, enhance their conceptual understanding, and engage more deeply with the course materials. The remaining lab sessions are problem-solving sessions, covering topics such as vector operations, forces along a line and free body diagrams, moment computations, rigid body equilibrium, truss analysis, machinery and frames, internal forces, drawing internal force diagrams, and moment of inertia. In addition to regular lecture classes,

students have opportunities to tackle more Statics problems and ask questions to the Student Instructor (SI) and the faculty instructor freely.

Student Reception

The lab session enables students to spend more time tackling Statics problems and working collaboratively as a team. It fosters a more interactive environment, free from the pressure of completing assignments during lab hours. As a result, students can approach the assigned problems at their own pace. During the lab session, students engage with the problems and discuss their solutions with peers, sharing thoughts on problem-solving strategies. Some students take on teaching roles, which reinforces their understanding of concepts. In hands-on activity sessions, they exchange a variety of ideas related to the assigned problems. A tangible hands-on model allows them to demonstrate different static conditions, often leading to those enlightening "aha" moments with the models. Overall, students enjoy lab sessions and make the most of them to succeed in Statics class. Some students hesitate to attend office hours or SI sessions due to time conflicts and feelings of discomfort when alone with the instructor. Thanks to the more interactive environment, they also use the lab session to ask various Statics questions

Intervention- Mastery Based Assessments

Motivation

Mastery-based assessments in Statics and Dynamics are the second feature of the gateway approach to these classes. Mastery-based assessment addresses two major shortcomings of traditional high-stakes assessment. It significantly decreases the importance of test-taking skills in evaluating student achievement of outcomes. Secondly, it supports deep conceptual understanding and skill in problem-solving, rather than just focusing on immediate results. We have observed students who passed traditional exams in Statics and/or Dynamics being unable to demonstrate the basic concepts of these courses in later courses. The mastery-based assessment forces students to demonstrate mastery of each learning outcome rather than just achieving a satisfactory score on a time limited exam. This significantly improves the students' ability to master the essential concepts of Statics and Dynamics [5], [6].

Description

The mastery-based assessment structure used in Statics at Angelo State University is adapted from the model developed by Papadopoulos et al. [5]. The most current version of this structure is outlined in Table 2, which details the mastery levels, associated topics, homework assignments, and prerequisites for each level. The mastery system is organized into four levels: D, C, B, and A. For instance, to earn a minimum grade of C in the course, students must successfully complete all tasks at the D and C levels, meaning that the student has shown mastery of the concept by completing each task without error. If errors are observed, the student must go back to the concept, and demonstrate mastery by completing a new problem related to the topic or for smaller errors, fix their existing work until it meets the standard. Unlike traditional grading systems, the mastery approach does not rely on weighted averages; instead,

grades are determined solely by the level of mastery each student demonstrates. More information on grading is provided in the next subsection.

Table 2: The Overall Structure of Mastery Tests

Grade Level	Topic	Prerequisite
D1	Vector addition	HW 1 & 2 Submitted
D2	Free body diagram (FBD) of a single body	HW 3 submitted
D3	FBD of concurrent forces	D2 complete, HW 3 submitted
D4	Particle equilibrium (concurrent forces)	D3 complete, HW 3 submitted
D5	Moment calculations	D3 complete, HW 4 submitted
D6	Equilibrium of rigid bodies	D3 complete, HW 5 submitted
D7	Concept question quizzes 1-12: 80% submitted	None
C1	FBDs of connected bodies	D3 complete, HW 5 submitted
C2	Trusses: method of joints	D6 complete, HW 6 submitted
C3	Trusses: method of sections	D6,7 complete, HW 6 submitted
C4	Frames	D6,7& C1complete, HW 7 submitted
C5	Concept question Quizzes 13-16: 75% submitted	None
B1	Beams/internal reactions	All D & C1 complete, HW 8 submitted
B2/B3	Centroids & moment of inertia	All D & C1 complete, HW 9 submitted
B4	Project	None
B5	Concept question Quizzes 17-21: 75% submitted	None
A1	Friction	All C complete, HW 10 submitted
A2/A3	3D equilibrium	All C complete, HW 11 submitted
A4	Concept question Quizzes 22-27: 75% submitted	None

At the D level, there are six tests: D1 – vector addition, D2 – free body diagram (FBD) of a single body, D3 – FBD of concurrent forces, D4 – particle equilibrium (concurrent forces), D5 – moment calculations, and D6 – equilibrium of rigid bodies. The C level includes four tests: C1 – FBDs of connected bodies, C2 – trusses: method of joints, C3 – trusses: method of sections, and C4 – frames. The B and A levels each include two tests: B1 – beams/internal reactions, B2/B3 – centroids and moment of inertia, A1 – friction, and A2/A3 – 3D equilibrium.

To take each mastery test, students must submit homework assignments, which allow them to practice beforehand. They must also complete specific mastery tests to advance to the next level, meaning they cannot take C level tests without finishing specific D level tests, for example.

In addition to the tests, each level has other requirements. To pass each level, students must complete concept questions (pre-class quizzes) assigned before the class. These concept question completions are D7, C6, B5, and A4. At the B level, there is one unique assignment: a group project. Students must complete the group project if they want to achieve a B in the Statics class. This project is intended to give students an opportunity to apply the principles of Statics to a simple real-world structure. It is a team project where each team selects a structure to analyze and performs static analysis. Teams write a report and present a 5-minute in-class presentation on their analysis of the structure.

Implementation

At present, the mastery tests in the course are available to the students twice per week on days and during a timeframe agreed upon by the instructor and the students. The Mastery Tests are administered through Respondus Lockdown Browser in Blackboard. Students should find a quiet room away from others, log into Blackboard, select the available Mastery Test, and complete the exam while being recorded. After completing their work, students enter selected answers into Blackboard. They must then scan and submit their problem work into Gradescope within 10-15 minutes, where the instructor will grade and provide feedback. By limiting time availability, it is hoped that the students have fewer opportunities to take the Mastery Tests and then share the information with any other student. In addition, the instructor needs time to grade the submissions, as some Mastery Tests depend on the completion of prior Mastery Tests or Homework assignments.

When grading, the instructor has three options for scoring the Mastery Tests:

- 0/2: The student has not mastered the content. The student will need to try the next version of the test.
- 1/2: The student had minor errors. The instructor provides feedback and the student must address the feedback and re-post the revised solution to Gradescope until it meets the standard.
- 2/2: The student has mastered the concept.

The instructors have developed numerous versions of the Mastery Tests, ranging from 3 to 9 different versions for each concept. Figure 1 provides an example of 3 of the 7 different versions for Mastery Test D6: Equilibrium of rigid bodies in which students must solve for applicable support reactions. Within each version, each student will be randomly assigned different problem ID numbers, which correspond to different values for the variables in the problem. The instructors have developed extensive spreadsheets to help with grading the various possible solutions. See Figure 2 for a sample of the spreadsheet used to calculate the answers for 16 different sets of assigned variables, randomly displayed to each student.

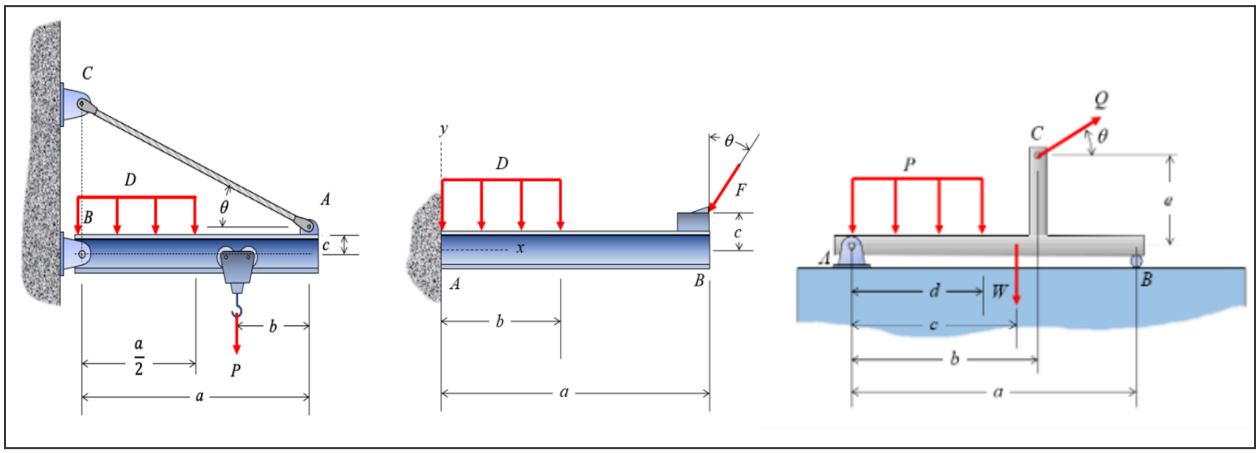
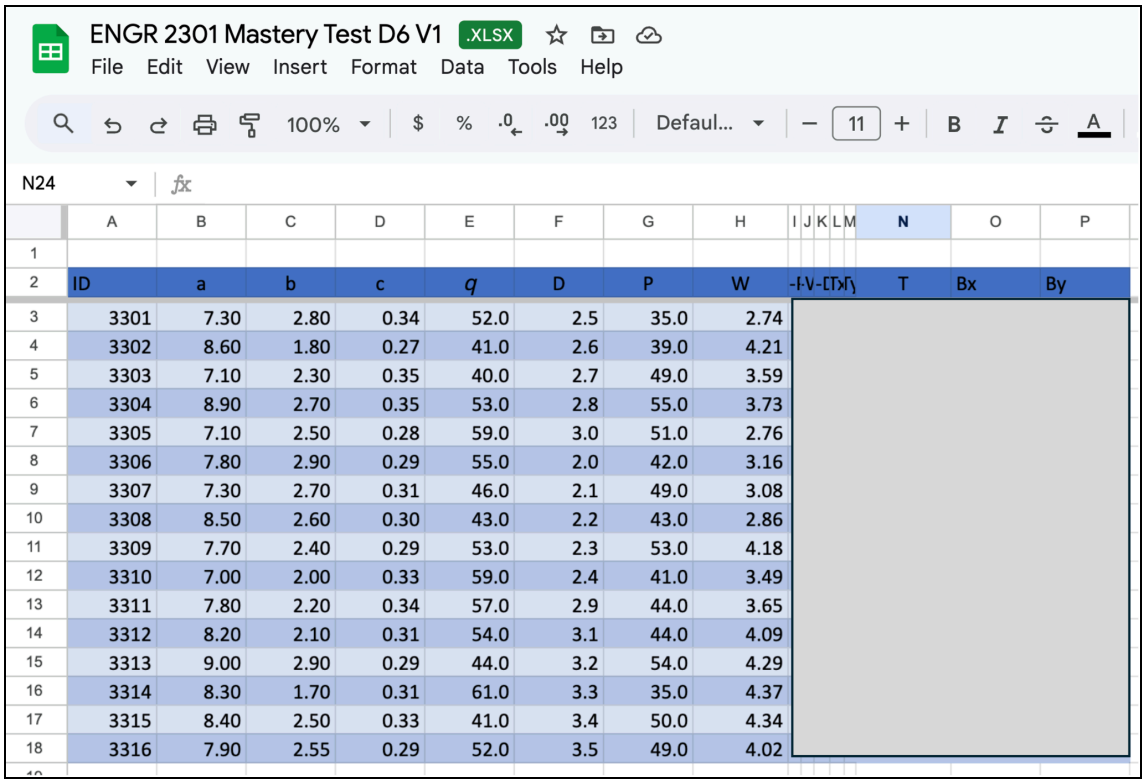


Figure 1: Problem Graphic for Mastery Test D6: Equilibrium of Rigid Bodies Versions 1, 2, and 3



	A	B	C	D	E	F	G	H	I J K L M	N	O	P
1												
2	ID	a	b	c	*q*	D	P	W	-I-V-[T›Γ\	T	Bx	By
3	3301	7.30	2.80	0.34	52.0	2.5	35.0	2.74				
4	3302	8.60	1.80	0.27	41.0	2.6	39.0	4.21				
5	3303	7.10	2.30	0.35	40.0	2.7	49.0	3.59				
6	3304	8.90	2.70	0.35	53.0	2.8	55.0	3.73				
7	3305	7.10	2.50	0.28	59.0	3.0	51.0	2.76				
8	3306	7.80	2.90	0.29	55.0	2.0	42.0	3.16				
9	3307	7.30	2.70	0.31	46.0	2.1	49.0	3.08				
10	3308	8.50	2.60	0.30	43.0	2.2	43.0	2.86				
11	3309	7.70	2.40	0.29	53.0	2.3	53.0	4.18				
12	3310	7.00	2.00	0.33	59.0	2.4	41.0	3.49				
13	3311	7.80	2.20	0.34	57.0	2.9	44.0	3.65				
14	3312	8.20	2.10	0.31	54.0	3.1	44.0	4.09				
15	3313	9.00	2.90	0.29	44.0	3.2	54.0	4.29				
16	3314	8.30	1.70	0.31	61.0	3.3	35.0	4.37				
17	3315	8.40	2.50	0.33	41.0	3.4	50.0	4.34				
18	3316	7.90	2.55	0.29	52.0	3.5	49.0	4.02				

Figure 2: Sample Spreadsheet used to Score Student Assessments (Mastery Test D6: Version 1) - Answers Hidden

Over the years, some Mastery Tests have been updated to address key skills that instructors wanted to include in a given problem. For instance, all the rigid body equilibrium Mastery Tests (like shown in Figure 1) now include a distributed load in the problem statement.

Student Reception

Students have responded positively to the introduction of mastery-based assessments in the Statics course, highlighting their effectiveness in enhancing learning and reducing exam-related stress. Many students appreciated the mastery test format as it provided a better chance of passing the course compared to traditional exams. Instead of focusing solely on grades, this system promoted greater engagement with the material, allowing students to revisit and deepen their understanding through repeated opportunities and attempts. Several students found the mastery approach particularly helpful for reinforcing key concepts and making the learning process more manageable. They noted that the option to retake tests motivated them to improve rather than feel discouraged by failure. This iterative learning process ensured they thoroughly understood the material before moving forward, a feature they felt was lacking in conventional exams. One student specifically mentioned that the format “challenged me to learn the course material” rather than just memorizing it for a single test. Overall, students found the mastery-based assessment system as an engaging, supportive, and effective method for learning Statics. The format not only offered ample opportunities for success but also fostered a growth mindset, promoting continuous improvement and a deeper understanding of fundamental engineering principles.

Table 3: Selected IDEA Survey Comments or Feedback from Students

Fall 2024	• I liked the way the course was set up into Mastery Tests instead of normal exams. I feel like it gives the students a better chance to pass the course.
Spring 2024	• Mastery test were great. The times could have been more spread out, but overall a great course. Really enjoyed it. • Mastery Test system was very interesting and helpful in terms of learning course materials, no buts nor howevers. Simply put, it was great.
Spring 2023	• Gave students as many opportunities as possible and made various attempts to understand the class. I have nothing to complain or anything to add, amazing class and professor! • I really enjoyed your class and learned a lot. I think the way it's formatted is nice and limits the work to manageable levels. I think you should emphasize the importance of not getting behind on mastery tests because some of my friends did get behind not paying attention but that is more their fault than yours.
Spring 2022	• I really enjoy the idea of the mastery tests • I really like the mastery test format, I feel like it challenged me to learn the course material. Instead of passing or failing, it allowed me to review the material and learn, which is not possible with normal exams. • I really like mastery tests, when I took them, even if I didn't pass initially, I was still encouraged to better my understanding of the material due to the tests being re-takeable.

Intervention- Experiential Learning Modules with 3D Coordinate Model

Motivation

Experiential learning is the process of learning by inquiring about the nature of experience [7]. Kolb stated that *experiential* learning includes all modes of the learning cycle and ensures effective knowledge acquisition [7]. Experiential learning includes four modes: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). The concrete experience and active experimentation can be achieved by hands-on experience of a physical model, followed by a recording of experimental observations and measurements. Afterwards, students should reflect on these observations, facilitated by guided questioning, and then connect their observations to the derived theories (abstract conceptualization). Students can then actively perform additional experiments to test their new understanding.

Description

The research pertaining to the experiential learning modules (ELM) is a continuation of research presented by two of the authors at the 2022 ASEE Conference and Exposition [8] and the 2023

ASEE Gulf Southwest Conference [9]. In the research, the authors created dimensionally accurate 3D units to model typical Statics problems. An example of a unit is shown in Figure 3.

Figure 3: Prototype Unit

Student Reception

A student survey was performed after IRB approval in two semesters, Spring and Fall 2022 semesters for both Statics and Dynamics courses. The number of total students who participated in Statics and Dynamics is 31 and 21, respectively. The survey results are given in Table 4, followed by students' comments for improvement, which are listed in Table 5.

Statics reception: Over 80% of the students agree that hands-on learning was helpful and increased their confidence in solving similar problems. About 90% prefer hands-on problem-solving over text-book problem-solving during the lab session. All Statics students feel that the learning modules were fun and engaging.

Some student comments to improve the learning modules include a pre-discussion of the module with more time for the lab session. At least one student suggested he would prefer the mastery-based test after the hands-on learning.

Dynamics reception: The students' reception of Dynamics is less than that of Statics. However, over 80% agree that they would learn better if they could observe a physical model. Though 71% agreed that hands-on problem-solving was interesting, only 43% expressed confidence that they would be able to solve similar problems. Their comments reflect some reason for their lack of confidence.

Some comments are similar to those of the Statics students, such as the modules should be uploaded at least a week earlier, and it would be easier for the students to follow the worksheet if

the instructor explained the tasks. The worksheets need to be revised for clarification; there are two ways to do this:

1. Further breakdown the task with an additional description
    a. May be limited due to a 50-minute time restriction
    b. A longer lab duration may be helpful for going through it step-by-step, but would be difficult to justify for a currently 0 hour lab for the students
2. Reduce sub-tasks such as the derivation of the formulas
    a. Derivations can be covered in the classroom
    b. Break down remaining tasks into sub-steps

Table 4: Student Survey Results of Statics and Dynamics for Spring 2022 and Fall 2022

Survey Results: [Strongly Agree + Agree]% + [Neutral]% + [Disagree +Strongly Disagree]% (rounded)		
Survey Questions	Statics	Dynamics
1. I enjoyed the course more because of the hands-on learning module(s) during the lab session.	[85%]+[9%]+[6%]	[61%]+[33%]+[5%]
2. The hands-on learning module helped me better comprehend the principles it employed.	[84%]+[13%]+[0%] *No response [3%]	[58%]+[28%]+[14%]
3. I learn a concept principle better when I can observe a physical model of the principle.	[84%]+[12%]+[4%]	[81%]+[10%]+[9%]
4. I would prefer the hands-on problem-solving module over textbook problem-solving during the lab session.	[90%]+[10%]+[0%]	[67%]+[14%]+[19%]
5. The hands-on learning module was interesting, fun, and engaging for me.	[100%]+[0%]+[0%]	[71%]+[15%]+[14%]
6. I am confident I could solve similar problems after having completed the lab.	[87%]+[13%]+[0%]	[43%]+[43%]+[14%]
7. I learn better with active tasks than in the normal lecture setting.	[86%]+[10%]+[4%]	[61%]+[34%]+[5%]

Table 5: Student's Comments on Improvements

Statics: a. Explain the procedure with an example before students hear me b. I think a mixture of hands-on learning and textbook questions would help solidify the material. c. I liked that we got to be in groups, collaboration is done, it seemed nice to me so I don't really know what to improve. d. Mastery tests are way to go after a hands on lab e. May be have some longer labs, the 50 min has a bit short for some of the modules. Everything else was great though, being in groups and discussing cleared up a lot of misconceptions for some of the people struggling. f. I would love more hands on labs
Dynamics: a. The prelabs and lab handouts should be uploaded earlier so that we can familiarize ourself with the topic at hand. b. Actually going over the project with us would have been beneficial, especially since it was unaware of our knowledge of this topics. c. I would've liked to have more information on the sheet and/or more help from the professor/ Si leaders. d. Make the language clear and concise for the steps to ensure the lab is done correctly. e. The packet was set up a little complicated, so if it was simplified a little more it'd be easier. f. I really liked the module and I suggest more should be implemented into the harder lesson. g. More equipment for the students & better measuring devices/procedures.

Faculty Adoption

Experiential Learning Modules featuring a 3D Coordinate Model were utilized during the Statics lab sessions: 2D particle equilibrium and 3D static equilibrium. Initially, the model was implemented as designed for 3D static equilibrium; later, the Statics instructors modified it for hands-on activities related to 2D particle equilibrium. This model was easy for instructors to use. The worksheet that was designed by model developers was used to record experimental values from the 3D coordinate model experiment and encourage students to calculate the tension in cables based on provided coordinates and loads. The pros of this model were that students could have a clearer view of the 3D coordinates, link experimental values to calculated outcomes, and apply knowledge gained from lectures to the actual model. While no major drawbacks were identified, expanding the model's application to more 3D equilibrium problems could further enhance its instructional value. Increasing its versatility would provide students and instructors even more opportunities to explore complex Statics concepts in a hands-on, interactive way.

Comprehension- Statics

Final grade data from Statics is presented in Table 6 for the semesters studied.

Table 6: Longitudinal Data for ENGR 2301- Statics Final Grades

ENGR 2301: Final Grade Data by Percentage									
Semester	**Enroll-ment**	**A**	**B**	**C**	**D**	**F**	**W**	**AB**	**DFW**
Fall 2016	32	9.4%	18.8%	28.1%	9.4%	21.9%	12.5%	28.1%	43.8%
Spring 2017	15	6.7%	33.3%	46.7%	0.0%	6.7%	6.7%	40.0%	13.3%
Fall 2017	22	-	-	-	-	-	-	-	-
Spring 2018	23	13.0%	43.5%	21.7%	8.7%	8.7%	4.3%	56.5%	21.7%
Fall 2018	27	25.9%	11.1%	14.8%	11.1%	33.3%	3.7%	37.0%	48.1%
Spring 2019	31	19.4%	22.6%	12.9%	12.9%	19.4%	12.9%	41.9%	45.2%
1 Hour Lab Session Added to Course									
Fall 2019	30	3.3%	23.3%	13.3%	13.3%	16.7%	30.0%	26.7%	60.0%
Spring 2020	28	21.4%	17.9%	17.9%	3.6%	7.1%	32.1%	39.3%	42.9%
Fall 2020	19	10.5%	15.8%	21.1%	10.5%	15.8%	26.3%	26.3%	52.6%
Spring 2021	23	17.4%	17.4%	21.7%	0.0%	21.7%	21.7%	34.8%	43.5%
Mastery Based Assessments Added to Course									
Fall 2021	26	34.6%	42.3%	7.7%	7.7%	3.8%	3.8%	76.9%	15.4%
Experiential Learning Modules Added to Course									
Spring 2022	18	66.7%	22.2%	11.1%	0.0%	0.0%	0.0%	88.9%	0.0%
Fall 2022	21	38.1%	38.1%	4.8%	9.5%	9.5%	0.0%	76.2%	19.0%
Spring 2023	19	36.8%	15.8%	26.3%	10.5%	5.3%	5.3%	52.6%	21.1%
Fall 2023	23	21.7%	34.8%	30.4%	0.0%	13.0%	0.0%	56.5%	13.0%
Spring 2024	19	47.4%	10.5%	21.1%	10.5%	10.5%	0.0%	57.9%	21.1%
Fall 2024	24	37.5%	8.3%	37.5%	4.2%	4.2%	8.3%	45.8%	16.7%

From the grade data presented, it is observed that the Mastery-based Assessments have had the most significant effect on student outcomes in the class, lowering the DFW rate and increasing the number of students receiving the grade of A or B. The one hour lab session did not really seem to help, and it is hard to determine if the experiential learning modules have had a more significant or continued impact than the mastery-based assessments.

Proportionality Index for Hispanic Students

It is hoped the experiential learning modules will benefit all students, but will disproportionately benefit the Latinx student population who, in general, associate with more collectivistic, integrated, or higher context cultural frameworks [3], [4], [10], [11], [12]. The data in Table 7 seems to support that both the mastery based assessments and lab modules have improved equity.

Table 7: Aggregate Final Grade Data for Hispanic Students in Statics Across the Course Changes Implemented

ENGR 2301: Aggregate Course Data			
	Fall 2016 - Spring 2019 **Total Enrollment** = 128 **Hispanic Enrollment** = 30	**Fall 2019 - Spring 2021** **Total Enrollment** = 100 **Hispanic Enrollment** = 32	**Fall 2021 - Fall 2024** **Total Enrollment** = 150 **Hispanic Enrollment** = 58
Grades	**Hispanic Equity Index (Proportionality Index)**	**Hispanic Equity Index (Proportionality Index)**	**Hispanic Equity Index (Proportionality Index)**
A	0.43	0.72	0.79
B	1.10	1.15	1.29
C	0.74	1.22	1.12
D	0.71	0.89	0.86
F	1.88	1.25	0.78
W	0.00	0.94	1.29
QW	0.95	0.39	1.29

Future Work

The authors are excited by the results and look to continue to study these improvements.

Limitations

First and foremost, the authors acknowledge that variations in data could occur with the changes in the instructor of record. Over the 9 years of data presented for Statics in Table 6 and Table 7, there have been 6 different instructors. While there is some consistency in materials from semester to semester, different instructors and teaching styles can impact the data. However, it is encouraging to note some consistency in the data from Fall 2021 to Fall 2024, over which two instructors alternated teaching the Statics course.

In addition to rotating faculty, the undergraduate student instructor (SI) for the course typically changes each Fall. Many students utilize the SI office hours and study sessions to learn the material. Depending on the teaching qualities of the student, students' overall performance could be impacted.

The period studied also covers the COVID-19 pandemic. At Angelo State University, only the Spring 2020 data would be impacted by a switch to remote learning for the second half of the course. By Fall 2020, instruction had returned to face-to-face with social distancing protocols.

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