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Evaluating the Effectiveness of a Statics Recitation Course

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Evaluating the Effectiveness of a Statics Recitation Course

Abstract:

In order for a student to complete an engineering program, they must first be able to successfully build their fundamental skills during their introductory engineering courses. Those students who struggle may not be able to graduate on time and as a result these courses end up impacting retention. This paper describes the development and effectiveness of a Statics recitation course designed to improve the passing rate in a fundamental class. Learning data such as grades and self-reported information from surveys were analyzed through binomial logistical regression analysis to determine their ability to predict student success in Statics. The goal was to develop a method of identifying students who would be at risk of failing the course based on historically predictive indicators of student learning and invite "at-risk" students to join the recitation course early in the semester. The impact of recitation was then determined by comparing the passing rate of at-risk students who registered for recitation with those who did not take the recitation course. Early results showed midterm 1 exam scores were the best predictor for student success and those who scored below 70% would be defined as at-risk. The resulting data shows passing rates of these students were higher when they were enrolled in the recitation course. Binomial logistical regression supports the idea that recitation plays a role in predicting student success. This paper discusses the motivation for intervening with Statics, the recitation course pedagogy, the statistical methods used to predict student performance, and the effectiveness of recitation.

Introduction:

Statics is an introductory engineering course where sophomore-level students first synthesize the technical skills gained in math and physics courses. As such, it can be a challenging introduction to engineering concepts and routinely has a high attrition rate. Most engineering majors in the Penn State system require a Statics grade of C or better before graduation. As a result, poor grades require students to repeat the course and failing Statics has a large impact on retention of engineering students. The Mechanical Engineering (ME) Department at Penn State Behrend has identified the Statics course as one of the major factors for delayed graduation in that major. As a prerequisite for other required courses, a setback in that class can severely limit the amount of schedulable engineering courses. A student must be able to pass Statics by the end of their fourth semester in order to graduate from the ME program within four years.

In addition to retention issues associated with passing rates, the Behrend School of Engineering has seen a drop in enrollment over the past few years. Although some may be attributed to more students opting to complete their degree at the University Park campus, the overall forecast for Pennsylvania is a steep enrollment decline through 2026 due to declining birthrates [1]. In 2019 Hoover [1] reported that there was a 20% enrollment drop since 2010 at state-owned universities in PA and forecasts another 15% drop to occur in the near future. With a declining number of high school graduates entering the system, the School of Engineering has made student retention a priority.

Justification for Recitation

Universities have looked to innovative teaching pedagogies to effectively engage engineering students, improve passing rates, and increase retention in their programs. Active learning [2], increased class time [3], recitation [4], project-based learning [5], and peer tutoring [6] are just a few of the methods chosen to enhance traditional lecture-based courses. However, studies for some of these methods point to mixed results when integrated into the main Statics course [3], [5]. Some show that the results are statistically insignificant when compared to previous lecture-based approaches, and that any improvement can be attributed to factors such as student attendance, participation, and course satisfaction [5], [7], [8].

Additionally, active learning and other innovative pedagogies have barriers which prevent instructors from embracing instructional change. Bonwell and Eison [9] list issues such as maintaining faculty-student interaction in large classrooms, increased pre-class preparation, and a difficulty in covering all required course content within limited class time as a few of these major obstacles preventing active-learning from achieving widespread use. Faculty egos and limited incentives to change also discourage new practices, especially when the course is shared among multiple instructors. For these reasons, an optional recitation course offered outside of the traditional class structure would be the best choice for ease of implementation that does not affect other professors and their unique teaching styles. A single instructor could create a supplemental course with innovative teaching methods that does not force other faculty members to practice new methods, spend more time prepping, or revising course outcomes. Recitation is also easily testable to determine efficacy without potentially harming students who learn best through traditional methods. A recent study by Gannon University has shown that although a similar supplemental instruction program gave ambiguous results for grade improvement, it did prove that the additional help was not harmful to students [6]. Thus, a recitation course provides a low-risk method to increase student performance without negatively affecting the other faculty or students.

The Statics course is often taught over multiple sections divided between instructors; a recitation could also provide additional continuity between sections. This is especially true in semesters where students may have hybrid or completely online classes. The recitation allows students another point of view on class material, especially if they have trouble learning from their specific instructor's teaching method. Recitation can provide an opportunity for a single instructor to unify course goals across the sections and bring students together to collaborate with peers outside of their normal class. Students may feel more inclined to participate when surrounded by peers who struggle with the same topics. Results from a North Carolina A&T State University study found "a strong direct relation between grades and recitation attendance." It went on to praise recitation's effectiveness at encouraging feedback loops between students and instructors, allowing faculty to tailor lecture material to student needs which resulted in a deeper understanding of the material [4].

Online supplemental instructional material can also be a no-risk, high-reward tool for improving student performance when integrated with the recitation course. Open Educational Resource (OER) learning modules provide instruction and video tutorials which can provide a flexible learning environment. Online course material allows students to learn at their own pace and review specific topics when stuck. Douglas [10] found that online students spent more time with course material than face-to-face or hybrid learning modes. Higher student interaction generally correlated to higher grades. Therefore, online OER tutorials will be combined with a recitation course to increase the likelihood of student success in Statics.

John Burkhardt published a study in 2015 which showed that an extra hour of weekly lecture, delivering the same amount of material per week, provided little to no significant improvements over the traditional course for at-risk students. It is suggested that student learning and engagement may be more dependent upon the implementation rather than the pedagogy [5], [3]. Therefore, a recitation course for Statics was developed to not simply increase instructional time but to deliver foundational principles and a supportive learning environment as stated by [5].

Methods*:*

The recitation class developed in this paper focuses on creating a student-centered learning environment aimed at improving performance in Statics by reinforcing guiding principles and better identifying and addressing individual weaknesses in a personal classroom environment. There are 6 individual steps being implemented in the course to improve student learning. The course intends to 1) deliver flexible online course material 2) practice effective problem-solving methods 3) bolster problem recognition 4) establish Statics theory 5) reinforce guiding principles and 6) identify individual weaknesses.

It has been observed by the authors that students need flexible resources to supplement the course material. Students have regularly supplemented classroom material with free online resources and videos such as Khan Academy [11]. Without guidance, however, some students would watch the wrong video topics or try to apply incorrect methods to Statics problems. This would result in more confusion. To supply more accurate information and topics, a series of OER video tutorials were created and organized by major topic to be available to students taking the recitation. For example, the Frames and Machines webpage has a short description of a frame system, the assumptions that allow simplification of the problem, the steps for solving, and an example problem with the video tutorials to follow as shown in the Appendix. The video tutorials are further broken down into short learning modules for the problem setup, free body diagram, solving, and common errors. A screenshot of a tutorial on common errors can be seen below in Figure 1. Videos are usually between 4-8 minutes long to keep students' attention and allow them to easily determine where they are getting stuck in the problem-solving process. The bottom of each topic's webpage contains additional resources such as handwritten solutions and a problem handout for students to write their notes as they follow along with the videos. These resources are previewed in-person during recitation and referenced on homework assignments for students to get a refresher if they got stuck. Overall, there are 10 modules containing a total of 27 videos for 180 minutes of supplemental tutorial content made specifically for the recitation course. Another 32 videos provide 497 minutes of classroom lecture that they should have experienced in the original Statics course and can use for review. These online resources provide a flexible learning environment where students can learn and review material at their own pace throughout the semester.

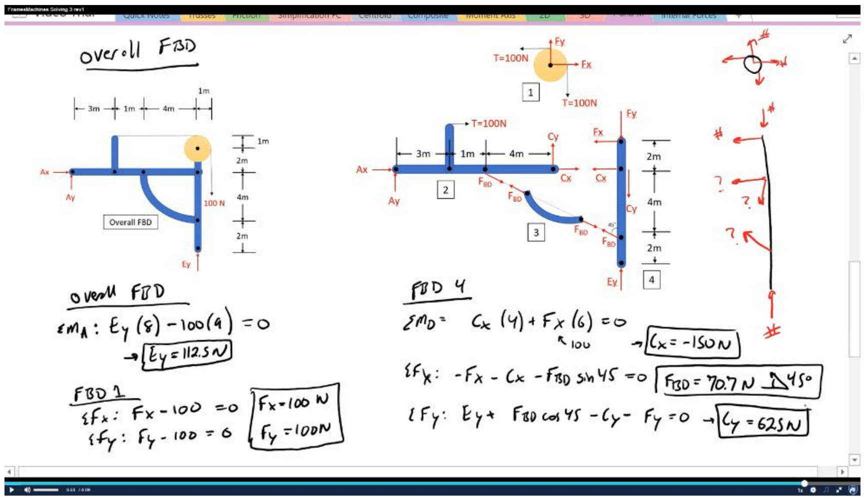


Figure 1: Screenshot of video tutorial on common errors with frames and machines

Class time is devoted to creating effective problem-solving methods. A standard step-by-step approach is taught and used on in-class work and homework assignments. Before solving, students must identify the type of problem, the steps required to solve, the associated equations, and the assumptions. The focus is on improving problem recognition and setup rather than the actual math where most students already succeed. To strengthen problem recognition, the students take turns identifying the major Statics topic as they solve a cumulative list of problems. The hope is to develop the ability to recognize topics and identify major formulae relevant to the problem. Statics theory is examined as students are quizzed on the assumptions behind each topic, and how those assumptions simplify and change the way each problem is approached. This provides a deeper understanding of how topics differ from one another and how that changes the way forces are applied on the free body diagram, for example in 2-force members in a truss instead of a multi-force member in a frame system. These guiding principles are reinforced through homework and collaborative classwork designed to give students the fundamentals with which they need to succeed in Statics. Assignments are designed to complement and reinforce principles learned in Statics and help them understand the major topics at the rudimentary level. The small course size allows the instructor to implement feedback loops and work closely with students to develop an understanding of weaknesses and develop a strategy to fix them.

As a standalone course, students receive a grade for recitation independent of the Statics class. The purpose is to encourage attendance and participation rather than simply adding to the students' hefty workload. A study at the University of Texas San Antonio which tried to prove that an optional recitation course would improve grades in their associated core classes, instead found that the attendance and participation in the recitation course tracked with the grades. Student motivation, attendance, and completion of recitation assignments played a larger role in success than simply enrollment in the recitation course [7]. Essentially, a student that does not show up will not get the opportunity to benefit from the recitation. Therefore, the structure of a new recitation course should encourage attendance, participation, and assignment completion in order to stress these goals. The grading rubric developed for this course is shown in Table 1. With homework grades based on completion instead of correctness, effectively 90% of the grade comes from student effort.

Table 1. Recitation grading rubric

Category	**Weight**
Attendance	40%
Participation	10%
In-class Quizzes	10%
Homework	40%

Recitation Implementation:

EMCH 297 is the optional, 1-credit class that was developed based on the aforementioned pedagogy. It is not used to fulfill any degree requirements, but is taken concurrently with EMCH 211, the traditional Statics course. It was offered for the first time in SP21 to all students, although an attempt was made to identify at-risk students and specifically invite them to add recitation. All students who wished to improve were welcomed into the course to prevent a stigma of only poor performers attending recitation and discouraging others from seeking improvement. Therefore, the effect of recitation would best be measured by comparing at-risk students with and without recitation to gauge their ability to achieve a passing Statics grade.

The small recitation class, limited to 15 people, meets in-person with a seasoned faculty instructor once per week for a 75-minute session to supplement coursework in Statics. The 10-week course starts on the 6th week of the semester, which is one week after students complete their first exam and offers a chance for students to improve their grade in the course. Recitation material trails the Statics course by one week, allowing students to first learn the material in the main course and then practice those concepts in a personal recitation environment where instructors can more easily identify sticking points. Each week 2 homework problems are assigned, and relevant online video tutorials and lessons are released for students to review. A typical recitation day starts by answering questions about the previously assigned homework and solving the problems either together as a class or in groups on the board. Together the class completes an exercise developed to enforce new problem-solving methods by first identifying the type of problem, determining methods to solve, listing key equations, and citing assumptions that could simplify the problem, all without taking the time to solve the problem. A quick review lecture to reinforce Statics principles and discuss the difference between topics will follow. Finally, the class puts the lesson into action by practicing the new principles by solving 2-3 problems in small groups to encourage cooperative learning. The instructor visits each group to check on progress, answer questions, and identify class weaknesses. Every week, the students will have a 5–10-minute quiz which focuses on problem recognition and identifying relevant equations rather than mathematically solving. The techniques and material developed for this recitation will be made available to all instructors if they choose to add them to the main Statics course, however, individual instructors are still encouraged to teach towards their strengths and allow recitation to unify course goals across the sections.

Results:

To explore the efficacy of the recitation course, the plan is to examine the passing rate of students with similar exam scores both with and without the course. In the fall of 2020, the recitation course was not offered to students and thus will serve as a baseline for student grade comparison. Statics classes are limited to 30 or less students per section and typically six sections are taught in the fall with three additional sections in the spring. Although baseline data was collected during the COVID pandemic, students were able to choose their mode of choice (in-person, hybrid, or asynchronous online) with five out of six sections held in-person. This choice remained throughout the entirety of this study and highlights the potential benefit of having an in-person recitation to add continuity between sections. Within the first 3 weeks of the semester an invitation was sent to all students throughout the 6 sections of Statics asking for participation in the upcoming study. If they consented, they were asked to complete a short survey and their learning data was used for the study. At the end of the semester, gradebooks were compiled and anonymized so that no personally identifiable student information remained. The data from the grades and survey were analyzed to determine if they can be used as predictive indicators of student success. If a correlation exists, it could be another tool to help identify students who are at-risk of failing the course and allow instructors to recommend intervention.

Baseline Student Performance

In the baseline semester of Fall 2020, 45 out of the 139 total Statics students consented to data being collected. Of those, 41 students completed the course and have data for midterm grades while 4 students dropped Statics. This sample of students had a passing rate of 73.3%, which is similar to the overall course pass rate and highlights the importance of improving student performance. Statistical tests were performed comparing students' exam 1 grade and their final grade in the course. The results of a two-sample paired t-test can be seen below in Table 2. Data shows that the mean score between the first midterm and final grade is not statistically different.

Table 2: Paired t-test two sample for means

	Midterm 1 Grade	*Final Course Grade*
Mean	81.5	80.6
Variance	230.0	138.8
Pearson Correlation	0.7	
P(T<=t) two-tail	0.6	

The correlation coefficient between the exam score and final grade is 0.7. With a value of 1 showing a perfect positive relationship and a value of zero implying no relationship, the correlation between midterm exam score and final course grade is strong. However, the data may be slightly skewed since only those who completed the course would have a final grade and be counted in this test.

Binomial logistic regression analysis can more accurately predict the effect of midterm score on the final course grade and account for the dropped students. This technique is commonly used to determine which factors play a role in predicting a certain outcome by taking continuous and dichotomous (yes/no) variables into the model and assigning them a coefficient which predicts the importance of each. Positive coefficients would signal that the predictor variable makes the outcome (passing Statics) more likely to occur while negative coefficients make it less likely. Final course grades were converted to pass/fail by considering all students who dropped or scored below 70% as failing. The analysis showed midterm 1 was statistically significant (P=0.027) in predicting student outcome. As data from the recitation course is gathered, it will be compared to the baseline. Students with similar midterm 1 exam scores will be compared to measure the correlation between passing rates of those with and without the recitation course.

Student Survey

Student attitudes towards their personal course progress were assessed through surveys. The first portion was given in the week preceding the first midterm. Students who consented to participation in the study received a short survey which asked them to rate their ability to understand and complete Statics problems. The Likert Scale was used for the prompts shown in Table 3. Student responses were converted to a numerical value by assigning 1 for Unsatisfactory to 5 for Excellent. In addition, they were asked to rate their level of confidence in understanding what a question is asking on homework and exam problems on a scale of 0-100. The self-evaluation responses showed that on average, students were 73.4% confident in their understanding, with a standard deviation of 18.5%. A follow-up survey offered at the end of the semester will track student progress in the recitation course and ask for qualitative feedback to gauge student perception of the intervention and suggest changes.

Table 3: Likert-scale survey prompts (1 indicates unsatisfactory and 5 indicated excellent)

	Statement	Avg. Score
1	Your ability to understand the problem statement and decide what information is important and which information is irrelevant (i.e. “fill”)	3.7
2	Your ability to understand the type of problem (i.e. dot product problem vs vector addition vs 3D equilibrium)	3.5
3	Your ability to remember the equations that are associated with each type of problem	3.5
4	Your ability to correctly draw the associated FBD	4.0
5	Your ability to work through the math correctly (writing equilibrium equations, solving system of linear equations, performing trigonometry)	3.7

A binomial logistical regression was performed to explore the potential correlation between grades and students’ perceived confidence in their abilities as shown in Table 4. The self-reported data did not correlate with student performance, as each variable had a significance (P-value) larger than the commonly accepted value of $P<0.05$.

Table 4: Coefficients and importance of survey data in the logistic regression model

Term	Coef	P-Value
Confidence	0.0482	0.15
Prompt 1	0.383	0.623
Prompt 2	-0.466	0.446
Prompt 3	0.074	0.866
Prompt 4	-0.998	0.115
Prompt 5	-0.292	0.558

Out of the 7 performance indicators considered in the baseline logistic regression model, only midterm 1 proved to have an impact on student success in the course. This was backed by a correlation coefficient of 0.7 and t-tests showing no statistical difference between the midterm grades and final grades. Self-reported data from the survey proved insignificant. Data collection will continue in the coming semesters to verify midterm 1’s ability to accurately predict student performance and will be used as a tool to help instructors identify struggling students. Students who score below 70% on the midterm will be considered “at-risk” for the remainder of the study and their performance will be compared with and without the recitation course to determine the effectiveness of the intervention. In later semesters, supplementary data will be tracked to identify additional student performance indicators. A similar study found that college GPA, Calculus, and Chemistry grades were found to be most significant predictors for student placement into at-risk courses [12].

Recitation Data

The recitation course was first offered during the Spring 2021 semester. During that time, 36 students registered for the Statics course, seven of which enrolled in recitation after receiving the results of the midterm 1 exam. During the Fall 2021 semester, 133 students enrolled in Statics and the recitation maxed out at 15 students. At-risk students clearly performed better when enrolled in recitation as demonstrated by their increased passing rate shown in Table 5. The benefits of the recitation for at-risk students remained true despite variations in passing rates across the three semesters.

Table 5: Passing rates for Statics

	FA20	SP21	FA21
Total pass rate	73.3%	64.3%	56.4%
At-risk non-recitation pass rate	N/A	0%	11.76%
At-risk recitation pass rate	N/A	50%	36.36%

A two-sample proportion test was conducted to determine if the two groups statistically differed on passing rate. As shown in in Table 6, the two groups were statistically similar ($P>0.05$). However, the at-risk students did see the benefit of recitation as shown by the difference in their passing rate in FA21 and the cumulative data ($P<0.05$). This demonstrates that although the demographic is similar between the two groups, the students who need the most help can improve their grades in recitation. Statistical analysis could not be performed on the SP21 students as there were only 6 at-risk students participating in the study.

Table 6: Two-sample proportion tests on passing rate of students with and without recitation

	All Students			At-Risk Students		
	SP21	FA21	Cumulative	SP21	FA21	Cumulative
Z-test	-0.915	0.254	-0.278	N/A	-2.012	-1.972
P-value	0.360	0.800	1.219	N/A	0.044	0.049

Binomial logistic regression analysis considered learning data such as the midterm 1 score (Midterm_1), enrollment in the recitation course (Recitation), cumulative GPA (GPA), and a prerequisite math quiz grade (Math_Score) to determine their ability to forecast student performance in the course. As shown in Table 7, student GPA, recitation status, and midterm scores were statistically significant ($P<0.05$) in predicting if a student would pass the course. Prerequisite math scores did not correlate with student performance with a P-value of 0.114. The most successful predictors were the recitation status (Coef=5.41) and cumulative GPA (Coef=4.43) of the student.

Table 7: Coefficients and significance of learning data in FA21 regression model

Predictor	Coef	P-Value
Math_Score	4.81	0.114
GPA	4.43	0.001
Recitation	5.41	0.004
Midterm_1	0.132	0

Student surveys were conducted before the first midterm and repeated in the last week of class to determine student attitudes towards personal course progress. The same Likert-scale survey prompts as shown previously in Table 3 were used and the results are shown below in Table 8. Students were also asked to rank their confidence in understanding problem statements. On average, recitation students went from 58.6% to 83.8% in the SP21 semester and from 78.7% to 81% in FA21. This increase in confidence indicates that recitation students believe they have a deeper understanding of the problems by the end of the semester.

Table 8: Likert-scale survey responses

	Q1	Q2	Q3	Q4	Q5
FA20 week 5	3.7	3.5	3.5	4.0	3.7
SP21 week 5	3.00	2.92	2.69	4.31	3.15
SP21 week 15	3.83	3.67	3.50	3.33	3.83
FA21 week 5	3.95	3.52	3.38	4.43	3.81
FA21 week 15	3.60	3.90	4.10	4.20	3.60

Recitation students rated the effectiveness of EMCH 297 in multiple categories as shown in Table 9 through Likert-scale questions. Overall, they found it helpful, easy to navigate the online portions, and would recommend recitation to a friend. Qualitative feedback was also provided and is summarized in the Appendix.

Table 9: Likert-scale survey prompts for recitation students

	Statement	Avg. Score
6	Rate the helpfulness of the recitation class to assist your learning in Statics	4.4
7	Rate the helpfulness of the online review modules and video tutorials	4.1
8	Rate the ease of navigation through the online recitation review modules	4.0
9	What is the likelihood that you would recommend the recitation class to a friend in Statics?	4.7

A logistical regression analysis considered self-reported data to determine if any of the prompts could be considered performance indicators, as was done previously in the FA20 baseline year. Table 10 demonstrates that the survey responses from week 5 of the Statics course were poor predictors of student success (P>0.05) throughout all semesters.

Table 10: Survey predictors of student performance in a binomial logistic regression model

Survey Predictor	SP21 (13)		FA21 (21)		Cumulative (77)	
	Coef	P-Value	Coef	P-Value	Coef	P-Value
Confidence	-0.23	0.918	0.0386	0.552	0.0165	0.44
Prompt 1	-4	0.93	-2.22	0.141	-0.004	0.993
Prompt 2	-7.4	0.806	0.204	0.82	-0.024	0.95
Prompt 3	-0.6	0.995	1.96	0.149	0.446	0.199
Prompt 4	35.2	0.676	0.84	0.469	-0.18	0.647
Prompt 5	1.9	0.968	-1.21	0.292	-0.26	0.484

In summary, the passing rate for at-risk students was higher in the recitation course for both semesters and a two-sample proportion test confirmed the statistical difference. Binomial logistical regression confirmed that learning data such as GPA and midterm scores can be used as early indicators of student success in the course and help instructors identify at-risk students. It also shows recitation plays a role in the likelihood of passing Statics. Regression models demonstrate that self-reported data from the survey were poor predictors of performance and may indicate that students are not good judges of their own ability, especially in the early stages of a course. Overall, feedback shows students viewed the recitation as helpful and would recommend to their peers.

Future Plans

The ME department plans to offer the recitation course and continue to monitor its effectiveness over the next few semesters. Improvements to the course will be made based on feedback from the follow-up surveys and eventually integrated into the traditional Statics course as supplemental learning material. Performance indicators based on learning data will be tracked to try and predict at-risk students and invite them to seek help.

Additionally, OER material will continue to be compiled and added to the tutorial modules. These will later be shared with other courses, providing Statics tutorials as a review for students in Dynamics or Strengths of Materials. The goal is for other core classes to create similar material for their course and add to the collection. As the library of material continues to grow, there is the potential for an Engineering Mechanics library which houses common lessons and tutorials for students at all stages of their academic career.

Finally, improvements will continue to be made to increase accessibility to students. One of the goals of this study is to determine if the recitation course is effective and a proper use of department resources. One problem with this approach to improving passing rate and retention, is that it can be hard to make recitation effective on a large scale if only a few students sign up for the course and only a percentage of those really participate. As shown in the University of Texas study, the improvements in student grades based on recitation may be statistically insignificant because of a larger influence from student participation and attendance [7]. In the spring of 2021 at Penn State Behrend, one recitation section was offered and had 7 participants. In the fall of 2021, more students requested the course than there were open seats. More sections will need to be opened to increase availability to students with conflicting schedules because students cite scheduling conflicts as the main factor for skipping or not registering for recitation courses [13], [14]. During semesters where demand outpaces supply, controls may be implemented to ensure priority scheduling for at-risk students. It is hoped that with proper tracking of the success of the recitation, the data can be used to convince future students to improve their performance by joining the course.

References

[1] S. Hoover, “Pennsylvania colleges face steep enrollment declines in 2026,” *WHY*, PBS, Apr. 292019, whyy.org/articles/pennsylvania-colleges-face-steep-enrollment-declines-in-2026/. [Accessed January 20, 2021]

[2] J. Tsai, D. Kotys-Schwartz, and M. Hannigan, “Learning Statics by Feeling: Effects of Everyday Examples on Confidence and Identity Development,” *2013 ASEE Annual Conference & Exposition*, Atlanta, GA, USA, June 23-26, 2013

[3] J. Burkhardt, “The Effect of Additional Statics Class Time on At-Risk Student Performance Paper” *2015 ASEE Annual Conference & Exposition*, Seattle, WA. June 14-17, 2015.

[4] M. Saad, T. Abu-Lebdeh, D. Pai, and C. Waters, “Recitation In Core Engineering Mechanics Courses: Implications For Retention And Student Performance,” *2007 Annual Conference & Exposition, ASEE 2007,* Honolulu, HI, USA. June 24-27, 2007

[5] Z. Kou and S. Mehta, *“*Research In Statics Education – Do Active, Collaborative, And Project Based Learning Methods Enhance Student Engagement, Understanding, And Passing Rate?” *2005 Annual Conference, ASEE 2005*, Portland, OR, USA, June 12-15, 2005.

[6] S. Steinbrink, A. F. Nogaj, K. M. Vernaza, L. Zhao, and S. Tiari, “A Study of the Effects of Peer Tutoring in Relation to Student GPA,” *2020 ASEE Virtual Annual Conference*, Virtual Online. June 22-26, 2020

[7] A. Karimi, “Does Problem Solving Recitation Session Improve Student Retention And Success?*” 2002 Annual Conference, ASEE*, Montreal, Canada, June 16-19, 2002.

[8] Y. Hu, J. Montefort, and E. Tsang, “An Innovative Redesign of Statics: Approach and Lessons Learned*,” 2015 ASEE Annual Conference & Exposition*, Seattle, WA, USA, June 14-17, 2015.

[9] C. Bonwell and J. Eison, *Active Learning: Creating Excitement in the Classroom*. Washington, DC: Office of Educational Research and Improvement, 1991 ASHE-ERIC Higher Education Reports ED336049

[10] J. Douglas, “Comparing Learning Outcomes and Content Mastery in Online and Face-to-Face Engineering Statics Courses*,” 2015 ASEE Annual Conference & Exposition*, Seattle, WA, USA, June 14-17, 2015.

[11] *Khan Academy*. Accessed January 4, 2021. https://www.khanacademy.org

[12] J. Burkhardt, “Evaluation of the Effectiveness of Additional Class Contact Time on Student Performance in Statics,” *2012 ASEE Annual Conference & Exposition*, San Antonio, TX, USA, June 10-13, 2012.

[13] S. Sorby and C. Vilmann, “Going Online with Statics,” *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, June 26-29, 2011.

[14] H. Vasquez, A. Fuentes, and R. Freeman, "Improving Student Retention and Engagement in Statics through Online Formative Assessments and Recitations," *2012 ASEE Annual Conference & Exposition*, San Antonio, TX, USA, June 10-13, 2012.

Appendix

Frames and Machines

Description

A frame or machine has a structure composed of multiple members, possibly connected to additional ropes, pulleys, or springs. The difference between a truss and a frame/machine is that trusses are composed of 2-force members while **a frame/machine must have at least 1 multi-force member.** This can be a force that acts on the middle of a member instead of just at the joint, or a moment couple that is applied to the object. On multi-force members, the pinned reactions must have both an x- and y-component.

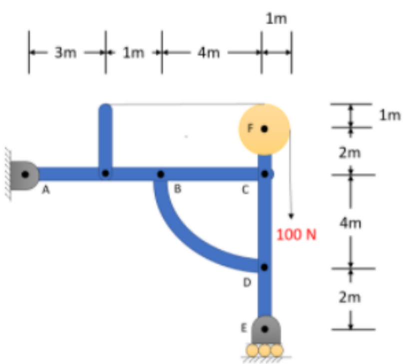
General Steps

Step 1: Draw FBD (overall and exploded view)

- Identify 2 force members (equal and opposite collinear forces acting at point of application)
- Draw forces common to any two contacting members with equal magnitude and opposite direction. (If drawing the overall system, most of the forces are internal and should not be shown.)
- Draw FBD for pins with multiple forces
- Do not reverse support reactions between overall and exploded view

Step 2: Apply equilibrium equations $\sum F_x = 0$ $\sum F_y = 0$ $\sum M_{point} = 0$

Example



Determine the forces in member FCDE.

Note: A printable version of the problem is available below in Resources for you to write on and take notes

	Recitation Feedback	
10	What helped you learn the most in recitation?	• Just the extra practice problems and going through them at a slower pace, • The individual homework problems that were focused on what we were doing during the 211 course, • The students doing the homework problems on the board and the Professor showing me exactly where I went wrong on my specific work and explaining why. • The quizzes at the end of class

11	What aspect of the recitation class was the least helpful?	• When the Professor would make up a problem. It was sometimes hard to understand without an exact picture. • The examples would be more helpful if we had the time to go through and solve them instead of just going over the concept on the board
12	What changes would make the recitation more valuable to learning?	• Do more problems that allow the student to do all the work instead of just writing them on the board. • Doing more of a mix of problems based on what we've previously learned in the semester. • I feel like it should have started before the first exam. I think I would have been more prepared if it started at the beginning of the semester.