Board 271: Evaluating the Effect of Multi-Attempt Digital Assessments on Student Performance in Foundation Engineering Courses

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Evaluating the effect of multi-attempt digital assessments on student performance in foundation engineering courses

Abstract

This paper discusses the design and implementation of multi-attempt digital assessments in the foundation engineering courses of Statics and Dynamics as part of an NSF-funded project entitled "Enhancing Student Success in Engineering Curriculum through Active e-Learning and High Impact Teaching Practices (ESSEnCe)." Statics and Dynamics are fundamental courses that are critical in the graduation pathway of almost all engineering majors. At the authors' institution, the average ten-year student success rate in these courses is typically low, and the success rates of Hispanic transfer students are even lower. To address this, the authors introduced multi-attempt digital assessments to improve student success rates. Prior research has shown that frequent testing is beneficial for student learning as it allows the realization of knowledge gaps via self-regulated learning and metacognitive monitoring strategies.

In this semester-long study, the authors redesigned the major assessments for multi-attempt testing in both Statics and Dynamics by creating extensive test question banks in the learning management system of Canvas. The assessments were administered digitally to the students using a Lockdown browser in Canvas at a proctored testing facility. End-of-semester surveys were administered in both courses to gauge student satisfaction and experience with this testing method. Preliminary results indicate very promising positive effects of the multi-attempt digital assessments in Statics and Dynamics courses on student performance, satisfaction, and self-reported motivation and self-regulation for *all* students, including Hispanic transfer students.

1. Introduction

Assessments are an integral component of the teaching and learning process. Hanna and Detmer have defined assessment as the process of gathering data by instructors about their teaching and students' learning using a range of activities such as pre-tests, observation, and examination. [1]. According to Huba and Greed, "the process culminates when assessment results are used to improve student learning."[2] Assessments can be categorized into diagnostic, formative, and summative assessments. Diagnostic assessments help identify students' current knowledge, formative assessments provide feedback and information during the instructional process, and summative assessments occur after learning has been completed. Tests or exams are considered devices of summative assessments, and pedagogical literature shows several benefits of testing.[3] Roediger and coworkers have listed ten benefits of testing that include better retrieval and retention of knowledge, identification of gaps in knowledge, better learning in students, better organization of knowledge, improved knowledge transfer to newer contexts, improved metacognitive monitoring, prevention of interference from older content, feedback to instructors and encouraging students to study more. [4]

In recent years, assessments in higher education have shifted into the digital space, and the onset of the COVID-19 pandemic accelerated this process, resulting in widespread use of online assessments in almost every discipline. Online assessments can be a powerful pedagogical tool

as they provide effective and quicker feedback to students in comparison to paper-based assessments. [5], [6] Pedagogical literature shows that timely and good feedback aids students in their learning. [5], [7] As outlined in the principles of good feedback practice, by Nicol, good feedback can "facilitate the development of self-assessment and reflection in learning" and motivate the students to "close the gap between current and desired performance." Online assessments can also provide students with a certain amount of flexibility, which can be advantageous for those with work responsibilities and family care needs. One challenge in implementing online assessments is academic dishonesty, as students have increased opportunities for cheating, especially in poorly proctored assessments. However, measures such as test-taker verification, plagiarism detection software, and supervised monitoring of testing conditions can alleviate academic integrity cases in online assessments. [5], [8]

An advantage of online assessments is that they are relatively simpler to implement in a multiple-attempt format without cutting down class lecture time. Multiple-attempt online assessments, if implemented carefully with rigorous test banks, can enhance the benefits of both test-taking and effective feedback.[9] Student learning elevates as they are provided with opportunities for self-improvement based on timely feedback from previous attempts. This serves as the motivation for our current study, where multi-attempt online assessments are implemented in two high-enrollment engineering courses in Statics and Dynamics at the authors' institution. Statics and Dynamics are two foundation courses in engineering that serve as a gateway to higher-level courses in almost all engineering disciplines. The student success rate is typically low in both these courses and ranges from 45 to 79% at the authors' institution. [10] These rates are even lower among Hispanic students transferring from two-year colleges to the university. Low success rates in these courses have adverse consequences such as delays in graduation timeline, dropping from engineering majors, and lower graduation rates, thus reducing progression and retention of students in engineering majors.

In this brief paper, the authors report their findings in implementing and evaluating the effect of multiple-attempt online assessments as a measure to address the high attrition rates of second or third-year engineering students in Statics and Dynamics. The multi-attempt assessments are applied to one section of Statics and one section of Dynamics across two semesters The paper also highlights the effects of the implementation on the performance of Hispanic transfer students in engineering majors at the authors' institution.

2. Methods

In this study, the authors implemented a multiple-attempt format for all the major assessments in the courses of Statics and Dynamics to provide students with greater flexibility and opportunity for grade improvement. The authors redesigned these assessments for multi-attempt testing by creating extensive test question banks in the learning management system of Canvas. For Statics, two assessments (two mid-terms) were in the multi-attempt format accounting for 50% of the cumulative course grade. For Dynamics, three major assessments (two mid-terms and a Final) were administered in this multi-attempt format. These assessments accounted for 75% of the cumulative course grade. Distinct sets of question banks were created for each assessment attempt with multiple versions of different questions, and each attempt pulled questions from these rotating question banks, resulting in a unique combination of questions for each student

attempt. The assessments were administered at a proctored testing facility maintained by the college at the authors' institution. The students used a lockdown browser to access and take the assessments at the proctored facility. The students were allowed two attempts for an assessment, each spanning a two-day window. The proctored testing facility was open from 9 am to 9 pm, and students had the flexibility to choose a time and day to complete each attempt in the two-day window.

For Statics, the mid-terms were 80 minutes and tested the concepts of vectors, particle equilibrium, moment of forces, rigid body equilibrium, trusses, and internal forces. The two mid-term assessments in Dynamics were 60 minutes each and tested the concepts of particle kinematics, particle kinetics using Newton's laws and energy and momentum methods, and systems of particles. The final assessment was 120 min and was comprehensive while focusing on rigid body kinematics and kinetics in 2D. In both courses, all assessments had problem-solving questions in a multiple-choice format where students would solve the problem and choose the correct answer. Students were required to show their work for each problem in each attempt in worksheets provided by the testing facility and the worksheets were scanned and uploaded to a portal by the proctoring facility for further review and grading. After each assessment was administered, the scanned student worksheets were retrieved from the portal and reviewed for partial scoring and grade adjustment based on a student's correctness in problem-solving.

The students in both courses took end-of-semester course surveys to provide feedback on the multi-attempt assessment method. The survey questions gauged student perceptions of the effect of the multi-attempt format on their course performance and was approved by the Institutional Review Board (IRB). The survey questions were rated using a 5-point Likert scale, with responses ranging from "Strongly Agree" to "Strongly Disagree. "

3. Results and Discussion

The effect of multiple-attempt assessments on student learning was evaluated by comparing score improvement data in the multiple-attempt assessments. The total enrollment for the Statics and Dynamics sections were 147 and 236, respectively. We present the data for two groups of students, the "Hispanic transfer student" group which includes students who are Hispanic and are transfer students and the "Remainder of the class" student group which includes all the remaining students in the sections of Statics and Dynamics. For the Dynamics section, the total number of Hispanic transfer students and remainder of the class students who completed the course (without withdrawing) was 20 and 210, while for Statics, the numbers were 5 and 113 respectively. Figures 1(A) and (B) report the score improvement data for students in both groups who completed both attempts for each assessment in the sections. For the Statics Section, the remainder of the class students showed slightly higher score improvement than the Hispanic transfer students in both multi-attempt exams, with 75% of the Hispanic transfer students and 78.3% of the remainder of the class students showing improvement after the first mid-term exam, and 64.3% of Hispanic transfer and 70.8% of remainder of the class students showing score improvement after the second mid-term.

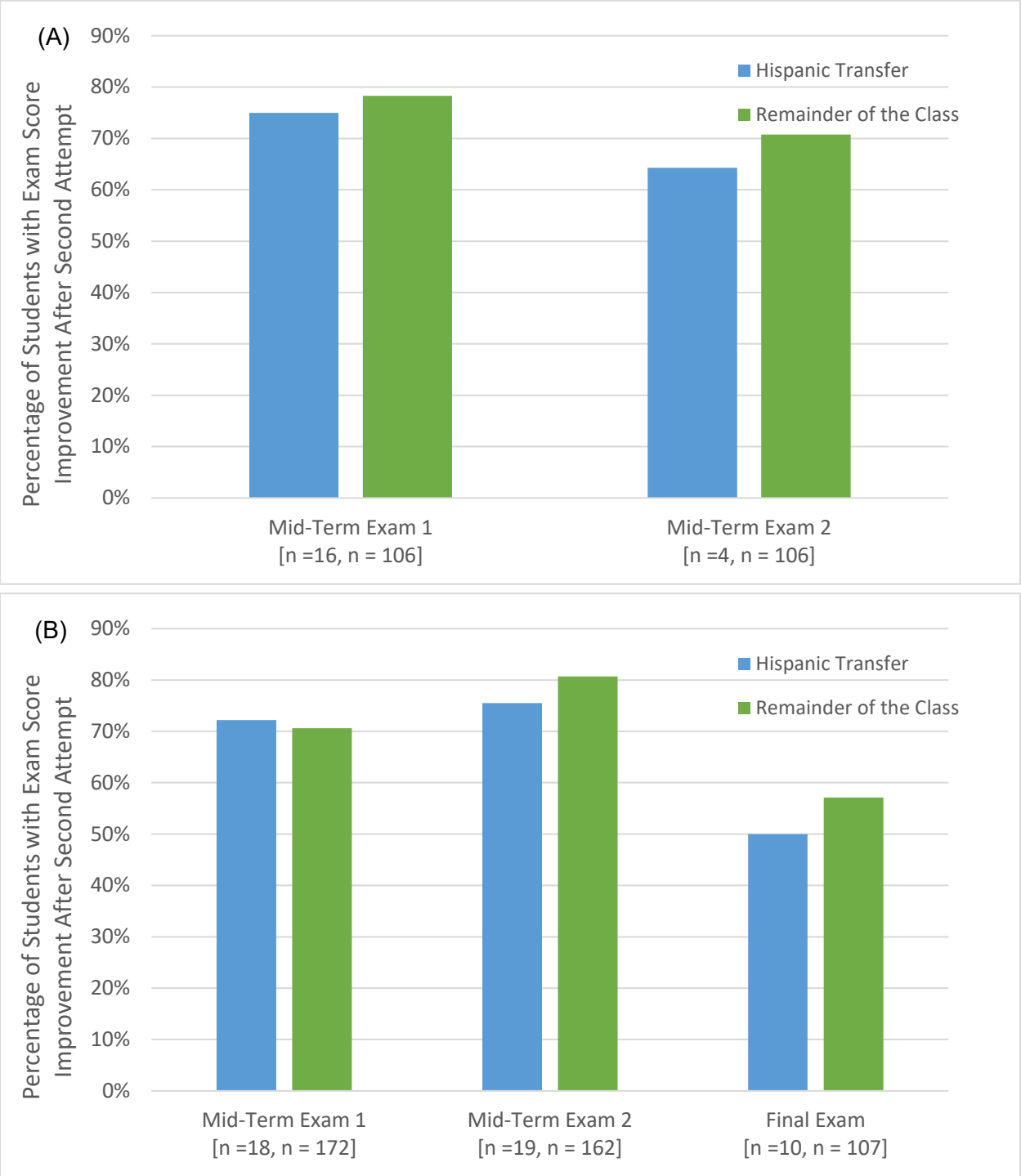
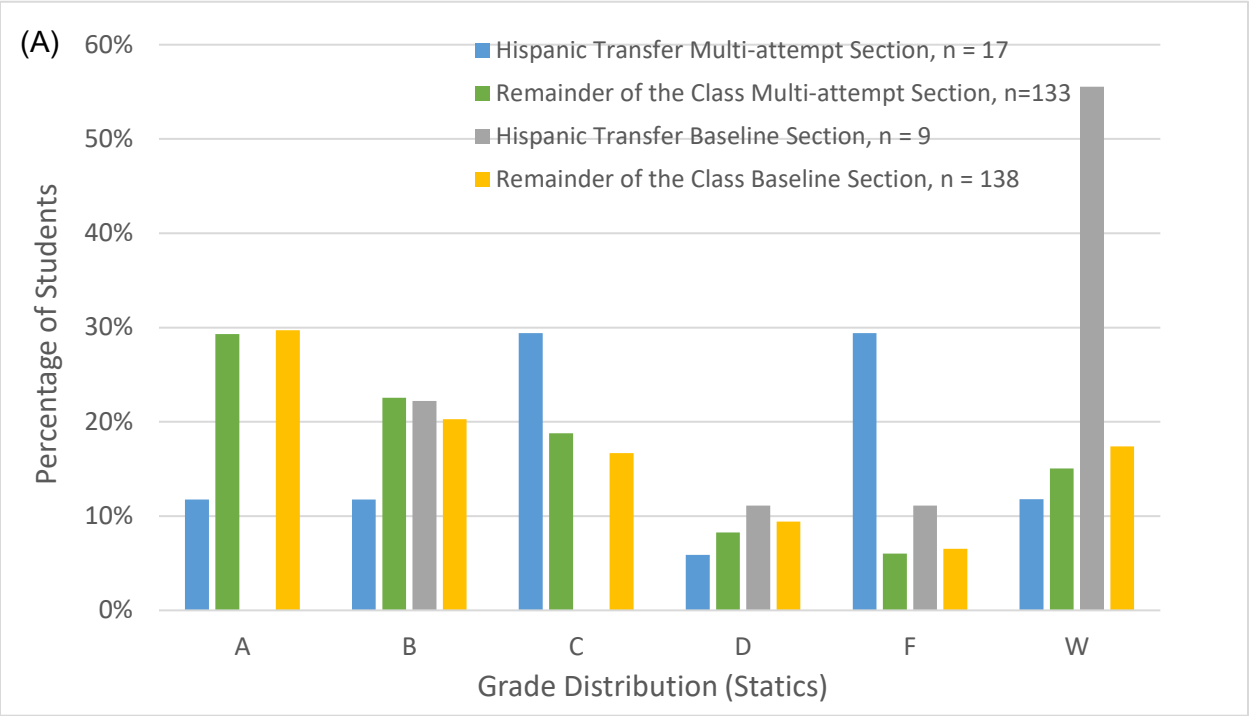


Figure 1: Percentage of students showing score improvement after the second attempt in the multi-attempt assessments in (A) Statics section and (B) Dynamics section.

As observed in Figure 1(B), for the Dynamics section, the score improvement trends were similar in the Hispanic Transfer and remainder of the class groups, with better performances in the second mid-term than the first mid-term and a decline in the final exam. However, the Hispanic transfer group performed slightly better in the first mid-term than the remainder of the class group. In the Dynamics section, 72% of Hispanic transfer and 70.6% of remainder of the class students showed score improvement in mid-term exam 1, 75.5% of Hispanic transfer and 80.7% of remainder of the class students showed score improvement in mid-term exam 2, while 50% of Hispanic transfer and 57% of remainder of the class students showed score improvement in the final exam. The decline in the final exam for both groups was partially related to the lower number of students completing both attempts for the finals in both student groups. Only 50% of the Hispanic transfer students and 53% of the remainder of the class students took both final exam attempts.

The effect of the multi-attempt assessments on student success and retention was also evaluated by comparing the cumulative class performances of the Statics and Dynamics sections with control baseline sections for both courses taught by the same instructors in the same format without multiple-attempt assessments. Figures 2(A) and (B) present the comparative cumulative grade distribution and failure and withdrawal rate data for Statics and Dynamics for both remainder of the class and Hispanic transfer student groups. For the Statics section, the Hispanic transfer group received higher A's and C's and lower B's and D's in the multi-attempt section in comparison to the baseline section. However, the student failure rate was still high in the Hispanic transfer group with multi-attempts. For the Dynamics section in which multi-attempt assessment was implemented, a marked increase in students receiving A's and a sharp decline in the students receiving C's across both student groups was observed compared with the baseline section. The Hispanic transfer group also received higher B's in the multi-attempt section than the baseline section. Another positive trend observed was the reduction of failure rates (measured in terms of D's and F's) to almost 0% in both student groups in the multi-attempt section.

Student retention measured in terms of student withdrawal rates was also evaluated between the multi-attempt and the baseline sections. In both Statics and Dynamics, the reduction in student withdrawal rates was higher for the Hispanic transfer group than the remainder of the class student group. In Dynamics, the student withdrawal rates reduced from 7% in the baseline section to 2% in the multiple-attempt section for the remainder of the class group. In contrast, for the Hispanic transfer group, this reduction was from 14% in the baseline section to 5% in the multi-attempt section. Similarly, in Statics, a stark reduction in the student withdrawal rate for the Hispanic transfer group was observed from 56% in the baseline section to 12% in the multi-attempt section. These results corroborate the positive effects of multi-attempt assessments in improving student success and retention in foundation engineering courses.



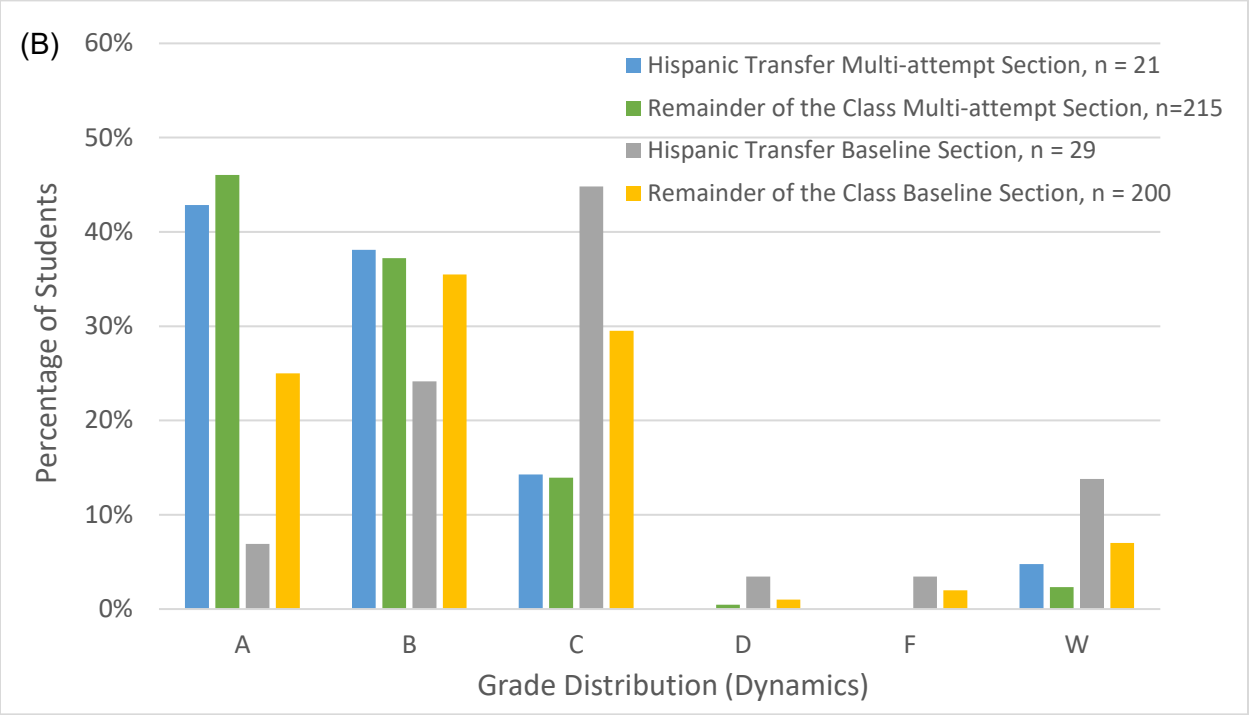


Figure 2: Comparison of cumulative grade distribution in the multi-attempt section and baseline section in (A) Statics and (B) Dynamics

Student perception of the multi-attempt-based intervention as gauged through an IRB-approved end-of-course survey administered in the Statics and Dynamics sections are detailed in Table 1. The survey data presented is for all students, including the Hispanic transfer students. 89 - 95%

of the students in both sections perceived that the multi-attempt assessments helped them learn the course concepts better and helped improve their performance. 91 – 95% of students in both Statics and Dynamics agreed that the multi-attempt method helped them recognize their course standing and the amount of preparation needed. Similarly, 89 -96% of students agreed that the multi-attempt method made their exam-taking process less stressful. The survey responses were positive for both sections and thus solidified the benefits of the muti-attempt assessment method observed through student performance data in both courses.

Table 1: Student responses to multi-attempt survey questions in Statics and Dynamics (*S = Statics, n = 59; D = Dynamics, n = 236)*

Post-Course Survey Questions on Multi-Attempt Assessments	**Strongly Agree (%)**		**Agree (%)**		**Neutral (%)**		**Disagree (%)**		**Strongly Disagree (%)**	
	S	**D**	**S**	**D**	**S**	**D**	**S**	**D**	**S**	**D**
The multiple attempts helped me take the exams with less stress, knowing that I had other chances.	71.19	79.84	16.95	16.53	8.47	2.02	3.39	0.4	0	1.21
The multiple attempts gave me the opportunity to go back and learn the concepts better before my next attempt.	74.58	81.05	15.25	14.11	8.47	3.63	1.69	0.0	0.0	1.21
The multiple attempts gave me the opportunity to recognize my standing in the course before my next attempt.	76.27	78.14	15.25	16.6	1.69	4.05	5.08	0.0	1.69	1.21
The multiple attempts gave me the opportunity to recognize the amount of preparation I need before my next attempt.	74.48	82.11	20.34	13.01	3.39	3.25	0.0	0.41	1.69	1.21
The multiple-attempt exams helped improve my performance in this course.	74.58	80.57	15.25	13.77	8.47	3.24	1.69	0.40	0	2.02
Irrespective of my grades in the class, I feel that the multiple-attempt exams helped me learn the course concepts better.	50.85	77.02	39.98	17.34	5.08	3.63	1.69	0.40	3.39	1.61

4. Conclusion and Future Work

The results of implementing multi-attempt assessments in high-enrollment foundation engineering course sections of Statics and Dynamics were promising. In this study, the authors redesigned the major assessments in these courses in the multi-attempt format through the creation of test question banks while delivering the assessments through a proctored testing facility at the authors' institution. The effectiveness of the muti-attempt format in enhancing student success was evaluated through student through a comparison of cumulative grades with baseline sections with no multi-attempt taught by the same instructors. In both Statics and Dynamics, 50 to 80 % of the students demonstrated score improvement after multiple attempts in the different assessments that used the same format. The overall course performance, as measured through cumulative letter grades, was also better in the multi-attempt sections than the baseline sections, with an increase in A's and B's and a decline in C's and D's for all students. The multi-attempt format was successful in significantly reducing the high attrition rates of Hispanic transfer students in these foundation course sections, with 78% and 64% reductions in withdrawal rates across sections in Statics and Dynamics, respectively. Student perception of the effectiveness of the format in enhancing student success and learning was also high as measured through survey responses. The preliminary results presented in this study are promising and motivate the authors to continue examining and expanding multi-attempt-based assessments in future courses.

Acknowledgement

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