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Preliminary Readiness Evaluations to Motivate Improved Exams (PREMIEs)

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Abstract: Short, early, forgivable tests on basic concepts improved scores on midterm exams in sophomore and junior electrical engineering courses and were viewed favorably by students. Unexpectedly low test scores demotivate many students, supporting not only the use of repeated, spaced testing to enhance knowledge recall but also incremental, low-stakes testing to bolster student confidence and hence motivation. In response to poor midterm exam scores and subsequent demoralization, Preliminary Readiness Evaluations to Motivate Improved Exams (PREMIEs) were introduced into 200-level circuits and subsequently 300-level electronics courses. The PREMIEs are given two weeks prior to each midterm exam; are worth 30% of the total exam points; and cover the most basic concepts, which are foundational to the more advanced concepts on the exam. Risks and rewards associated with the PREMIE are structured to motivate preparation for both the PREMIE and midterm exam while still offering a second chance. Students can choose to replace their score on a PREMIE with their score on a comparable portion of the midterm if – before the midterm – they commit to doing so, regardless of which score is higher, and meet with the instructor or an assistant to review their mistakes on the PREMIE. Students who are satisfied with their PREMIE score do not repeat the comparable portion of the midterm and thus do not risk a lower score on those basic questions and are rewarded with less work on the midterm. Uncurved median scores on the first and second midterm exams in the two semesters before PREMIEs were introduced averaged 56% and 53%. They increased to an average of 71% and 68% in the first two semesters afterward. Student comments about PREMIEs in course reviews in both courses were predominantly positive before and during the COVID-19 pandemic.

INTRODUCTION

For many students, learning increases with the level of instructor expectations until those expectations appear unachievable or unreasonable, at which point student motivation and thus learning declines. Summative exams with scores dramatically lower than student expectations risk demoralizing students, leading to yet worse scores on subsequent exams. Many students only study if they believe the extra preparation will yield commensurate improvement in grades. More numerous, incremental, and lower-stakes challenges can lead students to greater achievement by avoiding unrecoverable failure while simultaneously maintaining expectations for student abilities at the end of a course. These observations led to the introduction of short, forgivable, tests over foundational concepts prior to midterm exams in two undergraduate electrical engineering classes taught by the presenting author. The tests are called Preliminary Readiness Evaluations to Motivate Improved Exams (PREMIEs). The acronym is intended to evoke the image of an early state of learning that needs additional, special care to reach maturity. The forgiveness process has been designed to motivate early preparation for exams as well as foster more personal engagement with the instructor or assistants.

COURSE DESCRIPTIONS

PREMIE tests were first tried in a service (non-major) class predominately populated by mechanical engineering majors and subsequently adopted in an electronics class for electrical engineering majors. Details of the classes including the topics of the PREMIE tests are provided in Table 1. The PREMIE tests occur two weeks before the full midterm exams and cover the most foundational concepts to be assessed on the exams. Mastery of these concepts is critical to demonstrating knowledge of the more advanced concepts assessed on the full midterm exams.

Table 1. Electrical and Computer Engineering (ECE) courses incorporating PREMIE tests

ECE Course	204 – Fundamentals of EE 3 credit hours, no lab		331 – Electronics Principles 1 4 credit hours including lab	
Student Major	~99% mechanical engineering ~1% chemical & biological eng.		~60-90% electrical engineering ~10-40% computer engineering ~2% engineering physics	
Enrollment	Before PREMIEs: 78 in Fall 2016, 201 in Spring 2017; with PREMIEs: 96 Fall 2017, 80 Spring 2018,		96 Fall 2020, 96 Fall 2021, 70 Fall 2022	
PREMIE	30 points total, 5 questions; approximately 2 weeks before midterm exams, 25 minutes in class			
PREMIE Format	Multiple choice questions		Numerical calculation questions with limited partial credit grading	
PREMIE Topics (see abbreviations and initialisms below table*)	<u>Midterm 1</u> KCL, KVL, Ohm's law, parallel & series recognition	<u>Midterm 2</u> C&L impedance, i-v phase, phasor KVL or KCL, AC Ohm's law, sinusoid graph, RMS, complex math & conver.	<u>Midterm 1</u> Diodes: expon. model I or V, rectifier output, rectifier filter C, differential resis.	<u>Midterm 2</u> I-V behavior of npn & pnp BJTs and n-channel & p-channel FETs, simple circuits, output resistance
PREMIE Redo (optional)	Same format, number of questions, points, and topic coverage as PREMIE; optional portion of midterm exam, 75 minutes in class for entire midterm			
Midterm Exam	70 points, 75 minutes including optional PREMIE Redo			
Midterm Exam Format	9 multiple choice questions (54 pts) + 1 or 2 free response quest. (16 pts)		Typically 7 to 10 numerical calculation and fill-in-the-blank q's	
Midterm Topics (in addition to optional PREMIE Redo section) Not all topics are tested on a single year's midterm.	<u>Midterm 1</u> I & V dividers, superposition, Thevenin & Norton equiv's, max power transfer, equiv. R, L, C; equiv. circuit reduction & re-expansion, L & C DC behavior, energy storage; L & C i-v relationships, RC & LC circuit transients	<u>Midterm 2</u> Avg, reactive, & apparent power, AC Thevenin & Norton equiv's, AC superpos., AC nodal eq'ns, wye & delta 3-phase circuits, simple filters, op amp circuits, D-R circuits using load lines, multiple D & R circuits, diode clipper circuits	<u>Midterm 1</u> Ideal diode circuits (clipper, clamp, rectifier, multiple Ds and Rs), filtered rectifier design, Zener diodes, junction C, semiconductor vocabulary, BJT I-V char., simple BJT circuits, D & BJT operating regions.	<u>Midterm 2</u> Common source & common drain FET amplifier circuits, source degeneration, biasing circuits, combined AC & DC waveforms in FET amps, small signal parameters, velocity sat., multi-region BJT & FET operation.

*Topic abbreviations, initialisms, and symbols: C = capacitor, D = diode, L = inductor, R = resistor, KCL = Kirchoff's current law, KVL = Kirchoff's voltage law, BJT = bipolar junction transistor, FET = field effect transistor, RMS = root mean square (conversion to or from amplitude)

PREMIE TEST STRUCTURE AND PHILOSOPHY

The instructional goals for PREMIE tests include mastery of fundamentals, improved study habits, fostering personal connections to the instructor or course assistants, and familiarization with testing formats and expectations. Early and spaced study of fundamental concepts enhances students' ability to recall and apply them. To better motivate students to prepare early for a test that can be replaced, the procedures for replacing the PREMIE test are designed to require non-trivial effort and some level of planning. If a student is not satisfied with their score on a 25-minute 30-point PREMIE test, they can replace the score on the original PREMIE with the score on an equivalent section of the midterm, called a PREMIE Redo, if they commit to doing so before the midterm and meet with an instructor or assistant to discuss their mistakes on the PREMIE. Meeting with the instructor or an assistant is intended not only to help the student identify and understand technical mistakes or misconceptions but also to establish a more personal connection in hopes that the student will be less hesitant to seek personal help in the future during office hours or other times. At the meeting, which must occur at least 48 hours prior to the midterm to provide sufficient study time, the student is required to sign a form stating that they will accept the score on the PREMIE Redo even if it is lower than their original PREMIE score. Partial replacement of only some questions on the PREMIE is typically not allowed. Students redoing the PREMIE are thus placing their original score at risk, which is intended to incentivize more study. They will also need to use some portion of the 75 minutes allocated to the full midterm exam on the PREMIE Redo. Avoiding redoing PREMIE questions during the midterm time motivates students to prepare for the original PREMIE while still providing a safety net should they perform poorly on the test. Beyond the PREMIE Redo section, the rest of midterm exams are typically worth 70 points.

ANALYSIS OF IMPACT ON MIDTERM EXAM SCORES

After disappointing exam scores and student disengagement in a particularly large section of ECE204 during spring 2017, PREMIE tests were introduced in this course in fall 2017 and were accompanied by increases in test scores for all percentiles as shown in Figure 1. Comparing the two semesters immediately prior to PREMIEs to the two immediately after, introducing PREMIEs corresponded to an increase in the median score (averaged across the two semesters) from 56% to 71% for the first midterm and from 53% to 68% for the second midterm prior to any curving. Prior to PREMIEs, all 5-percentile scores were below 40% and were above that mark afterwards, keeping the vast majority of students within reach of a passing grade, and thus fostering continued engagement.

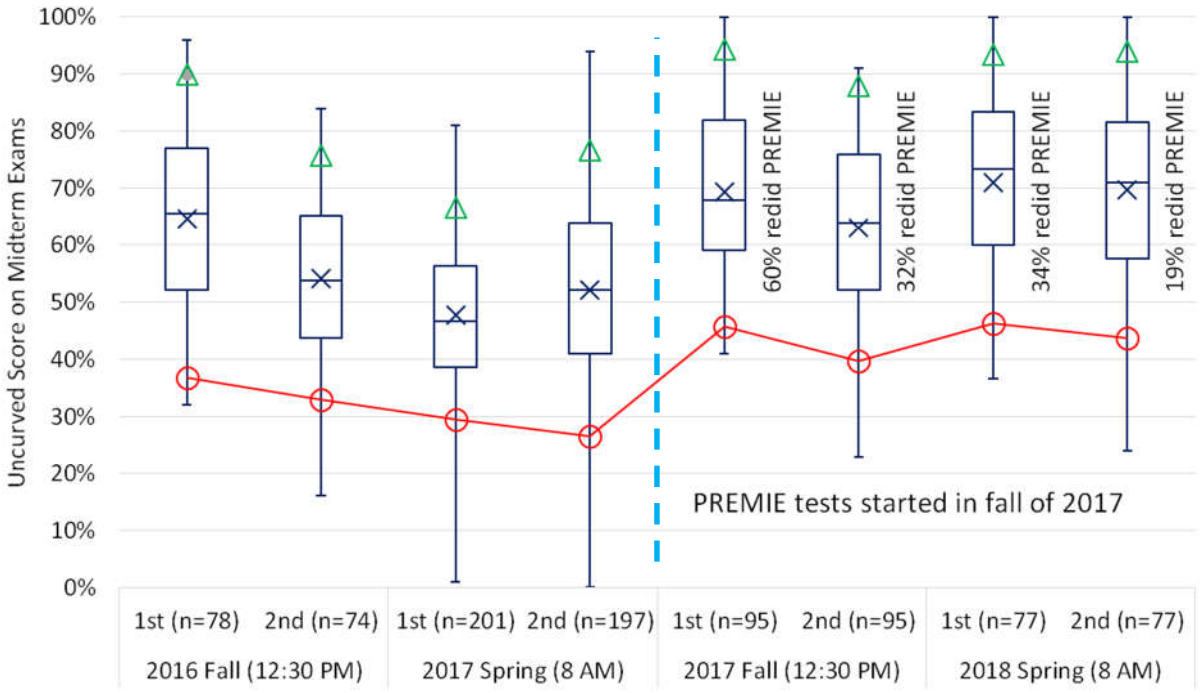

Figure 1. Statistical box plots showing the quartile distribution of midterm exam scores augmented with mean (X), 5-percentile (O), and 95-percentile (triangle) before and after PREMIE tests were introduced two weeks before each of two (1st & 2nd) midterm exams across four semesters. The number of students taking each exam (n) and fraction electing to redo their PREMIE are also noted.

Additional analysis has investigated correlation between overall midterm exam scores with PREMIE scores, whether or not students redo PREMIEs, and the level of score improvement for those students redoing the PREMIE. The Pearson correlation coefficient for students' PREMIE score (including the Redo) and the remaining 70-point sections of the midterm exams that have more difficult questions range from 0.20 to 0.23 for Midterm 1 and 0.33 to 0.36 for Midterm 2. One factor weakening the correlations is the saturation of PREMIE scores near the 30-point maximum. Except for the one time the majority of students elected to redo their PREMIE, students who redo the PREMIE score significantly lower than students who keep their original score, on average. While lower-scoring students are the ones predominantly electing a PREMIE redo, we hypothesize that stress reduction, early study, or other factors may benefit most students. Finally, no clear correlation is seen between the 70-point midterm sections and the change in PREMIE score upon redoing it as shown in Figure 2. This data does indicate that the majority of – but not all – students score better on the PREMIE on their second attempt.

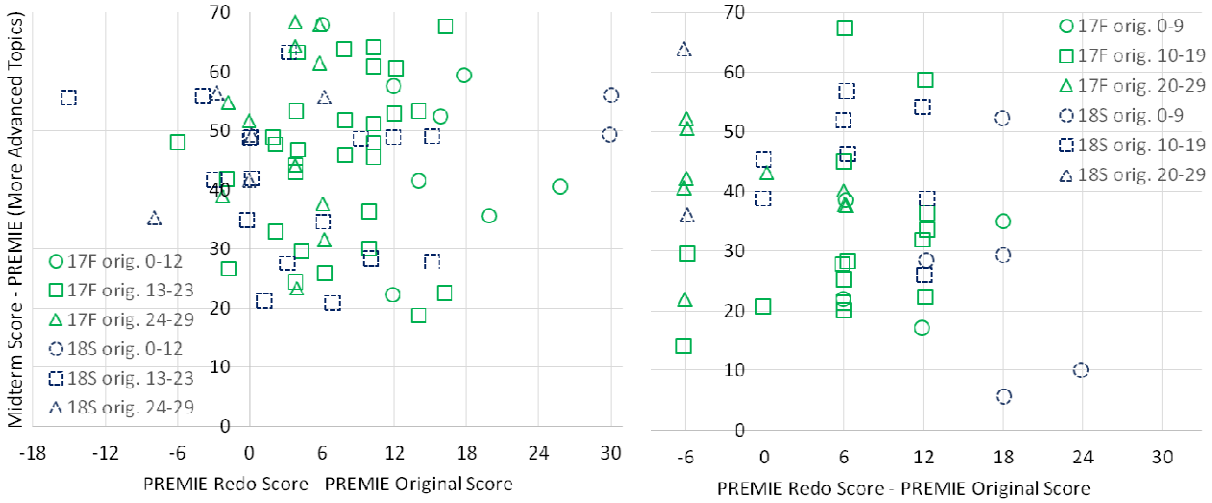

Figure 2. Scatter plots showing no obvious correlation between the non-PREMIE portion of midterm exam (1st on left, 2nd on right) scores and the net score change on redoing a PREMIE. Shapes of symbols indicate the ranges of initial PREMIE scores as indicated in legends.

In conclusion, despite no clear statistical data showing the specific mechanism for improvement, the introduction of PREMIE tests is highly correlated with improved midterm exam scores.