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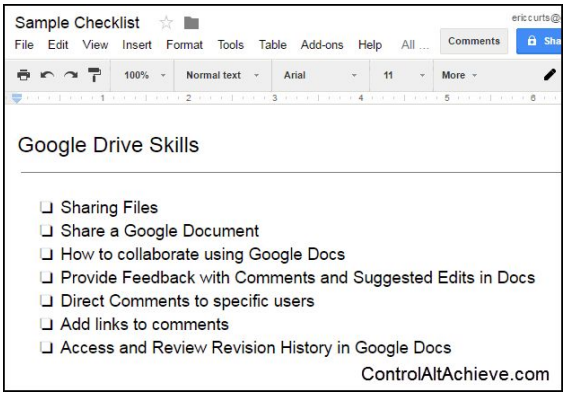

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Title

Topical, Randomized Quizzes Administered Electronically in an Introductory Electromagnetism Course at MIT

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Abstract

We developed five 30-minute topical quizzes for Introductory Electromagnetism (8.02 at MIT) and administered the quizzes electronically in class in the fall 2018 semester (n~150 students). The quizzes each had ~8 questions and covered one or two topics. To allow online administration in an environment where students could view others' screens, each problem on the quiz was selected randomly from up to three variants (four in one case) that had slight differences (such as the rotation of a coordinate system, a different figure, different parameter values, etc.). We examined student scores for each problem, which showed its relative difficulty and highlighted any differences among its variants. Finally, we observed that quizzes correlated more strongly with the final exam than did any other component of the course (correlation coeff. ~0.69), including the two hour midterm exam. Based on these data, we intend to optimize the overall difficulty of each quiz, and we ultimately hope to make these online quizzes available to instructors at other institutions, possibly with an easier and a harder version.

Introduction

8.02 Electricity and Magnetism is a large, general requirement course at MIT. It utilizes the TEAL (Technology Enhanced Active Learning) format of blended learning, where in-class instruction is bolstered by active engagement (e.g. group problem solving and online response questions). Students interact with much of the material online, and we decided to incorporate online, bi-weekly quizzes into the course for the following reasons: (1) more frequent assessments encourage students to engage with the course material more regularly and are pedagogically beneficial [1, 2], (2) online quizzes enable automated grading, which has better reliability than hand grading and takes less time, (3) online quizzes provide immediate feedback to students and can allow them a second attempt if the first one is incorrect, and (4) having more quizzes than midterm exams reduces student stress, particularly if the lowest quiz is not averaged.

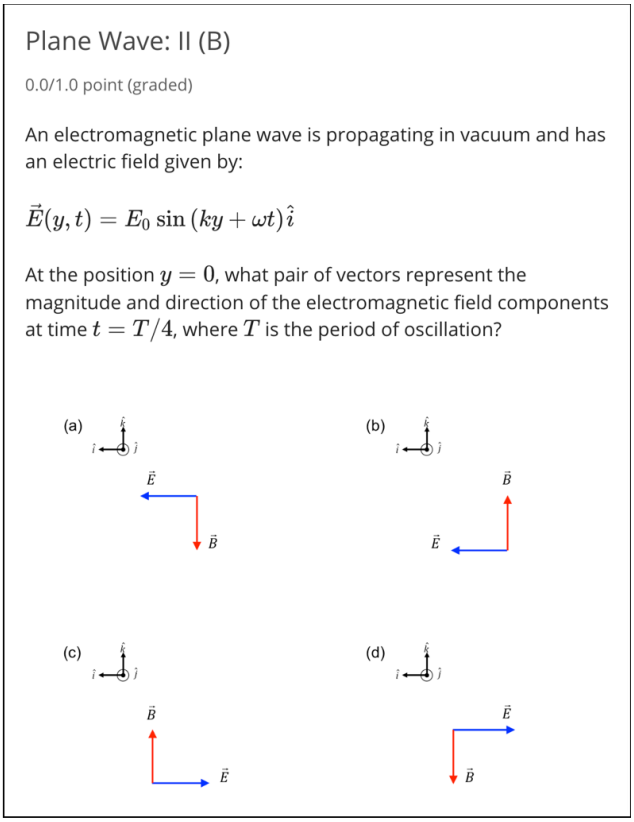

Figure 1: Quiz 5, Problem 3, Variant B. Plane wave traveling in the negative y-direction. Other problem variants present a plane wave traveling in the positive y-direction. This variant may have been less difficult compared to the other variants, based on student scores.

We created a set of 5 quizzes, each focused on one or two topics chosen from a "topic inventory" of the course, addressing the most frequent topics covered during the week(s) preceding each quiz. Together, these 5 quizzes provide basic coverage of the traditional E&M

syllabus. Each quiz had ~8 problems, divided evenly between multiple-choice problem type and formula (or numeric) response type. Where possible, we directly used or adapted problems from research-based assessments (CSEM [3], BEMA [4], SGLCS [5], Physics GRE). In the figure above, we show a sample problem, which we will refer to again in the next section.

Results

Below we show a histogram of student scores for all problems on all 5 quizzes. In this figure, the vertical axis indicates the average score, the color magnitude indicates the number of students answering each question, and problem variants are grouped together (where relevant). We make the following observations based on these results: (1) Some problems are very easy (e.g., Quiz 1, Problem 4), and we hope to alter or remove these problems in the future to produce more appropriate assessments for our class. (2) Difficult problems (e.g., Quiz 2, Problem 0) may highlight areas needing better instruction. (3) Average scores on variants do show differences (e.g. Quiz 5, Problem 3), and we intend to perform additional analysis to determine whether these differences are attributable to the inherent difficulty of problem variants or statistical effects. Differences between problem variants may elucidate conceptual barriers, and as an example, we show Quiz 5, Problem 3, Variant B in Figure 1. The difference between this high-scoring variant and the low-scoring variants is simply the direction of the propagating wave that is given. Students may have an easier time conceptualizing this variant.

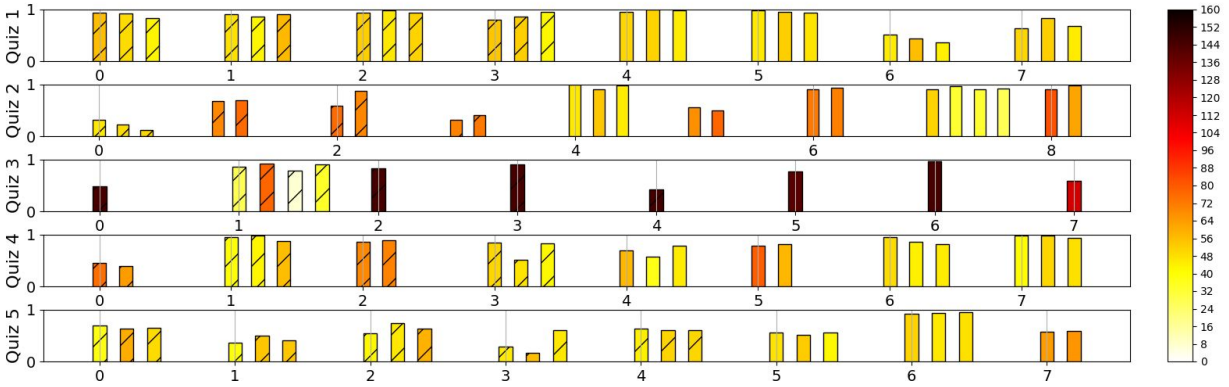

Figure 2: Histogram of student scores on quiz problems. Each quiz is represented as a row (description in text).

Finally, we also show the correlation of student grades in each category with students' final exam grade in the table below. Amongst the types of assessments within this course, quizzes correlate best with final exam scores. This strongly suggests that our bi-weekly quizzes are perhaps an even more effective assessment of students' abilities than traditional hand-graded tests. This, in addition to the benefits of online quizzes enumerated in the introduction, further motivates their broader implementation (in subsequent semesters and at other institutions, and possibly as a replacement for the hand-graded final exam).

Table 1: Correlation of student grades in each category with students' final exam grade.

Category of Assessment	Quizzes	Midterm	Psets	Prepsets	In-class Problems	Experiments	Concept Questions
Correlation w/ Final Exam	0.69	0.55	0.43	0.41	0.39	0.33	0.24

References

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