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Benefits of webcasts "Muddy Points"

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Introduction and background:

Classroom assessment techniques are simple formative activities designed to gather near-immediate feedback from the students about the teaching-learning process which the instructor can use to improve student learning and his/her teaching effectiveness [1]. Classroom assessment techniques also help students reflect on their understanding of the course content as the course is unfolding and, in this way, promote the development of lifelong learning skills [2]. Multiple classroom assessment techniques have been described and collated in the classic reference “Classroom Assessment Techniques: a Handbook for College Teachers” by T.A. Angelo and K.P. Cross [3].

The “muddy points” or “muddiest point” (MPs) is one of the most commonly used classroom assessment technique that consists in asking students at the end of a lesson to jot down their answer to the question “what was the muddiest point in today’s lesson” in which “muddiest” signifies “most confusing”. The student responses collected anonymously are reviewed by the instructor who addresses the most common or most relevant MPs at the beginning of the next lesson. The use of MPs encourages students to think about the content they were just exposed to and decide if they understand it. MPs also demonstrate to the students that the instructor is motivated to help them learn by tailoring a part of each lesson to their specific questions [4]. The use of MPs has been shown to improve students’ performance in an introductory engineering course [5] and in a junior-level bioinstrumentation course [1].

In traditional implementations, the hand-written students’ MPs are collected on paper before the students leave the classroom. Current extensions use a variety of online survey tools and website fill-in fields to query the students. In the present study, we extended the MP technique to clarify using short webcasts misunderstandings identified in students’ questions and in their responses to short formative quiz problems.

Methods:

The MP technique was used in the context of a Medical Electronics course offered at our institution to undergraduate students in Biomedical Engineering. The semester-long course is required for a subset of students pursuing the BS degree in Biomedical Engineering, with a typical enrollment between 40 and 50 students evenly divided between juniors and seniors. The course discusses fundamental analog electronic components found in most biomedical instruments (pn diodes, transducers, operational amplifiers, instrumentation amplifiers, bipolar junction transistors) and their applications in common electronic functions used to measure and condition biomedical signals (dc power generation, sensing, amplification, filtering, switching). Students attend two 80 min class periods and one 3-hour laboratory every week. The course is organized as a “flipped classroom”, with the learning material distributed through short narrated video presentations posted on the learning management system (LMS) supplemented with textbook readings. In the classroom, a short review of the content driven by students’ questions is followed by group exercises in which the students work on problem sheets. The instructor and the teaching assistant roam the classroom and work with individual groups as they are solving the problems to encourage the students to collaborate, to check their progress, and eventually to help them start toward the solution. When most students’ groups complete or are well-advanced in solving a problem, the instructor reviews the key steps toward the solution and the problem’s answers verbally or at the white board before moving on to the next problem. Several assessment tools are used to track the students' progress and to assign grades, including short objective (multiple-choice) formative quizzes administered in class after each section of the course is completed, for a total of 6 or 7 quizzes in the semester.

The flipped classroom model has been well appreciated by most students who enroll in the course, as demonstrated by their engagement during the completion of the problem sets and has resulted in measurable improvements in student performance in summative exams [6]. However, students who perform poorly in summative exams usually fail to ask questions when asked if they understand the video lessons or the problem sets, often because they do not want to appear less qualified in front of their classmates. These students often do not stand out from among their classmates during the problem-solving group activities either because they "hide" in the group or because they can solve the problems with initial help from the classmates but are not able to complete similar problems by themselves during the examinations.

In this context, we experimented with the MP technique to attempt identifying topics that caused problems to students and to encourage the less performant students to ask questions. Students' MPs were collected in 3 ways: 1) the traditional way with a large envelope in which students were invited to write down anonymously any confusing issue they had encountered during the video lesson or the class meeting; 2) with email by asking the students to send a message when they had difficulty understanding part of a lesson or the solution to a problem; 3) by examining the answers to formative quiz questions that a large number of students had answered incorrectly. The students' answers to the formative quizzes were graded immediately after each quiz was completed and the tabulation of the answers was used to identify the MP to address.

For each MP, a brief (3-5 min) narrated video webcast presentation was developed with Camtasia Studio within 24 hours after the MP was identified. About 30-45 min time was necessary to design and produce a webcast, divided between the time to prepare the solution, record the narration, editing, and posting the webcast on the LMS. Each webcast presented the original circuit drawn with a circuit simulation software or the question copied from the student's email message, a conceptual approach to the solution contrasted with the reasoning error made by the student(s), and the numerical calculations to reach the expected solution.

The LMS recorded when each student watched each MP webcast. Students could watch the MP webcasts as often as they chose, and the webcasts remained posted on the LMS until the end of the course and the final exam. In addition to the webcast viewing record were available the scores of the students on each question of the two summative exams (midterm and final exam).

We examined three questions in relation to the use of the MP webcasts in the course:

<u>Question 1:</u> Do the students watch the MP webcasts and how does their viewership change during the semester? Using the LMS record, we coded the student access to each webcast as 0 (not accessed), 0.5 (partly accessed), 1 (accessed in full). We examined how many students accessed each MP webcast at least once in the semester.

<u>Question 2:</u> Is there an association between the student's access to the MP webcasts and their performance on the summative exams? An overall exam score was computed for each student using the midterm and final exam scores weighted by the percent value each exam carried toward the course score. The correlation between number of MP webcasts viewed and exam score was examined for

significance. We also compared the exam scores of the students who watched 10 MPs or more (> 70%) to those who watched 4 MPs or less (< 30%) considering these bounds as indicative of diligent vs. limited use, respectively.

Question 3: Do students who watch a MP webcast do better on an exam question that addresses a similar problem than students who do not watch that webcast? Seven questions on the final exam asked students to analyze a circuit that was like a circuit presented in a MP webcast. We examined the average score on these questions for the students who had watched the webcast and those who had not (score = 100% for correct answer; score = 0% for incorrect answer).

Results:

Fourteen MP webcasts were produced in the semester (~ one/week) with 7 MP webcasts motivated by students' questions and 7 MP webcasts resulting from quiz questions that the students answered poorly.

Figure 1 presents screenshots from a MP webcast generated in response to a student question. The circuit is a full-wave rectifier that produces a negative pulsating voltage which the students are asked to analyze in one of the video lessons. The lesson explains in detail the analysis of a full-wave rectifier that produces a positive voltage but the student who asked the question could not replicate the analysis to the situation when the direction of the diodes is inverted to create a negative waveform. The MP webcast uses the circuit simulator to help the students visualize the load waveform that is produced by the circuit (left panel). The narrated explanations clarify the effect of the direction of the diodes on the waveform sign. Calculations of the load voltage and current (right panel) included in the MP webcast demonstrate that the same formulas are used to compute these parameters irrespective of the direction of the diodes.

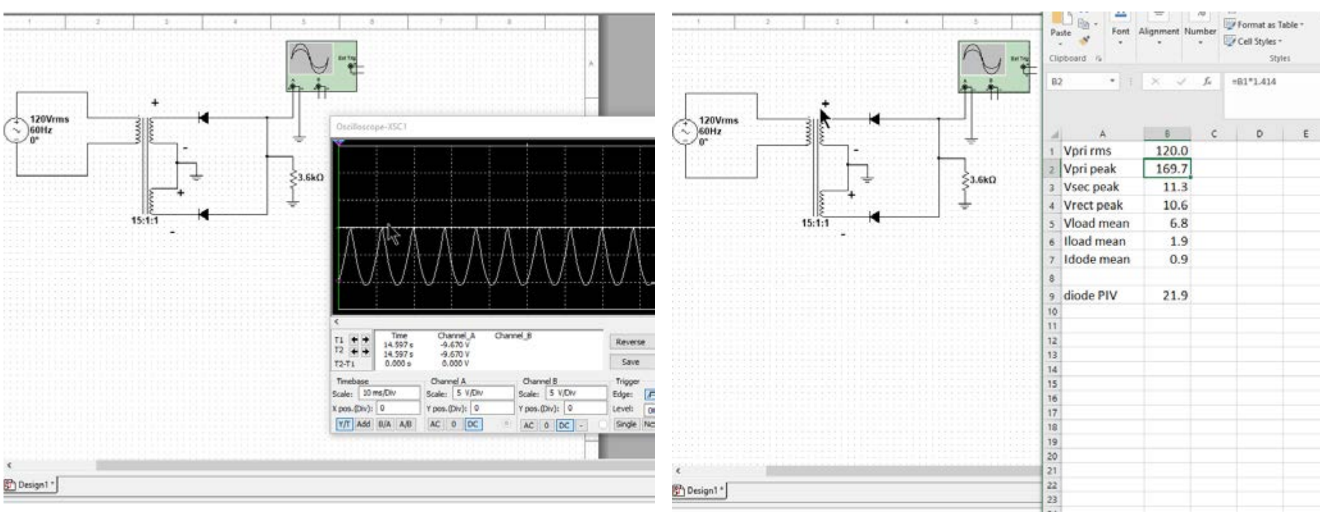

Figure 1: negative full-wave rectifier MP webcast

Figure 2 shows screenshots from a MP webcast generated to address widespread errors in answering a formative quiz question dealing with an inverting op-amp amplifier circuit in which the source driving the amplifier has a finite resistance. The output voltage produced by the circuit is shown (left panel) and contrasted with the answer selected by the students during the quiz. The recording explains why the students' answer is different from the actual output voltage. Students used as input voltage to the amplifier the voltage at the mid-point of the voltage divider connected to the amplifier input, but they fail to account for the voltage divider equivalent resistance (the resistance of the Thevenin equivalent). The circuit that would produce the answer selected by the students is shown (right panel) and the difference between that circuit and the circuit that accounts for the input source resistance (bottom circuit in the two panels) is highlighted.

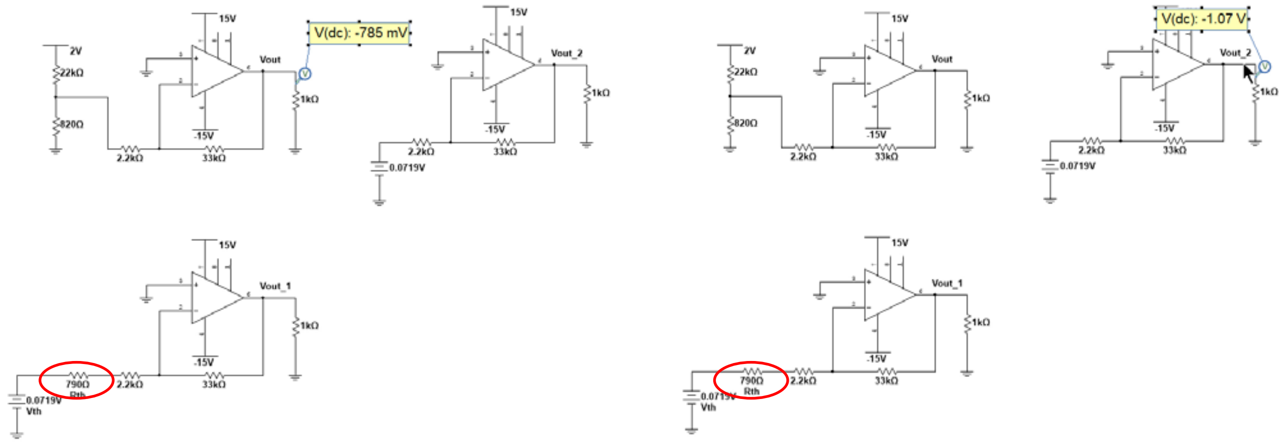

Figure 2: inverting op-amp amplifier with finite source resistance MP webcast

Approximately 65% of students (range 54% to 73%) watched the first 11 MP webcasts (not shown for MP 1) posted before the 10^{th} week of the semester (Figure 3), with some fluctuations resulting in part from co-current demands on the students' time in other courses. The highest percentage (MP 11) was recorded just prior to the midterm exam and addressed a question of the exam review that some students had difficulty answering and for which they asked for additional clarification. In contrast, about 42% of students watched the last 3 MP webcasts posted after the "Spring Recess" period. In part, several misconceptions which repeatedly confused students and were addressed in the initial MP webcasts were eventually rooted out, decreasing the viewership and the need for additional webcasts. It is also likely that the approach of the end of the academic year and college graduation for the seniors affected the MP viewership. Juniors tended to access the MP webcasts more than seniors (average 8.2 MPs for juniors vs. 6.6 MPs for seniors) but the difference was not significant.

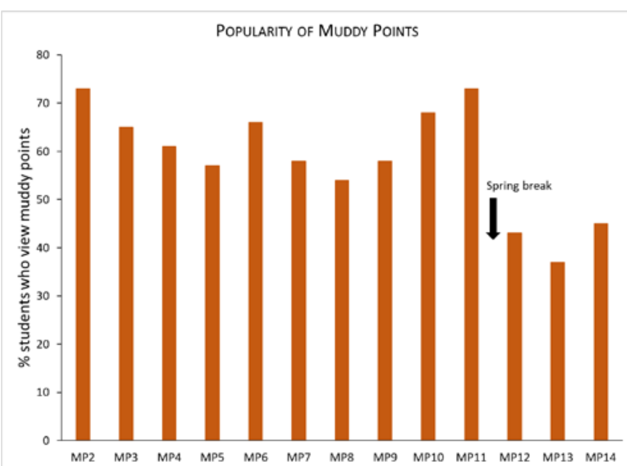

Figure 3: MP viewership

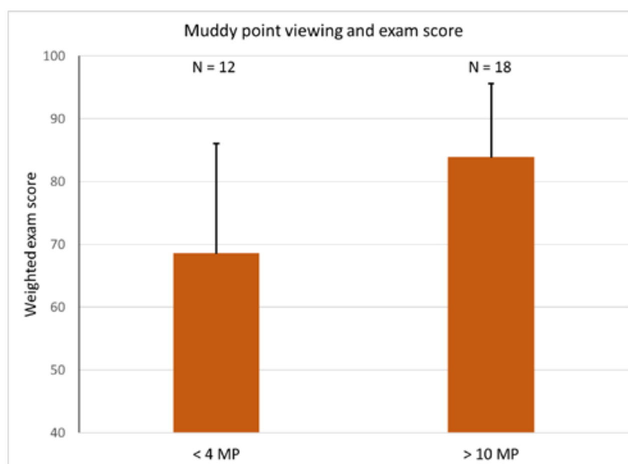

Figure 4: Exam scores for low and high viewership students

There was a significant positive correlation between the number of MP webcasts viewed by a student and his/her weighted summative exam score ($r = 0.44$, $p < 0.01$). In addition, the 18 students who viewed more than 10 MP webcasts scored on average 15 points higher on summative exams than the 12 students who accessed less than 4 MP webcasts (Figure 4).

The success rate in answering questions that had been addressed in a MP webcast was significantly different depending on whether the student had watched the MP webcast or not ($p < 0.05$). Students who had watched the webcast answered the question successfully 74% of the time (±44% SD) while students who had not watched the webcast answered the question correctly 64% of the time (±48%).

Discussion:

The results of this preliminary study demonstrate that a large majority of students used the MP webcasts as additional aid in learning the course material during a substantial part of the semester. We found positive correlations between the number of MP webcasts viewed and summative exam performance and between having watched a MP webcast and answering correctly a related question on a summative exam.

When examining whether a student had accessed a MP webcast, we counted having viewed the webcast if the student accessed the recording at least once between its posting and the end of the semester. In the record, it was clear that most students accessed the webcasts several times, particularly during their preparation for summative exams. A few students who began preparing for the May final exam during the month of April started re-accessing the MP webcasts at that time even when they had viewed the webcast earlier at the time of its posting. Other students who studied intensely during the study days period leading to the final exam likewise reviewed the MP webcasts as part of their preparation. Thus, in addition to their benefit in dispelling misconceptions or providing clarifications during the presentation of the course content, the MP webcasts presented the advantage over fleeting in-class discussions of providing a permanent record on topics which had been troublesome to the students during the semester.

A substantial benefit of the MP technique is that issues that are troublesome to a few students are often equally troublesome to many other students who for various reasons do not seek help to address their misunderstandings. As noted by others [1], instructors often spend considerable time answering the same questions to individual students during office hours or by email. The MP discussion, whether it takes place in the classroom or through a webcast avoids these repeated conversations since the students can find their answers in the MP presentation. In this way, instructor time used to generate the MP webcast is more than compensated by the time saved in responding to the same questions during office hours.

This being a correlational study, we cannot affirm that access to the MP webcasts helped students perform better on summative exams. It is possible that the more driven or more studious students who would have performed well on the exams without the MPs found in the webcasts an additional resource to help them prepare and obtain high test scores. However, even excellent students can be confused on a specific aspect of a course or a problem. These students are more likely than others to ask for clarification and the answer to their queries in a MP webcast can benefit many other students. Ramos [1] provided the answers to MP questions in written documents made available online to all students in a bioinstrumentation project course. The author noted that the feedback available in the MP documents helped students better understand technical content and justify their design decisions. Krause and Colleagues [5] produced "Youtube" videos webcasts to explain MPs in an introductory engineering course. They observed that students who had access to the webcasts received better scores on exams that previous student cohorts who did not have access to the MP webcasts. In their study, the MP webcasts consisted in ~ 20 min narrated lessons to clarify concepts from the course material and in this way, they differed from the MP webcasts we developed which were much shorter and focused on solving analytically and numerically a specific quantitative problem.

Distractors (wrong answers) in formative quiz questions are chosen based on perceived common students' confusions or errors. For instance, it was assumed that some students would fail to account for the effect of the Thevenin resistance in the loaded voltage divider in the example of Figure 2 and one of the distractors was chosen based on this reasoning error. By examining the relative frequency with which distractors are chosen, one could objectively identify the most frequent student confusions in a student group and specifically address them when developing the MP webcast. While we did not pursue this approach for this first study, it could add to the benefit of the MP webcasts especially for large classes.

We did not survey the students to query them about their perception of the MP webcasts, but based on their usage, we can assume the students appreciated them. Krause et al. [5] who had surveyed their students in relation to MP webcasts found that 93% of students agreed these tools helped support learning. Mansfield et al. [4] who used MPs in an online graduate course also received favorable student feedback when the MP questions were addressed rapidly after they had been identified.

We have yet to decide whether collating the MP webcasts from a previous offering of the course and making them available in a "library" of MP webcasts would be useful. Rationale for MPs are to respond in a timely manner to student questions, to help students reflect about the content of a course as they are learning it, and to sensitize the students to the fact that the instructor is responsive to their questions and difficulties [2]. In that regard, a record of previous MPs does not appear to beneficial even if many students' questions are likely to be similar from year to year.

Conclusion:

MP webcasts are useful learning complements that help students clarify difficult concepts and create a lasting record enriched by computer simulations and visualization. Students access the MPs sufficiently frequently to justify the preparation time and effort. Students who watch the MP webcasts diligently obtain higher scores on summative exams and do better when answering exam questions previously addressed in the webcasts.

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