AC 2010-366: WEB-BASED AUTOMATED STUDENT LEARNING ASSESSMENT TOOL FOR INTRODUCTORY ELECTRICAL ENGINEERING COURSES

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Web-based Automated Student Learning Assessment Tool for Introductory Electrical Engineering Courses

Abstract

Establishing cost-effective procedures to obtain assessment data without excessive academic staff efforts is an important issue for most academic institutions. Assessment becomes especially problematic for large classes, because it demands excessive instructor resources. Computer-based online assessment has great potential to provide viable solutions to this problem, because web-based assessment has many unique advantages such as convenient administration, automated data collection and analysis, timely feedback, and easy update. In this paper, the online assessment for an introductory electrical engineering course we recently implemented is described. The assessment tool is developed through the popular educational software, Blackboard. The assessment functions provided by Blackboard, such as “Test Manager” and “Pool Manager”, are especially suitable for automated assessment. Our assessment project not only confirms the efficiency of online assessment, but also indicates that carefully designed web-based assessment has the great potential of improving classroom instruction and providing students opportunities of self-evaluation and quality review of the course materials.

***Index Terms*— Web-based assessment, blackboard, electrical engineering education**

I. Introduction

It is well known that an assessment challenge facing most academic institutions is how to establish cost-effective procedures that provide necessary assessment outcomes without excessive academic staff efforts. Quality measures in education are often difficult to quantify because they depend on various factors, some of which are subjective. In addition, assessment becomes increasingly problematic for large classes, because it demands excessive instructor resources. Computer-based online assessment has great potential to provide viable solutions to many of these problems. In this paper, we present our recently developed web-based tool used for summative assessment of an introductory Electrical Engineering course at Embry-Riddle Aeronautical University (ERAU). Our major objective is to adopt web-based assessment to help faculty members manage workloads in spite of rising class sizes and ensure that student learning is objectively assessed in terms of targeted learning outcomes.

The assessment initiative is supported through ERAU’s University Assessment Grant funded by Office of the Provost. The initial experimentation was conducted in Fall 2008 and Spring 2009 on the course EE 335: *Electrical Engineering I*, which has an enrollment of around 140 students (four sections) each semester. This introductory circuit analysis course is required for students in Aerospace Engineering, Civil Engineering, Mechanical Engineering and Engineering Physics. Over the past decade, the number of students taking EE 335 has been steadily increasing and particularly so as new degrees such as Mechanical Engineering and Civil Engineering were introduced. Consequently there has been a significant challenge for quality assessment of student learning.

The remaining of the paper is organized as follows. **Section 2** describes the preparation of online assessment questions. **Section 3** discusses the administration of online assessment assignments. **Section 4** suggests several different ways to evaluate the data obtained through online assessment. **Section 5** concludes the paper and briefly presents our future plan.

II. Preparation of Assessment Questions

In fall 2008, the three faculty members participating in this project collaborated on the creation of a database of more than 80 multiple choice questions. Many textbooks[1-6] in the area of circuit analysis are utilized as references. Also, we used example questions for the Fundamentals of Engineering and Professional Engineering exams as a reference. Many selected questions from reference sources were modified to make the questions suitable for online testing. In addition, we made questions by ourselves based on our own experiences in teaching the course to ensure that key concepts are emphasized. In particular, we paid special attention in focusing our questions on specific learning outcomes of EE 335. For example, for the learning outcome “Perform circuit analysis with nodal voltage and mesh current methods”, questions were designed that require students to determine certain node voltages or mesh currents in a given DC network; for the learning outcome “Use Thevenin's and Norton's equivalent circuits in circuit analysis”, questions were designed that ask students to determine open-circuit voltage, short-circuit current and Thevenin equivalent resistance.

The database provides a comprehensive coverage of the introductory circuit analysis course materials that are commonly required for engineering undergraduates (non-electrical engineering major), including:

1. DC circuit analysis methods: Kirchhoff laws, Voltage/current division, Resistor combinations, Nodal/mesh analysis, Superposition, Source exchange, and Thevenin’s/Norton’s theorem, Maximum power transfer theorem.
2. Transient analysis: Relationships between inductor/capacitor current and voltage, Inductor/capacitor combination, Energy stored in inductor/capacitor, First/second order transient analysis.
3. AC steady-state analysis: Phasor notation, Phasor relationships for circuit elements, Impedance and admittance, Applicability of all DC analysis methods in AC circuits.
4. AC power analysis: Instantaneous power, Average power, Complex power, Apparent power, Reactive power, Power factor and its correction.
5. Network frequency characteristics: Transfer function, Passive filters (Lowpass, Highpass, Bandpass, Bandstop filters), Resonance Circuits, Quality Factor, Bandwidth, Half-power frequencies, AM/FM radio basics.

The database was stored in Blackboard using the “Question Pool” function, and shared among three instructors, each of which teaches a different EE 335 section.

II.1. Sample Assessment Questions

Here are example questions we used to assess student understanding of the above five topics:

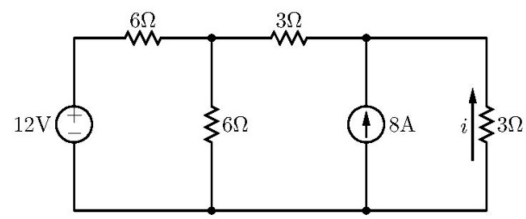
1)The value of the current I for the circuit shown is

a) -3 A

b) -10 A

c) -12 A

d) None of above



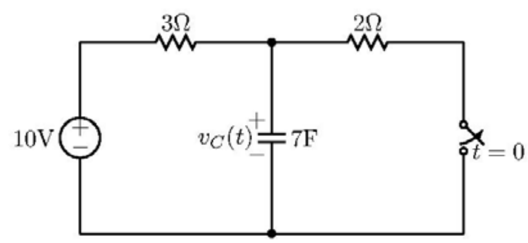
2)In the circuit shown, the capacitor voltage just before t=0 is

a) 10 V

b) 7 V

c) 6 V

d) 4V



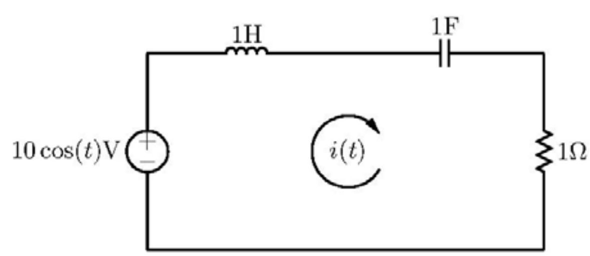
3)In the circuit shown, the current i(t) is

a) 10 cos (t) A

b) 10 sin (t) A

c) 5 cos (t) A

d) 4.472 cos (t - 63.43^o) A

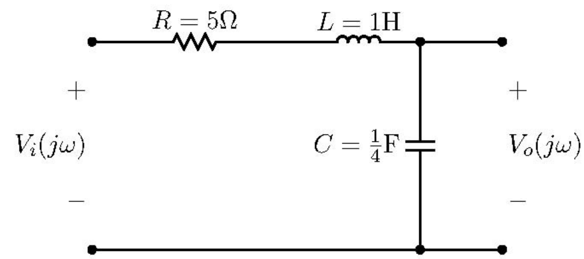


4)For the circuit shown, one of the poles of the transfer function, Vo(jw)/Vi(jw), is
a) 0

b) -5

c) -2

d) -4

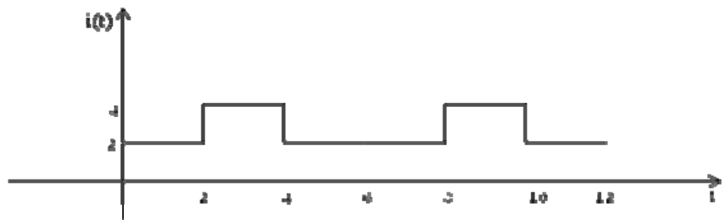


5)The current waveform in Figure is flowing through a 4-Ohms resistor. The average power delivered to the resistor is
a) 32 W

b) 16 W

c) 8 W

d) 4W



III. Administration of Online Assessment

Online assessment was experimented in fall 2008, and again in Spring 2009 with minor modifications on the question database. The implementation phase of the assessment activity can be summarized as follows:

1. In the process of generating online assignments in Blackboard, each instructor selects questions from the question database according to the specific needs of his class. The correct answer to each question is specified by the instructor to facilitate automated grading of student work.
2. Students are assigned a certain period of time, such as one week, to finish the assignment in their own time and pace through Blackboard. The assignment can be accessed from any location where internet connection is available. Also, multiple attempts are allowed, so students can save the questions they finished and come back to continue at a later time. And typically, they are allowed to modify the answers they previous entered.
3. Students submit the finished assignment online by the deadline.
4. The assignment is automatically graded by Blackboard immediately after the submission of the assignment. Normally, each multiple question is equally weighted.

5. The correct answers to all questions are displayed to the student, along with his/her score. Students are able to see simultaneously their answers and the correct answers, so they can further study the questions they have answered incorrectly on their own.
6. The student performance data, such as average / median / highest / lowest scores and standard deviation, is automatically generated in Blackboard and accessible to instructors.

Besides take-home assignments, assessment in the form of online quizzes was also adopted to evaluate student learning. The online quizzes have to be completed within very short period of time (such as 15-minutes) and do not allow multiple attempts. The quizzes are normally composed of two or three questions. This form of assessment is able to accurately reflect students' understanding of relevant materials, because it is less likely for them to communicate with each other in such a short time period.

Instructors can use the web-based assessment tool in the middle of the semester for particular chapters (or sections), as well as towards the end of the semester for a comprehensive review and assessment.

It is worth mentioning that, since each instructor teaches in a slightly different way and has unique emphasis on different concepts, sometimes there is a need to modify some questions from their original form in the database for a particular instructor's class, so the questions are appropriate for the students in that class. For example, in a second-order transient analysis question, the original question asks if the given circuit is underdamped, overdamped, or critically damped; however, the instructor may modify the question and asks for the damping ratio of the given circuit.

IV. Evaluation of Assessment Data

The obtained assessment data provide valuable insights into student learning and teaching effectiveness. In our project, they are used in several different ways:

1. The questions that most students fail to answer correctly help to identify topics and concepts that are most challenging for students. Thus, these data serve as the basis for improving instruction in the current and subsequent semesters. For example, it was found that second-order transient analysis is a difficult topic for majority of students. Therefore, more classroom instruction time may be dedicated to this topic in the future.
2. The detailed statistics of student performance indicates the level of difficulty and appropriateness for all questions, based on which the database may be updated periodically for better assessment quality. For example, it was found that the median score for the end-of-semester comprehensive assessment assignment is around 80 out of 100, with close to 60% of student scores in the range of 80 – 90, 10% of the scores below 60, and another 10% of the scores above 90. While we feel these are reasonable statistics, slightly increasing the difficulty level of the questions might lead to better assessment quality.
3. To assess the validity of the online assessment tool, we compare our end-of-semester comprehensive assessment results with final exam grade statistics. The comparison is based on our belief that the difficulty levels of the online assessment and final exam are

similar. In our case, the median score for final exam is 77, with around 60% of the scores in the 70-80 range, and around 16% of the scores in the 90-100 range. Overall, it is concluded that online assessment generates slightly better grades than the final exam. This is understandable, since online assessment allows students to solve the questions in their own pace and time, and some students receive help from others or solve problems together. Nevertheless, online assessment proves to be an effective measure of student performance, and it offers students an chance of self-evaluation and comprehensive review before the final exam.

4. The most straightforward way to use the assessment data is the identification of students that are struggling in the class. They may require extra help from the instructor. Taking the initiative to contact a struggling student sometimes results in a significant change in the student's motivation and academic performance.

The three instructors had monthly meetings discussing the administration of the online tests and effectiveness of the assessment practice. Issues like number of questions in each test, time allowed for each test, and the percentage of course grade online tests should account for were discussed in these meetings.

V. Conclusions and Future Plans

Our experiment confirms that web-based assessment has many unique advantages such as convenient administration, automated data collection and analysis, timely feedback, and easy update. The proposed assessment tool assists instructors to improve classroom instruction, and provides students opportunities for self-evaluation and quality review of the course materials. The student performance in these online assessment assignments also provides valuable feedback concerning the quality, level of difficulty and appropriateness of assessment questions. Consequently, the assessment tool can be dynamically updated and improved during the implementation phase. In our experiment, the questions designed for use in the web-based assessment are targeted to specific learning objectives of the introductory circuit analysis course, as specified in the course syllabus. Therefore, our efforts directly contribute to the achievement of overall student learning outcomes and program outcomes.

Given the current challenges facing STEM (Science, Technology, Engineering, and Mathematics) education, it is our belief that any new teaching or assessment practice in STEM disciplines should enhance students' motivation. Therefore, it is beneficial to use online assessment for extra credit assignments. For example, if all questions are correctly answered, a maximum of 5% of extra credit can be obtained. Based on our experiment, students are highly motivated in completing these online assignments. About 92% of the students finished all questions, 6% finished part of the assignment, and only 2% did not start the assignment. This is not only because students want to improve their grades, but also because they view the assignment as an effective way of review for course materials. Indeed, they went through an active round of review in the process of completing these assignments.

In the future, a survey can be adopted to solicit students' subjective opinions towards this new assessment practice. Their comments and feedback can be crucially in further improving our initiative. Also, adoption of the new assessment practice can be experimented on other engineering courses. Experience obtained and lessons learned from our initial implementation of online assessment will certainly help other programs in designing their own assessment tools. In this sense, our experiment serves as a pilot study and contributes to continuous program improvement.

Acknowledgement

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