Online Assessments in an Introduction to Digital Systems Course

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Abstract

This paper describes the use of online assessments in an Introduction to Digital Systems course at Grand Valley State University. Many engineering courses are incorporating Internet usage and online instructional material into their activities. Some schools now offer entire engineering courses online. Part of the move to Internet supported courses is the use of online assessments. Online assessments are popular due to their availability, flexibility, and automatic grading capabilities. The typical engineering problem, however, does not lend itself well to the online assessment format. This paper will present some online assessments that were developed for the Introduction to Digital Systems course offered at Grand Valley State University. The rationale behind the chosen online assessment format, implementation, and problems will be discussed. An evaluation of the effectiveness of the online assessments will also be presented.

Introduction

The evolution of e-Learning has made the Internet a very attractive media in which to expand upon the traditional classroom environment[1]. Many engineering courses are taking advantage of the Internet and incorporating part or all of their instructional material online. Online course structures range from the very basic HTML web pages to full online classrooms[2]. New software is constantly being developed for administering specific course material on the web[3].

Much of the e-Learning emphasis has been on how to effectively administer the course material online so that the students are actively engaged. For students to learn the material in an efficient manner requires lots of practice with timely feedback, especially in engineering and science courses. The traditional written homework assignments typically suffer in both quantity and timely feedback. Because the problems must be graded by hand, there can be a significant time delay between when the student solves the problem and when they receive feedback on their performance. Assigning a lot of problems for practice simply increases the feedback delay. Assigning fewer problems can help shorten the feedback time but results in less practice for the student. An alternative to this type of assignment is needed, one that encourages interaction and fosters learning[4].

The online assessment aspect of e-Learning can solve both of these issues. Students can obtain immediate feedback once their solutions are submitted. Because the grading is done automatically there is no feedback time penalty for assigning more problems. More and more engineering courses are now taking advantage of online assessments and are incorporating them into homework assignments[5,6] and practice problems[7,8,9].

Online Assessment Software – Blackboard

The e-Learning software platform used at Grand Valley State University is Blackboard. Blackboard is a comprehensive and flexible environment providing a wide range of e-Learning services[10]. Each assessment in Blackboard is made up of a set of questions. The question types available are: fill in the blanks, matching, multiple answer, multiple choice, ordering, short answer/essay, true/false. Each assessment can be comprised of any number of question types, each with their own point value. Blackboard also allows the creation of a pool of questions. Assessment questions can then be chosen from a pool, either specifically or randomly. There are several assessment options available that determine how the assessment will be administered to the students. These options are as follows.

- **Show detailed result:** Show your students the results for each question instead of simply their final grade.
- **Reveal correct answer:** Show your students the correct answer for each question. (Shown only when Show Detailed Result checked.)
- **Feedback enabled:** Allow your students to view the feedback that you have entered for each question. (Shown only when Show Detailed Result and Reveal Correct Answer checked.)
- **Allow multiple attempts:** Allow your students to take this assessment multiple times.
- **Set time for quiz:** Students are shown a running clock and warned when the time limit is approaching.

Introduction to Digital Systems Course

The Introduction to Digital Systems course at Grand Valley State University provides the basic theory, tools, and applications for all the engineering majors[11]. The course covers the fundamentals of digital signals and systems, with a focus on the evolution from digital circuits to microprocessor-based systems. The three main topics covered in the course are digital system fundamentals, structured programming, and microcontroller interfacing.

During the teaching of the course, it became apparent that many of the students were having a hard time mastering some of the basic skills being taught. The most noticeable area of deficiency was in basic number system concepts and conversions. In evaluating the problem it became obvious that the students simply needed more practice. They were not solving enough problems. The current assessment mechanism was traditional homework problems. Because of the pace of the course there was only time for one or two assignments on number systems. By the time the assignments were turned in and graded the course had progressed into the next topic area. The students were not getting enough practice and the feedback on their performance came too late.

In the fall of 2002, a set of online assessment problems in number systems was created as part of a homework assignment in an attempt to improve the students' performance. The objective of the online assessment was to provide the students with practice problems that gave immediate feedback on their performance. The blackboard assessment settings are shown in Table 1. The settings were chosen so that the students would get immediate feedback on whether or not their solutions were correct (Show detailed results On), but yet not reveal the correct answer (Reveal correct answer Off). The students were allowed to take the assessment multiple times (Allow multiple attempts On). This encouraged the students to repeat the assessment until they received a good score. Two steps were taken to help ensure they did not simply memorize (or write down) the answers to specific questions. First, when possible, large problem sets were created for the question pools. The individual assessment problems were then drawn randomly from each pool. This helped ensure that different problems would be asked each time a student took the assessment. Second, the correct answers were not displayed after each attempt (Reveal correct answer Off). This forced the students to work through the problems that they got incorrect.

Table 1: Blackboard Assessment Settings

Question Types:	Fill in the blank
Assessment Settings:	
Show detailed results	On
Reveal correct answer	Off
Feedback enabled	Off
Allow multiple attempts	On
Set time for quiz	Off

As the semester progress, more topics were added to the online assessments. By the end of the semester, online assessments had been created for the following topic areas:

Number systems
Combinational Logic
C Programming

Sample Online Assessment Problems

This section presents a sample of the online assessments used as part of the Introduction to Digital Systems course. Figure 1 shows the Number System assessment questions. The questions focus on basic comprehension and conversion. The student records their answers in the edit boxes under each question. Figure 2 shows the results of the assessment after the student has submitted their work. A check or X indicates whether the question is correct or incorrect, respectively. The number of points received for each question is displayed beside the question number. At the bottom of the screen, the student's score and total possible score are displayed. Figure 3 shows the Combinational Logic assessment questions. These questions focus on basic Boolean algebra manipulation. Figure 4 shows the C Programming assessment questions. These questions focus on the evaluation of bitwise and logic operations for both decimal and hexadecimal numbers.

Figure 1: Number System Sample Assessment Questions

Question 1		**Fill in the Blank**	**(10 points)**
	Question:	64_{10} = _____$_{13}$	
		41	
Question 2		**Fill in the Blank**	**(10 points)**
	Question:	8_{10} = _____$_{2}$ 4-bit signed	
		1000	
Question 3		**Fill in the Blank**	**(10 points)**
	Question:	What is the weight of bit 1 in the 8 bit number $C9_{16}$?	
		2	
Question 4		**Fill in the Blank**	**(10 points)**
	Question:	What is the value of bit 5 in the 8 bit number FF_{16}?	
		1	
Question 5		**Fill in the Blank**	**(10 points)**
	Question:	How many hex digits are in a 28 bit number?	
		7	
Question 6		**Fill in the Blank**	**(10 points)**
	Question:	What is the range of a 4 bit signed number [a,b]?	
		[0,15]	
Question 7		**Fill in the Blank**	**(10 points)**
	Question:	What is the largest digit that can be used in a base 16 number?	
		F	

Figure 2: Number System Sample Assessment Results

Question 1 (Received 0 out of 10 points)

Question: 64_{10} = _____$_{13}$

Your answer: 41

Question 2 (Received 0 out of 10 points)

Question: 8_{10} = _____$_{2}$ 4-bit signed

Your answer: 1000

Question 3 (Received 10 out of 10 points)

Question: What is the weight of bit 1 in the 8 bit number $C9_{16}$?

Your answer: 2

Question 4 (Received 10 out of 10 points)

Question: What is the value of bit 5 in the 8 bit number FF_{16}?

Your answer: 1

Question 5 (Received 10 out of 10 points)

Question: How many hex digits are in a 28 bit number?

Your answer: 7

Question 6 (Received 0 out of 10 points)

Question: What is the range of a 4 bit signed number [a,b]?

Your answer: [0,15]

Question 7 (Received 10 out of 10 points)

Question: What is the largest digit that can be used in a base 16 number?

Your answer: F

You scored **40** out of **70** points.

Figure 3: Combinational Logic Sample Assessment Questions

Question 1		**Fill in the Blank**	**(10 points)**
	Question:	Simplify the following Boolean equation: B+A*/B	
Question 2		**Fill in the Blank**	**(10 points)**
	Question:	Simplify the following Boolean equation: B*(A+/B)	
Question 3		**Fill in the Blank**	**(10 points)**
	Question:	Simplify the following Boolean equation: /(A+/B)	
Question 4		**Fill in the Blank**	**(10 points)**
	Question:	Simplify the following Boolean equation: A*(/A+B)	
Question 5		**Fill in the Blank**	**(10 points)**
	Question:	Simplify the following Boolean equation: A+A	

Figure 4: C Programming Sample Assessment Questions

Question 1		**Fill in the Blank**	**(10 points)**
	Question:	The variables x and y are 8 bit signed integers with initial values of x = 0x76 and y = 0x05. Determine the value of y after the execution of the following C statement. y = x ^ 66;	
Question 2		**Fill in the Blank**	**(10 points)**
	Question:	The variables x and y are 8 bit unsigned integers with initial values of x = 0xBD and y = 0xD3. Determine the value of y after the execution of the following C statement. y = x & 0x7D;	
Question 3		**Fill in the Blank**	**(10 points)**
	Question:	The variables x and y are 8 bit signed integers with initial values of x = 0 and y = 53. Determine the value of y after the execution of the following C statement. y = !(x > y);	

Evaluation of Online Assessments

The effectiveness of the online assessments was evaluated in two ways. First, towards the end of the semester, the students were asked to complete a survey concerning the online assessments. The survey questions, along with the average scores, are shown in Figure 5 below. The survey results indicate that the students felt the online assessments were very helpful in learning the material, and more effective than traditional written assignments. Most students took the assessments more than once. They appreciated the ability to take each assessment multiple times as well as the feedback provided for each problem as to whether or not it was correct. The one aspect of the online assessments that the students did not agree with was the correct answer not being displayed. As can be expected, the students would prefer to have the correct answers given to them. During the semester the student response was very favorable. Prior to the exams, they requested that the assessments be made available for review. Some of the students even suggested more assessments be made for other topics in the course.

Figure 5: Student Survey Questions and Results

The online assessment helped me learn the material?	Strongly Agree		Neutral		Strongly Disagree	**Survey Average**
Number Systems	5	4	3	2	1	**4.58**
Combinational Logic	5	4	3	2	1	**4.45**
C Programming	5	4	3	2	1	**4.18**
Compare the effectiveness of the online assessment to that of a written assignment.	Much More		Same		Much Less	
Number Systems	5	4	3	2	1	**4.24**
Combinational Logic	5	4	3	2	1	**4.24**
C Programming	5	4	3	2	1	**3.66**
How many times did you take the online assessment?						
Number Systems	0	1	2+			**1.92**
Combinational Logic	0	1	2+			**1.89**
C Programming	0	1	2+			**1.74**
Rate the usefulness of each of the following aspects of the online assessment.						
Taking the online assessment multiple times.	Strongly Agree		Neutral		Strongly Disagree	
Number Systems	5	4	3	2	1	**4.92**
Combinational Logic	5	4	3	2	1	**4.87**
C Programming	5	4	3	2	1	**4.84**
Having individual problems marked as correct or incorrect.	Strongly Agree		Neutral		Strongly Disagree	
Number Systems	5	4	3	2	1	**4.89**
Combinational Logic	5	4	3	2	1	**4.89**
C Programming	5	4	3	2	1	**4.84**
Not displaying the correct answer.	Strongly Agree		Neutral		Strongly Disagree	
Number Systems	5	4	3	2	1	**2.47**
Combinational Logic	5	4	3	2	1	**2.45**
C Programming	5	4	3	2	1	**2.50**

The second method for evaluating the effectiveness of the online assessments was to provide final exam review problems online and to compare the students' online results with their written exam performance. A set of online assessments for each topic area was made available before the final exam for review. In response to the students' requests, the settings were changed so that the assessment results displayed the correct answers. The average score on the online review problems was 98.7%, compared to an average of 93.1% on the written final exam. As expected, the online assessment scores were very high since the students could retake it multiple times. The high score on the written final exam indicates that the students actually learned the material.

Conclusion

This paper described the online assessments incorporated into the Introduction to Digital Systems course at Grand Valley State University. The assessments were used as a mechanism to provide practice problems with immediate feedback. The students were able to use the online assessments to improve their problem solving skills and thus their performance in the course.

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