UNIFORM ASSESSMENT OF PRECALCULUS SKILLS USING WEBASSIGN

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The mathematics department at the University of Georgia (UGA) has a long-standing tradition of standardized, electronic testing for all sections of precalculus. In 2009, the department transitioned to a new assessment platform. WebAssign® is a commercial product developed at North Carolina State University, and it provides enough flexibility to serve the needs of the precalculus curriculum at UGA. The motivation for using online assessment throughout the precalculus course was a lack of uniform assessment of basic precalculus skills. Since some 2000 students enroll in precalculus each year at UGA, there is a need for the earned final grade of A (B, C+, etc) to have some uniformity of meaning. Using the same homework, online quiz, and test for all students provides that uniformity. In this paper, I will discuss the assessment component of our uniform class. Finally, we present the conclusions based on the data we are gathering on calculus-readiness within this content format.

At UGA, we use WebAssign to deliver homework, both practice assignments and "quizzes". We also use WebAssign for testing. Testing is conducted in a lab outside of class time, proctored by student workers. Content for assessment in the form of perl-coded questions can be constructed by the instructor (in our case, the course supervisor). Content is also available by cooperative arrangements between WebAssign and publishers. As an instructor of such a course within a multitude of sections, you are held to a strict timeframe, but your only assessment duties are in-class quizzes. Since the primary responsibility is instruction, this course becomes an appropriate venue for graduate students as first-time teachers to develop their teaching skills.

The precalculus course covers five main units. The first unit includes a review of circles and lines, an introduction to function, and modeling with functions. The second unit includes transformations of functions both graphically and algebraically, a study of quadratic functions and their extrema, and modeling and using functions in an applied setting. The third unit studies exponential and logarithmic functions, their applications, and solving equations involving these functions. The final two units study trigonometric functions, including right triangle trigonometry, radian measure, the functions' graphs and properties, solving trigonometric equations, and various formuli and applications. Because testing for each content unit is available on specific days, the teacher is required to cover the mathematics content according to a fairly inflexible schedule.

Students enrolled in Precalculus at UGA are introduced to WebAssign in their first lecture. They self-enroll into their WebAssign course, and homework awaits them. Because the campus provides computer access and WebAssign works well on the

profusion of browsers available on the student's personal computers, access is not an issue. WebAssign allows for posting of syllabi, worksheets, video, and announcements and also has a gradebook, so there is no need to use an additional course management system. At UGA there is also a course website that reminds students of course requirements (ID necessary for tests, test format, test calendar, attendance policy, etc.). The homework format is designed to encourage study and minimize student frustration. Problems selected from the textbook content provided by the publisher include links to "read it" (the text) or "watch it" (see the problem solved in a step-by-step fashion with other numbers in place). The solution key to each homework problem is released after one student attempt at the problem, so a conscientious student can earn a 100% homework grade for just attempting the homework. The webquizzes have a different format: no solutions, hints or links before the duedate, and only 3 attempts per problem, with a penalty for errors on initial attempts. This design should help students prepare for tests—a problem marked incorrect that has another attempt available encourages and rewards student persistence, while the limit on attempts minimizes frustration.

Testing follows a similar format to webquizzes, except in a proctored environment. Students draw one of a pool of problems for each assessment item, and each problem features randomized numbers. This way, students who violate the academic honesty policy by outside discussion with other students about the test items have minimal information to convey. Using instant grading provides a quid pro quo for the loss of partial credit on a paper-and-pencil test: instant grading provides the student an opportunity to modify incorrect work for 75% credit. The testing takes place outside of class, in a proctored environment. Students are partitioned according to sections and may schedule a test time for any one of many blocks on a given test day; the scheduling is completed online as well.

WebAssign is perhaps the industry standard for protected mathematics testing. Other software product vendors insist that security can be maintained with just passwords, but at UGA we don't believe that test integrity can be protected over 4 days of testing with endlessly changing passwords, nor do we desire the course management protocol that would require. In WebAssign, the assignments can be restricted to (or away from) specific IP addresses. This means that a student can only access the test in a designated testing environment and also cannot access homework and quizzes while working the test. In WebAssign, tests can be timed and password protected as well, with an additional enhancement available that blocks access to any other software. At UGA, we use a desktop calculator emulator and so do not use this particular feature.

At UGA we have developed a standard format for questions and for answer types, so that communication of answers via computer during a test is less distracting to the student. Some questions are multiple-choice or True/False, and there is no difficulty with answer entry there. For other questions, the answer blank *always* accepts symbolic forms of the answer: 2 or 1/(1/2) or e^(ln(2)) are all marked correct for an expected answer of 2. Some question types disallow decimal forms of the answer, to preclude student use of the calculator solver when we want to test equation solving skills.

The course grading is set up so that the instructor is primarily responsible for instruction, with only 10% of the course grade determined by the instructor through in-class assessment activities (such as in-class quizzes). Additional assessment is all provided from within WebAssign. This serves the purpose of uniform assessment but also ameliorates the heavy teaching load that instructors experience. Course grades are set according to common gradelines. The uniformity of assessment and gradelines helps ensure that the grade of A symbolizes the same level of calculus-readiness, regardless of class section or instructor. The instructor is primarily responsible for instruction, with some attention to timely, adequate preparation for the (unknown) test. To keep the assessment fair, the test is not released until the day it is used for a particular testing block. However, teachers have access to the entire database of questions, both those from the textbook and those coded at UGA.

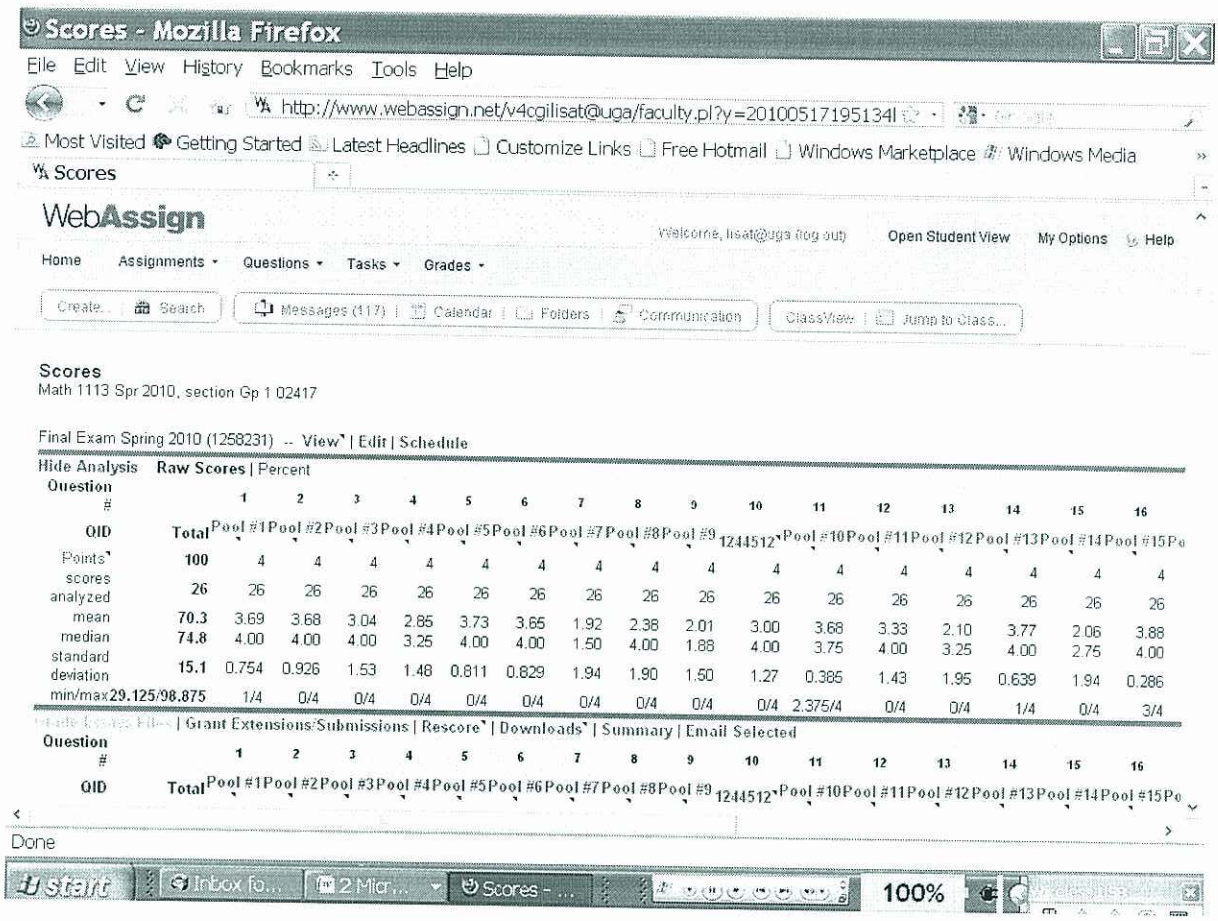

Figure 1
Test Score Analysis
The test was longer; the horizontal scroll bar revealed all question results.

WebAssign allows teachers and the course administrator to gather meaningful data about student progress and overall student scoring. In figure 1 above, both individual proble

and classwide mean and median statistics are available. By clicking on the student's name below, their work can be viewed. A teacher can see not just the final answer entered by a student, but all attempts (for example, the student may write a correct formulation, but spelled in upper case $y = 3X + 4$ rather than $y = 3x + 4$). In addition, the teacher can override scores on assignments (add or subtract penalties); together, these features allow the teacher to ameliorate the perceived pain of impartial computer grading. See figure 2 for additional class analysis available for each problem. Just as test means and medians are available for each section, a download of all section scores (that is somewhat cumbersome to manipulate in Excel) allows for comparison of individual class scores to overall means and medians.

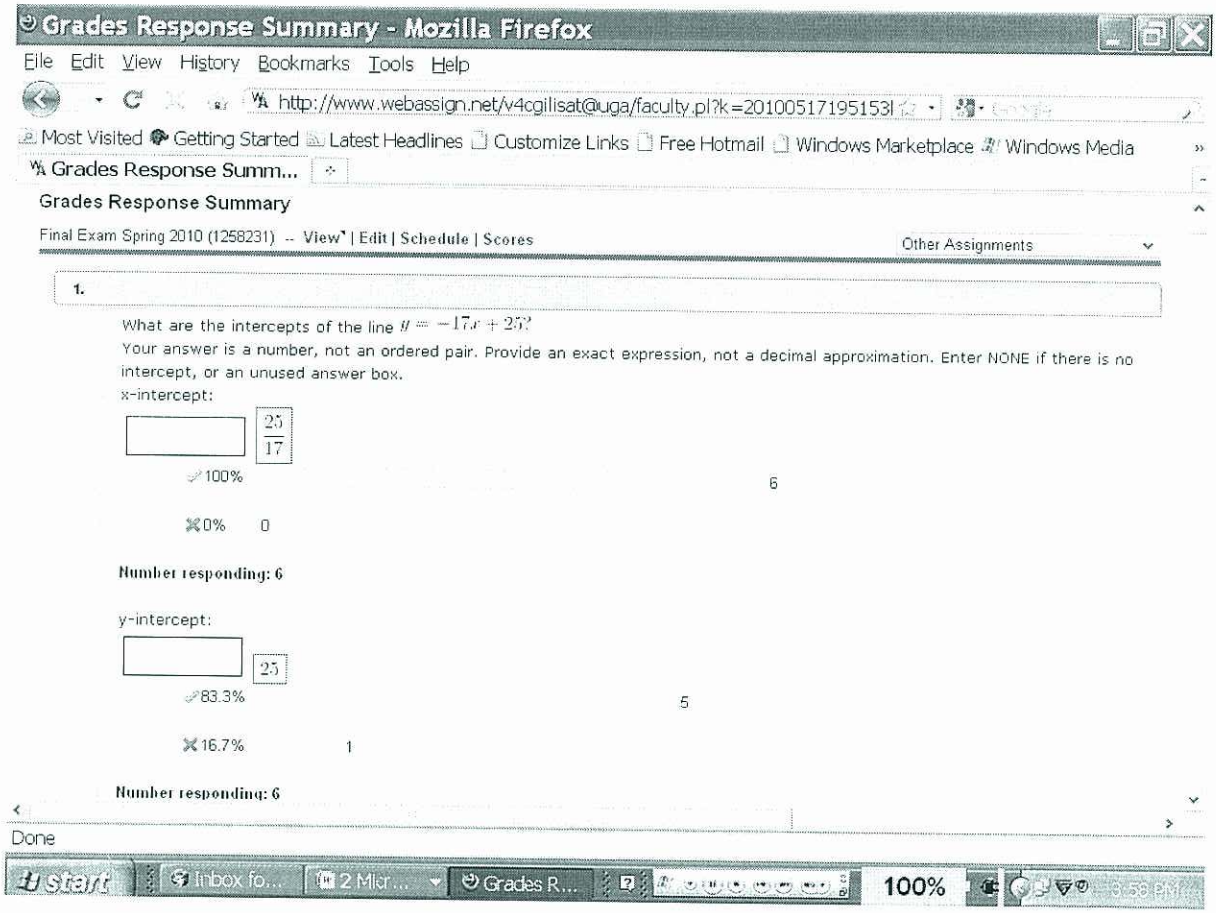

Figure 2
Response Summary for Individual Problem
Students drew one of a pool of 4 problems.
In this class 6 students drew this problem with randomized numbers.

In addition to being able to use individual student and separate section statistics to measure student success and teacher effectiveness in precalculus, the department has long kept statistics on placement scores relative to course success and student performance in subsequent courses (in this case, calculus). Now the individual test scores can be added to the measure of student performance. Placement scores compared to course success indicate that students who place into precalculus (score of 8 or higher) generally succeed (see table 3 below). In addition, those who are recommended to register for an "intensive" section of precalculus (33% more class meetings) do better when they heed our suggestion. Test 1 seems to be an accurate predictor of student success in the precalculus course. It is interesting to note that a grade of C or C- is not a predictor for success in calculus (students pass and fail without trend), but a grade of C+ (or higher) is (usually) a predictor (see table 4 below). The collection of this information validates our course content and assessment procedures. Future measurements to be made include comparing the calculus success rates of the three types of students registered: those who complete precalculus at UGA first, those who place directly into calculus as freshmen, and transfer students who have some other mathematics background. (Statistical analysis courtesy of Ed Azoff, UGA Department of Mathematics).

References

1. UGA Precalculus website: http://www.math.uga.edu/116/1113home.htm as part of Department of Mathematics website: http://www.math.uga.edu
2. Virtual TI v2.5 beta5. Download from http://www.ticalc.org/archives/files/fileinfo/84/8442.html . The organization ticalc.org is not affiliated with Texas Instruments Incorporated in any way.
3. WebAssign® is a registered service mark of North Carolina State University under license to Advanced Instructional Systems, Inc. © 1997-2003 by North Carolina State University. Portions © 2003-2009 by Advanced Instructional Systems, Inc. Various trademarks held by their respective owners. Website http://www.webassign.net

Placement Scores vs Course Performance - Fall 2008
Recommended Placement Shown in Yellow

Course	dmat	count	gpa	success%	t1	fnl
1113	20	3	3.43	100	86	87
1113	19	3	3.35	67	88	86
1113	18	5	3.28	80	88	81
1113	17	5	3.34	100	79	87
1113	16	6	3.22	100	86	83
1113	**15**	**119**	**3.36**	**99**	**85**	**85**
1113	**14**	**123**	**3.07**	**90**	**82**	**82**
1113	**13**	**130**	**2.83**	**85**	**80**	**80**
1113	**12**	**102**	**2.87**	**89**	**81**	**79**
1113	11	77	2.55	79	75	75
1113	10	59	2.62	68	72	75
1113	9	43	2.87	81	77	77
1113	8	30	2.16	63	66	73
1113	7	24	2.67	79	73	80
1113	6	14	2.23	54	64	67
1113	5	6	1.80	50	66	62
1113	None	97	2.03	45	66	68
1114	16	1	4.00	100	99	87
1114	15	6	2.95	100	89	79
1114	14	6	2.95	83	69	81
1114	13	5	2.46	80	72	81
1114	12	5	2.54	80	76	71
1114	**11**	**25**	**3.02**	**88**	**80**	**81**
1114	**10**	**18**	**2.96**	**94**	**79**	**78**
1114	**9**	**18**	**2.24**	**67**	**76**	**75**
1114	**8**	**11**	**2.44**	**82**	**80**	**72**
1114	7	9	1.73	33	65	64
1114	6	2	3.35	100	85	87
1114	5	5	1.00	40	62	61
1114	2	1	2.70	100	67	77
1114	None	10	1.81	30	58	71

Table 3
Placement vs. Success in Precalculus
1113 and 114 are the precalculus and intensive precalculus courses.
Dmat = average placement test score.
T1, fnl are average test 1 and final exam scores out of 100.
"Success" is 100 for grades of C or better, 0 for withdrawal and C- or lower grades.

Precalculus (Fall 2008) Followup (Spring 2009)

prec	calc	precgr	Count	calcgpa	calcsucc
1113	2200	A	56	3.67	89
1113	2200	A-	19	3.54	100
1113	2200	B+	30	3.17	90
1113	2200	B	64	2.81	83
1113	2200	B-	19	2.55	79
1113	2200	C+	18	2.69	78
1113	2200	C	19	1.79	53
1113	2200	C-	6	1.78	50
1113	2200	D	9	1.24	22
1113	2200	F	1		0
1113	2250	A	48	3.35	94
1113	2250	A-	19	3.43	100
1113	2250	B+	19	3.16	89
1113	2250	B	54	2.93	78
1113	2250	B-	21	2.32	67
1113	2250	C+	8	2.46	63
1113	2250	C	13	1.15	38
1113	2250	C-	6	2.23	83
1113	2250	D	4	1.07	50
1113	2250	F	1		0
1114	2200	A-	4	3.65	100
1114	2200	B+	6	2.93	100
1114	2200	B	1		0
1114	2200	B-	3	2.57	67
1114	2200	C	6	0.75	20
1114	2200	C-	2	1.85	50
1114	2200	D	2	0.50	0
1114	2250	A	6	3.32	83
1114	2250	A-	9	3.31	100
1114	2250	B+	3	3.15	67
1114	2250	B	3	2.50	67
1114	2250	B-	10	2.43	90
1114	2250	C	6	1.93	33
1114	2250	C-	3	1.67	33
1114	2250	D	3	0.85	0

Table 4
Precalculus vs Calculus Grades, Subsequent Terms.
1113 and 114 are the precalculus and intensive precalculus courses.
2200 is terminal differential calculus, 2250 is engineering calculus I.