ONLINE MATHEMATICS ASSESSMENT USING *MAPLE T.A.* AT EASTERN CONNECTICUT STATE UNIVERSITY

Salvatrice F. Keating, Ph.D., Marsha Davis, Ph.D., Christian Yankov, Ph.D.
Department of Mathematics and Computer Science
Eastern Connecticut State University
83 Windham Street
Willimantic, CT 06226
keating@easternct.edu, davisma@easternct.edu, yankovc@easternct.edu

Abstract

The authors have been involved with online mathematics assessment using Maple T.A. since fall 2004. This paper provides a brief history of student assessment at Eastern[1], our assessment model, data (both student and exams), and the program and curricular changes that resulted.

Introduction

We are all too familiar with the universal problem that many students taking a sequence of courses fail to retain sufficient knowledge from one course to another to successfully complete the next course in the sequence. This failure often requires some review of prerequisite course topics; but, review at the beginning of the semester takes time away from the program of study. This situation causes a significant amount of frustration both for faculty and for students. This lack of retaining sufficient knowledge on the part of students ultimately served as a mandate for faculty to take action.

The Plan

The tasks that had to be dealt with were:

- select assessment software,
- obtain funding,
- create a list of basic topics for each course in which students would be assessed,
- create exams for assessment and tutorials for remediation,
- implement a procedural plan,
- collect/analyze data and make necessary changes,
- disseminate information.

[1] Eastern Connecticut State University is one of four campuses of the Connecticut State University System (CSUS). It is an accredited (New England Association of Schools and Colleges, Inc., through its Commission of Institutions of Higher Education), coeducational, residential university with a fall 2008 enrollment of 5.427. First generation, minority, and low income students comprise *more than 50 percent* of Eastern's full-time undergraduate student body. [source: http://nutmeg.easternct.edu/admissions/fact.html]

Step #1: Select the software.

Faculty wanted software that would not only create questions but would also *correct* and give *immediate response* to student answers. Because we had been using the computer algebra system, *Maple*, in our *Calculus III* courses since 1991, it was natural for us to look to *Maplesoft*, a division of Waterloo Maple Inc., and their products. Based on our positive experience with the company and its product, we selected *Maplesoft's* latest assessment software, *Maple T.A.*. With the exception of an upgrade to *Maple T.A.* released at the beginning of fall 2007, we have been pleased with this product and the support that *Maplesoft* has provided.

Step #2: Obtain funding.

For the 2004-2005 and 2005-2006 academic years, various grants (FIPSE[2], CSU Learning Assessment and Improvement Grant[3]) were written and awarded. These funds allowed us to purchase the software and provide modest stipends for time to become proficient with the software. However, as of the 2006-2007 academic year, the Connecticut State University (CSU) System Office purchased an Enterprise License from Maplesoft which provided copies of *Maple* and *Maple T.A.*to faculty at each of the four CSU campuses and licenses for usage. We also continued to write CSU Learning Assessment and Improvement Grants[4] which were awarded.

Step #3: Create a list of basic topics for each course in which students are assessed.

Planning, writing grants, becoming familiar with Maple T.A., and arriving at consensus within the Department were accomplished in the 2004-2005 academic year.

Calculus II and *III* were the first pilot courses to be assessed in fall 2005, so a *Calculus I* basic topics list was created for the *Calculus II* assessment and a *Calculus II* basic topics list was created for the *Calculus III* assessment. The *Calculus I* topics focused on differentiation: limits, *delta-epsilon definition* of differentiation, differentiation rules, and applications. The *Calculus II* topics focused on integration: concept development, Riemann sums, the Fundamental Theorem of Calculus, techniques of integration, applications, and some series. Each basic topics list was presented to the Department and, after discussion and revision (if called for), there was agreement by *consensus*. Thus *everyone* in the Department *had ownership* of *the Plan*. As additional courses were added to the assessment process, this procedure was repeated.

Step #4: Create Assessment Exams and Remediation Tutorials using Maple T.A.

In order to create exams for purposes of assessment one must first create a question bank. There are many possible types of questions[5] that can be created; these include Maple-graded, multiple choice, fill-in-the-blank, matching, clickable image, and numeric with margins of error. Questions can also be symbolic, algorithmic or contain 2-D or 3-D plots. After the questions are created, they are 'tested' for proper identification by *Maple T.A.* and correction. Response from *Maple T.A.* software is *instantaneous*. Once the Question Bank has been completed, it is uploaded to the

[2] Davis, Keating, Johnson, and Ward
[3] Davis and Keating
[4] Davis, Keating, and Yankov
[5] http://www.maplesoft.com/products/mapleta/features.aspx

server and installed. Individual questions in the Question Bank are used to create exams for assessment and tutorials for remediation.

Step #5: Create a Procedural Plan.

Figure 1 illustrates the online assessment and remediation process implemented each semester.

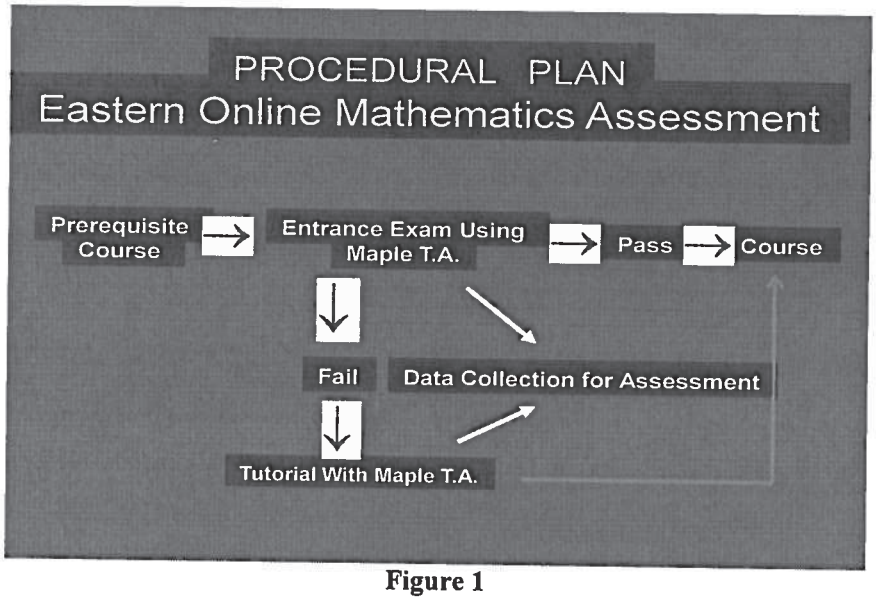

Figure 1

Step #6: Collect data, analyze, and make changes.

The assessment software, *Maple T.A.*, contains powerful data collection and analysis features. It provides an abundance of statistical information at both course level and individual student level. Statistical analysis of data collected to date and resulting changes, both procedural and curricular are discussed on the following pages.

Step 7: Disseminate results.

Our findings are shared with colleagues through presentations at professional conferences and publications in refereed journals.

Statistical Analysis of Collected Data

Assessment Chronology

Prior to fall 2007, *Calculus III* was taught only in the fall semester. As of fall 2007, this course is taught in both fall and spring. *Calculus I and II, Precalculus, and Intermediate Algebra* are fall and spring courses. Initial assessment exams and/or tutorials for *Calculus II* and *III* , *Calculus I,*

Precalculus were first administered in fall 2005, in spring 2007, and in fall 2008, respectively. A *pilot* exam for Intermediate *Algebra* was administered in spring 2008[6].

Descriptive Statistics

These statistics are based on a compilation of data collected during our assessment periods; these include periods when there were problems with individual computers, with the server, with the software, and with student unfamiliarity with *Maplesoft T.A.* software. Data for *entire academic years* was lost in 2007-2008 due to bugs in *Maple T.A. 3.0* (but recovered *to the degree that it was* because of the dedicated actions of *Maplesoft* technical support). We were *not* able to recover data collected using the very early versions of *Maple T.A.* due to the installation of a new server and an error in transferring data records. *However, in a spirit of openness and sharing, we present descriptive statistics of the accumulated data that we have access to.*

Because of the problems noted in the previous paragraph and the small sample sizes, in our opinions, the results of the descriptive statistical analysis do not truly represent the mathematical abilities of our students at Eastern.

Intermediate Algebra (Pilot)	
Grades: Spring 2008	
Mean	17.8
Standard Error	1.9
Median	20.0
Mode	20.0
Standard Deviation	11.5
Sample Variance	132.7
Kurtosis	-0.2
Skewness	0.3
Range	45.0
Minimum	0.0
Maximum	45.0
Sum	660.0
Count	37.0

Precalculus	
Grades: Fall 2008-Spring 2009	
Mean	50.7
Standard Error	1.7
Median	50.0
Mode	50.0
Standard Deviation	23.8
Sample Variance	566.0
Kurtosis	-0.9
Skewness	-0.1
Range	100.0
Minimum	0.0
Maximum	100.0
Sum	10485.0
Count	207.0

Figure 2

[6] However, no assessment exams have been offered due to a move in late summer to our new location, the Science Building, and to the opening of the *Mathematics Achievement Center (MAC)* where tutoring services are offered to students enrolled in courses in the Developmental Mathematics Program, students enrolled in *Mathematics for Liberal Arts* (a service course offered by the Department), *Precalculus*, and *Calculus I* courses.

Calculus I (Theory)		Calculus II (Theory)		Calculus III (Theory)	
Grades: Spring 2007-Spring 2009		Grades: Fall 2005-Spring 2009		Grades: Fall 2005, Fall 2006, Fall 2007-Spring 2009	
Mean	60.9	Mean	63.4	Mean	53.4
Standard Error	1.1	Standard Error	1.1	Standard Error	1.7
Median	65.0	Median	65.0	Median	52.5
Mode	65.0	Mode	80.0	Mode	45.0
Standard Deviation	18.9	Standard Deviation	20.6	Standard Deviation	19.7
Sample Variance	358.8	Sample Variance	423.1	Sample Variance	388.6
Kurtosis	-0.6	Kurtosis	-0.3	Kurtosis	-0.6
Skewness	-0.4	Skewness	-0.5	Skewness	0.1
Range	80.0	Range	90.0	Range	90.0
Minimum	15.0	Minimum	10.0	Minimum	10.0
Maximum	95.0	Maximum	100.0	Maximum	100.0
Sum	18935.0	Sum	22435.0	Sum	7150.0
Count	311.0	Count	354.0	Count	134.0

Figure 3

What have we learned from online assessment and remediation using *Maple T.A.?*

Improvement in accepting responsibility by students

Prior to the initiation of the online assessment and remediation process, students often complained that their course grades were due to their professor's inability to teach. However, students *now* make statements "*I guess I didn't review enough for the assessment exams*".

Improvement in completing the assessment exams and remediation tutorials by students within the time period specified

Perhaps the biggest initial obstacle was getting students to take the entry exams within the first two weeks of class and getting those students who fail the entry exams to complete the tutorials within the first three weeks, as required. We consistently received student requests at the end of the semester to provide them access to an assessment exam or tutorial. *This is no longer the case.*

Identification of student weakness with Algebra skills across the entire population

Prior to the initiation of the online assessment and remediation process, student weakness in Algebra was often relegated by faculty to students in the Developmental Mathematics Program. Much to our surprise, this weakness exists among *all* student populations.

Identification of course-specific student weaknesses

In addition to a general need for improvement in student algebra skills, through item-by-item analysis of assessment exam questions, we have discovered *Precalculus* students had significant problems with adding and dividing rational expressions and also with the Quadratic Formula. Students' problems with rational expressions persisted through *Calculus III*. A surprising number

of *Calculus I* students were not able to find the equation of a line given two points on the line and *Calculus II* students had considerable difficulty with the Chain Rule.

What are the changes that have been made?

In response to what we have learned from the assessment and remediation procedure, the following changes have been made:

- Assessment and remediation requirements now appear in course syllabi as *course requirements.*
- There is a *one-letter reduction of the earned course grade* for students who do *not* complete assessment or remediation requirements within the given time period.
- More Algebra content and other identified areas of "weakness" will be added to assessment exams, tutorials, and individual course content .
- Assigned problems and course examination problems will be selected such that algebraic and other identified "weakness" skills are critical to obtaining a solution.
- *Maple T.A. 4.0 Parent-Child* methodology is now used for all assessment exams and tutorials.

Conclusions and Future Directions

Conclusion

A strong grounding in high school mathematics through Algebra II or higher correlates powerfully with the access to college [and] graduation from college [7]. The Department's initial assessments and remediation took place within the Major. In light of our findings, perhaps our advice might be to begin with assessment and remediation of student skills in Algebra.

Future Directions

As a result of discussions and interactions at professional meetings, Dr. Keating became a member of *Joining Mathematics Education* (JEM), an organization that has its origins in Europe, which "supports the collaboration of professional educators, software engineers, publishers, and of learning theorists in mathematics education and provides a social forum to promote the change needed in academia to fully realize the promise of educational technology in mathematics"[8].

Having learned of collaborative partnerships to address mathematics deficiencies among secondary school students now taking place between 1) European secondary schools and various European Universities, and 2) Texas A&M University and Texas secondary schools, Eastern has facilitated *The Bridges Program*. This program has formed partnerships between Eastern faculty in Mathematics and Education and mathematics teachers in the Windham, Norwich and Colchester Connecticut School Systems. Through this program, *Campy Workshops* for middle and high school students will be given on the Eastern campus in late May, 2009.

---

[7] *The Final Report of the National Advisory Panel,* U.S. Department of Education, 2008. http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

[8] http://www.jem-thematic.net

Drs. Keating, Davis, and Ward have submitted a grant proposal, *Exploratory Online Assessments of Collegiate Developmental Mathematics and Secondary Level Algebra Comprehension: A Pilot Initiative*, to the CSU Learning Assessment and Improvement Grant Program[9]. If funded, our goal is to address Algebra deficiences in students *before* they are admitted to Eastern (or other universities) by forming partnerships with Connecticut Secondary Schools. This pilot will be modeled after the *JEM* and Secondary Schools Partnership in the European Consortium, the Texas A&M University and Texas Secondary Schools Partnership, and the Bridges Program at Eastern Connecticut State University.

[9] Announcements of awards will be made by June 1, 2009.