

Assessment of Mathematical Knowledge and Skills
Institutional Student Learning Outcome #6
Report to the Campus
2011-12

Prepared
By
The Executive Committee of the Assessment Commission

June 14, 2012

Contents

Executive Summary	1
Definition and performance criteria for mathematical knowledge and skills.....	2
Description of assessment.....	2
Data collection	3
Data scoring	3
Data elements.....	3
Assessment results	4
Overall results for all courses	4
Analysis by course	4
Other analyses.....	5
Program faculty reflections.....	5
Professional Exams.....	5
Fundamentals of Engineering Examination.....	5
Medical Imaging Credentialing Exams	6
ETS Major Field Test in Business	6
Indirect Assessment from Senior Exit Surveys	6
Math faculty recommendations.....	7
Executive Committee recommendations	7
Assessment reporting.....	8
Documentation.....	8
Appendix: Math ISLO Faculty Reflections	9
Tables	
1: Overall proficiency levels.....	4
2: Proficiency levels by course	4
3: April 2012 results of the FE exam	6
4: Level of proficiency rated by graduating students on math knowledge and skills.....	7

Executive Summary

During the 2011-12 academic year, the OIT Assessment Commission conducted an assessment of mathematics. The assessment considered student performance in math classes taken by a broad representation of majors as well as student performance in math within the major for select programs with math specific program student learning outcomes.

The assessment in math courses was based on three performance criteria, including the ability to perform symbolic computations, the ability to create, use and analyze graphical representations of mathematical relationships, and the ability to use mathematical concepts and techniques to solve applied problems. Problem sets were administered during final exams in math courses selected by the Assessment Commission and the Math Department. The courses included in the assessment were Math 111 College Algebra, Math 251 Differential Calculus, and Math 361 Statistical Methods. For each course, the math faculty wrote three problems of similar difficulty for each of the three performance criteria, i.e. nine total problems for each course.

The results indicate that students in these courses performed at a proficiency or high proficiency level at an acceptable rate for two criteria—65.1% for computation and 71.1% for graphical comprehension. The results, however point to a weakness in students' ability to use mathematical concepts and techniques to solve applied problems (44.4%). In exploring the data, the math faculty concluded that:

- Some of the exercises used for assessment may have been poorly designed. The department should pilot changes to those exercises on midterm and/or final exams to see if they can be improved.
- The expectation in the area of applications needs be more clearly defined and agreed upon within the department.

The Executive Committee reviewed cross tabulations of the data by course, class level, major, grade in current math class and placement exam. While the committee members noted various predictors and relationships in the cross tabulation data, they did not draw significant conclusions from the data in terms of action steps for the future.

The assessment at the program level was conducted fall 2011 and winter 2012 by faculty in programs which have a math specific program student learning outcome (PSLO) using program specified performance criteria. Program faculty were asked to review the results and complete a reflection indicating strengths and weaknesses and recommendations for improvement. Of the 24 programs that participated in this reflection, 96% reported their students met program expectations for math proficiency. The Executive Committee reviewed these reflections and was pleased with the results.

As an additional measure, the Executive Committee compiled and reviewed the results of professional credentialing exams of select engineering, health and management programs. On each of these exams Oregon Tech students' pass rate and/or performance was at or above National comparators.

The Executive Committee of the Assessment Commission also reviewed a survey of graduating students that was administered in to seniors spring 2012. The results indicated a high level of agreement among graduating seniors that they are proficient in mathematical knowledge and skills.

Definition and Performance Criteria for Mathematical Knowledge and Skills

The Executive Committee of the Assessment Commission approved the following expectations for mathematics:

Mathematical literacy is a vital skill in both professional and everyday life.

Expectations: Graduates should understand and be able to use the basic mathematical concepts relevant to their professions and be able to analyze numerical and statistical data accurately. These expectations may be met through math courses as well as through courses that apply mathematical concepts and skills specific to majors and professions.

In conjunction with the Math Department, the Executive Committee approved the following performance criteria for math:

Students will be able to:

1. Apply mathematical concepts and principles to perform symbolic computations.
2. Create, use and analyze graphical representations of mathematical relationships.
3. Use mathematical concepts and techniques to solve applied problems.

Description of Assessment

During the 2011-12 academic year, OIT assessed mathematical knowledge and skills by considering student performance in math classes taken by a broad representation of majors as well as student performance in math within the major for select programs with math specific program student learning outcomes.

The assessment in math courses included administering common problem sets during fall 2011 final exams in selected courses. For each course, the math faculty wrote three problems of similar difficulty for each of the three performance criteria, i.e. nine total problems for each course. The courses, selected in consultation with campus assessment coordinators, are required in many curricula and therefore have a broad representation of majors. They are:

- Math 111 College Algebra (six sections, including one HS section)
- Math 251 Differential Calculus (six sections, including three HS sections)
- Math 361 Statistical Methods I (two sections)

The assessment at the program level was conducted fall 2011 and winter 2012 by faculty in programs which have a math specific program student learning outcome (PSLO) using program specified performance criteria. Program faculty were asked to review the results and complete a reflection indicating strengths, weaknesses and recommendations for improvement. Twenty-four programs participated in the assessment (8 Management, 11 Engineering, 2 Health, 2 Natural Science and Applied Math).

Data Collection

A member of the Executive Committee of the Assessment Commission worked with the math instructors participating in the assessment to minimize differences in results due to administration conditions. The problem sets were completed by students during a proctored, two-hour final exam. No students were excused from the exam based on high performance prior to the exam.

The Director of Assessment provided score sheets for the math faculty and compiled all individual score sheets into a data set for each course. The math faculty requested that data by section be kept confidential. The aggregated data for all courses were then submitted to the Director of Institutional Research for analysis.

Reflections from program faculty were collected using a survey created by the Director of Assessment. Responses were compiled and comments are included in Appendix A. No quantitative data was requested from programs, though this data was collected and will be reported 2011-12 program assessment reports.

Data Scoring

For the assessment in math courses each section instructor scored the nine problems as either correct (score of 1) or incorrect (score of zero). No partial credit was given. The Assessment Commission and the math faculty agreed that student proficiency on each performance criteria (three problems) would be defined as:

- Severely deficient: student is unable to answer any questions correctly.
- Some proficiency: student gives correct answer to one of the questions.
- Proficient: student gives correct answer to two of the questions.
- Highly proficient: student gives correct answers to all three questions.

Data Elements

The data elements collected for the assessment in math courses included:

- Student ID (from course rosters)
- Student last and first name (from course rosters)
- Course Reference Number (CRN)
- Subject, course, and section number (e.g., Math 111-01)
- Scores for each of the three math computation problems, using zero for incorrect and one for correct on each problem
- Scores for each of the three graphical comprehension problems, using zero for incorrect and one for correct on each problem
- Scores for each of the three interpreting math results problems, using zero for incorrect and one for correct on each problem

In addition, the Director of Institutional Research linked the above data elements to student major (including pre-majors) from the institutional database.

Assessment Results

Both the Executive Committee of the Assessment Commission and the Math Department reviewed the results of this assessment.

Overall results for math courses combined

There were 232 students who participated in the assessment in math courses. The Math Department has set the acceptable level of performance at 60% of students achieving proficiency. Results for students demonstrating proficiency or high proficiency for all math courses combined are shown in Table 1.

Proficiency Level	Math Computation	Graphical Comprehension	Application	Overall*
Percent proficient (two correct)	39.7	33.2	27.2	
Percent highly proficient (three correct)	25.4	37.9	17.2	
Total proficient or highly proficient	65.1	71.1	44.4	31.0%*

Table 1. Overall proficiency levels

*Percentage of students performing at proficiency or high proficiency for all three criteria.

The Mathematics Department and the Executive Committee of the Assessment Commission reviewed these overall results and found math computation and graphical comprehension to be acceptable. Application is a newly defined performance criterion in this year's assessment; results showing proficiency at 44.4% is a concern. The percentage of students performing at proficiency or high proficiency for *all criteria* (31%), led to further exploration of the data.

Analysis by course

To determine strengths and weaknesses in student performance in each course, an analysis of student proficiency by course was completed, as shown in Table 2.

Proficiency Level	Math Computation	Graphical Comprehension	Application	Overall*
Math 111 (n = 98)				
Percent proficient (two correct)	40.8	34.7	30.6	
Percent highly proficient (three correct)	28.6	36.7	12.2	
Total proficient or highly proficient	69.4	71.4	42.8	31.6*
Math 251 (n = 94)				
Percent proficient (two correct)	36.2	26.6	23.4	
Percent highly proficient (three correct)	25.5	44.7	16.0	
Total proficient or highly proficient	61.7	71.3	39.4	26.6*

Math 361 (n = 40)				
Percent proficient (two correct)	45.0	45.0	27.5	
Percent highly proficient (three correct)	17.5	25.0	32.5	
Total proficient or highly proficient	62.5	70.0	60.0	40.0*

Table 2. Proficiency levels by course

*Percentage of students performing at proficiency or high proficiency for all three criteria.

The Math Department reviewed the data by course above and revisited the exam questions discussing the relationship between results and each question. They found that:

- Some concepts that were tested in the prescribed questions for Math 111 are not covered in much depth in College algebra textbooks.
- Not all members of the department agree on the level of Math 100 type simplification that should occur when performing computations in Math 111, 112 and 251. Poor performance in some of the computations (including those used in the applications questions) could be due to variation in expectations from instructor to instructor.

Other Analyses

The Executive Committee also analyzed other factors related to this assessment, including analysis by class level and major. While the committee noted various predictors and relationships, they did not draw significant conclusions from the data in terms of action steps for the future. The committee recommended that data analysis could be reduced in the next assessment by eliminating the reports that are interesting but not actionable.

Program Faculty Reflections

Twenty-four of the twenty-six programs with a math related Program Student Learning Outcome (PSLO) completed a faculty reflection based on the results of math assessments done in program courses fall 2011 and winter 2012. Of the 24 programs that completed the faculty reflection 96% report students met their program expectations as stated in the PSLO. There were eight management, eleven engineering, two health, and two natural science programs that participated as well as the applied math program. A summary of these reflections is included in the Appendix to this report.

Upon review, the Executive Committee felt confident that these results indicate graduates are well prepared in mathematical knowledge and skills necessary for their profession.

Professional Exams

The Executive Committee concluded that the data collected from math courses is not congruent with the reports from program faculty in regard to their students' ability in math. As a follow up, the committee looked at the results of professional exams for engineering, health and management programs as an additional indicator.

Fundamentals of Engineering Examination

The Fundamentals of Engineering Examination (FE exam) is a 120 question multiple-choice exam which is a first step to certification as a Professional Engineer. The exam is offered twice a

year in April and October. In April 2012, 34 enrolled Oregon Tech engineering majors sat for the exam with 31 passing, a pass rate of 91%. The exam results are grouped by topic with 19 mathematics questions and 8 engineering probability and statistics questions. Historical data suggests that approximately 50% in a given topic is passing. The April 2012 results for each of these topics by declared major are shown in Table 3.

Topic	Civil Engineering	Electrical Engineering	Mechanical Engineering	Other Engineering Disciplines
Mathematics	75	75	75	86
Engineering Probability & Statistics	49	56	42	67

Table 3. April 2012 results of the FE exam, n=34

Medical Imaging Credentialing Exams

Medical Imaging students receive their professional certification by passing National Registry exams. Examinations are specific to the medical imaging specialty. Each exam contains a significant number of questions related to math and physics. Image production and evaluation represents 25% of the questions on the Radiography exam, these questions require math and physics calculations. The 41 examinees on the 2011 Radiography exam scored 8.9 on a scale of 1 to 10 on this section as compared to the National average of 8.3. Oregon Tech radiology students enjoyed a 100% pass rate in 2011 as compared to the National pass rate of 92.7%.

ETS Major Field Test in Business

The ETS Major Field Test for the Bachelor’s Degree in Business contains 120 multiple-choice questions designed to measure a student’s subject knowledge and the ability to apply facts, concepts, theories and analytical methods. The questions represent a wide range of difficulty and cover depth and breadth in assessing students’ achievement levels. Approximately 11% of the exam questions are categorized as Quantitative Business Analysis which includes probability and statistics. The results for the 2011 cohort of 53 management seniors showed a mean percent correct of 45 which ranked in the 81 percentile of the National group.

Indirect Assessment from Senior Exit Surveys

The Executive Committee collected indirect assessment information from graduating seniors on their math knowledge and skills, using senior exit surveys administered by each program. Students were asked to rate their proficiency in mathematical knowledge and skill. The compiled results from the 227 students who participated in the survey are shown in Table 4.

	Limited/No Proficiency	Some Proficiency	Proficient	Highly Proficient
Mathematical knowledge and skill	0%	8.8%	59%	32.2%

Table 4. Level of proficiency rated by graduating students on math knowledge and skills, n=227

These results indicate a high level of agreement among graduating seniors that they are proficient in mathematical knowledge and skill with 91.2% of those who responded to the survey self-rating as proficient or highly proficient. The Executive Committee observed there is a good match between student perceived ability and faculty rating of student performance within the major.

Math Faculty Recommendations

The Math Department made the following recommendations to improve the ISLO assessment in the future:

- Some of the exercises used for assessment may have been poorly designed. The department should pilot changes to those exercises on midterm and/or final exams to see if they can be improved.
- The expectation in the area of applications needs to be more clearly defined and agreed upon within the department.
- The level of expectation for application of Math 100 computations in trailer courses (Math 111, 112 and 251) needs to be clarified and agreed upon as well.

The Math Department made the following recommendations to improve student learning in the areas noted above:

- Supplemental materials should be designed and used to provide opportunity for student practice on those criteria that are not adequately addressed in the textbooks used.
- A discussion of the expectation in the area of applications will take place over the course of the 2012/13 academic year, with the results being implemented and assessed in the fall of 2013.
- A discussion of the level of expectation for application of Math 100 computations in trailer courses will take place during the 2012/13 and 2013/14 academic years, with the results being implemented and assessed in the fall term of 2014.

For the next three academic years one of the areas of (1) graphing, (2) application and (3) computation will be assessed each year, in that order. The cycle will then repeat again in that order during the following three years.

Executive Committee Recommendations

The Executive Committee concluded that students' ability in regard to mathematical knowledge and skill is adequate for their profession at the time they graduate. This is likely contributed by math specific instruction within upper division courses in the major. In addition, assessment of math knowledge and skill in math courses seems to be more rigorous. To insure consistency math faculty scored exam questions as correct only when free of any error; minor errors were scored as incorrect. However, student performance in math courses, specifically when it comes to application, is an area that should receive additional focus to help more students find success.

The Executive Committee recommends the following to improve the ISLO assessment in the future:

- Continue assessment of the three performance criteria in math courses collecting two data points over the next six years to include in the ISLO report.

- Look for additional sources of data that indicate student proficiency in regards to mathematical knowledge and skill.

Assessment Reporting

The Director of Assessment, along with the Executive Committee of the Assessment Commission, will report the results of this assessment to the campus by email to the faculty list serve, by posting the final report on the assessment web site, and by a convocation presentation to the faculty.

Documentation

The Assessment Office will retain the final report and documentation of this assessment indefinitely.

Appendix Math ISLO Program Faculty Reflections

Summary

- 26 programs with math related PSLOs
- 8 Management, 12 Engineering, 2 Health, 3 Natural Science, and Applied Math
- 24 programs completed the faculty reflection

Of the 24 programs that completed the faculty reflection, 96% report students meet their program expectations as stated in the PSLO. The one program that did not meet listed the reason as a timing issue; students did not have the prerequisite knowledge at the data collection point.

Details by Program

Program(s)	PSLO	Course	Term	Activity	Met
IT-Accounting IT-Apps. Dev. IT-Bus/Sys IT-Health Inform Mgt-Accounting Mgt-Small Bus Mgt-Marketing Operations Mgt	Demonstrate the ability to use business tools.	MIS 375 Decision Support Systems	Fall 2011	1 assignment 2 lab exams	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
GEO-Surveying GEO-GIS	An ability to apply knowledge of mathematics, science and applied sciences	GME 451 Geodesy	Fall 2011	Students were asked to apply mathematical formula to the solution of a common geodetic problem	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
Mechanical Engineering	Graduates will have the ability to analyze and model physical systems or components using (apply knowledge of) mathematics (including multi-variable calculus and differential equations), basic science and engineering.	MECH 315 MECH 318 MECH 480	Fall Fall Wtr	Pre-exams in each class	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
Computer Engineering Technology (Hardware)	(6) the ability to apply mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems	CST 162, CST 344, CST 335; CST 442, CST 418	Fall Fall Fall Wtr Wtr	Activities involved problem formulation, computation, differentiation, integration and being able to compute probabilities.	Yes
Comments: While the seniors were able to perform acceptably, the freshman, sophomores and juniors had a harder time. The juniors this year were not able to use an integral to find the average of a rectified sine. Juniors were not able to properly read the subdivisions on a log scale.					

Program(s)	PSLO	Course	Term	Activity	Met
Manufacturing Engineering Technology	An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology	MFG 360 KFalls; ENGT 230 Seattle	Fall	Engineering related math problem on midterm	Yes
Comments:	The program could do more to enhance the math skills of students, they get by. Math applications in labs, math related problems on exams in program courses.				
Program(s)	PSLO	Course	Term	Activity	Met
Electrical Engineering	knowledge of differential and integral calculus and advanced mathematics including differential equations, linear algebra, vector calculus, complex variables, series and sequences, Laplace Transforms, Fourier Transforms, and probability and statistics with appropriate applications.	EE 225 EE 341	Fall 11	Lab project EE 225 Homework problems EE 341	No
Comments:	Weaknesses are associated with the timing of the assessment. EE students do not take Math 465 (statistics) until winter term of their senior year, therefore the assessment would not be effective until spring term of the senior year in EE 401. Program faculty suggested that additional criteria need to be added to assess this outcome. It is likely that all performance criteria associated with this outcome cannot be assessed in a single course.				
Program(s)	PSLO	Course	Term	Activity	Met
Mechanical Engineering Technology	An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology	MFG 360 KFalls ENGT 230 Seattle MET 313 Portland	Fall Wtr	exam questions/homework problems	Yes
Comments:	The results are consistent with what we know about MET students at OIT.				
Program(s)	PSLO	Course	Term	Activity	Met
Renewable Energy Engineering	An ability to apply knowledge of mathematics, science, and engineering	REE 253	Fall	Homework and lab assignment: the objective was to engage the class in a homework applying the knowledge of mathematics, science and engineering to address problems in the field of electrical machinery. The students then measured equipment performance and compared it to calculated values.	Yes
Comments:					

Program(s)	PSLO	Course	Term	Activity	Met
Civil Engineering	An ability to apply knowledge of mathematics, science, and engineering	CIV 328	Wtr 12	Solving math intensive engineering problems.	Yes
Comments:	1. Students are adequately prepared for their engineering courses, but tend to lose some of the higher level math quickly. 2. We would love to have more 101-type courses. These courses have been heavily encouraged by our faculty and highly successful for our students.				
Program(s)	PSLO	Course	Term	Activity	Met
Electrical Engineering Technology	ability to apply transform techniques to solve engineering problems (i.e., application of Laplace transforms to circuit analysis)	EE 320	Fall	Application of Laplace transform techniques to solve a circuit analysis problem in the final exam. The problem required finding initial conditions, transforming the circuit to the s-domain, solving the circuit, finding the poles, characterizing the circuit behavior, and computing the inverse Laplace transform of the final solution.	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
Applied Mathematics	3. Create, use and analyze graphical representations of mathematical relationships.	MATH 421	Fall	The criteria were measured through both homework assignments and exams.	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
Respiratory Care	No specific	RCP 235 Arterial Blood Gas RCP 236 Cardiopulmonary Dynamic	Fall	The final examinations for RCP 236 Cardiopulmonary Dynamics and RCP 235 Arterial Blood Gases. On these examinations there were multiple questions requiring a range of algebraic computations using 11 different formulas the students were to have memorized.	Yes
Comments:	These calculations must be repeatedly retested throughout the program or else we suffer the consequences of the exponential decay in learning that is well demonstrated. We do have one calculation that requires the use of logarithms.				

Program(s)	PSLO	Course	Term	Activity	Met
Radiologic Science	Demonstrate knowledge of x-ray physics and related math.	RDSC 202	Winter	15 exam questions	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
Software Engineering Technology	Application of mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems.	CST 162 CST 466 CST 417 CST 315	Fall Spring Fall Fall	Students are given a problem related to a topic in the course involving mathematical reasoning, related to probability, calculus, or discrete mathematics (466, 417, and 315). The problems are then graded with a rubric by the program director.	Yes
Comments:					
Program(s)	PSLO	Course	Term	Activity	Met
Biology/HS	Biology students will demonstrate mathematical knowledge and skills in the biological sciences.	CHE 450 PHYS 201	Fall Winter	CHE 450-mathematical concepts were assessed as part of a laboratory experiment on bacterial growth curves. This lab required quantitative measurement of data and graphing in both linear and non-linear forms. Students must relate values from graphs back to established theories about bacterial growth, and must also discuss the limits and usefulness of their imperfectly measured data. PHYS 222-final exam clustered around the four performance criteria.	Yes
Comments:					