Applied Mathematics Degree Program Assessment Report 2015/16

I. Introduction

The Applied Mathematics Degree was approved by the Oregon University System in the spring of 2006, and the program was implemented beginning in the fall of that year. We have had problems identifying our students because some of them are dual majors and do not need to declare themselves as an Applied Math major or have a math advisor until two terms before graduating. The program graduated its first student in the Spring of 2008, see the table below for graduatution numbers.

Academic Year	Number of Graduates	Graduates earning more than 1 degree
2007-08	1	1
2008-09	6	unknown
2009-10	1	1
2010-11	5	2
2011-12	4	1
2012-13	7	5
2013-14	4	0
2014-15	2	2
2015-16	3	2
Total	33	At least 14

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II. Mission, Program Educational Objectives, and Expected Student Learning Outcomes

The program faculty reviewed the mission, objectives, and student learning outcomes for the program in Fall 2015 and made no changes.

Mission

Graduates with the Applied Mathematics Degree will have knowledge and appreciation of the breadth and depth of mathematics, including the connections between different areas of mathematics, and between mathematics and other disciplines. They will be prepared for immediate participation in the workforce, or for graduate study.

Educational Objectives

Graduates of the Applied Mathematics Program will be prepared to do the following in the first few years after graduation.

1) Apply critical thinking and communication skills to solve applied problems.
2) Use knowledge and skills necessary for immediate employment or acceptance into a graduate program.
3) Maintain a core of mathematical and technical knowledge that is adaptable to changing technologies and provides a solid foundation for future learning.

Expected Student Learning Outcomes

Upon graduation, students will be able to

1. apply mathematical concepts and principles to perform computations
2. apply mathematics to solve problems
3. create, use and analyze graphical representations of mathematical relationships
4. communicate mathematical knowledge and understanding
5. apply technology tools to solve problems
6. perform abstract mathematical reasoning
7. learn independently

Other Learning Opportunities

In addition to coursework, students can participate in the department's colloquium series, attend regional mathematics conferences and/or compete in the national COMAP competition.

III. Data Collection/Assessment Schedule

Table 1 indicates the three year cycle for assessing the learning outcomes.

	Academic Year Assessed		
Learning Outcomes	**'14-15**	**'15-16**	**'16-17**
1. Apply mathematical concepts and principles to perform symbolic computations.			**X**
2. Apply mathematics to solve problems.		**X**	

3. Create, use and analyze graphical representations of mathematical relationships.	**X**		
4. Communicate mathematical knowledge and understanding.	**X**		
5. Apply technology tools to solve problems.		**X**	
6. Perform abstract mathematical reasoning.			**X**
7. Learn independently.	**X**		

Table 1. Three-year cycle for assessment of Applied Math learning outcomes.

IV. 2015-16 Assessment Activities

Assessment of two learning outcomes was conducted during this academic year.

Outcome 2: *Apply mathematics to solve problems* was assessed in math 354, in Winter 2016. There are three performance criteria for this PSLO.

a) Write a mathematical description of a physical problem.
b) Correctly solve the higher dimensional integral.
c) Interpret results.

These criteria were measured by oral presentations of a written report and the results *for only the math majors* are given in Table 2. Percents indicate the percentages of students performing at the given level for each criterion.

There were 9 math majors enrolled in Math 354 this term. The students were each given a very similar problem which had three parts. In the first part they were given a vector valued function and a surface and asked to set up and evaluate an integral over that surface, describing the process mathematically along the way. In the second part they were asked to use either Green's Therorm, Stokes' Therom or the Divergence Therom to evaluate / veryfiy the integral in a different (second) way. In the third part they had to demonstrate understanding of how the therorm(s) worked to provide two different ways to calculate the answer.

For the first criterion the instructor checked whether the student set up the integral in the first part correctly. For the second criterion the instructor checked to see if they had actually calculated the first and second parts correctly. For the third criterion the instructor checked to see if they understood that the relevant theorem applied, and what roles the first two answers played in the calculation.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
Mathematical description	0%	0%	100%
Correct Solution	0%	0%	100%
Interpretation	0%	55.5%	44.6%

Table 2. Assessment results for Outcome 2.

The math majors (and in fact all the students in the class) did an ourstanding job on this project / presentation. All students properly set up and solved integrals using the appropriate therorm. The students did have two weeks to work on this, but until they were called to the board, they did not know which problem (out of a pre-selected set of 20) they would be required to present. Every student demonstrated that they had done a great deal of work and had written up solutions to every problem, they all demonstrated outstanding technical / mathematical profiency. All of the students were able to give a reasonable argument as to how the relevant theorem worked but only half of the stuents were able to convince the instructor that they understood the concept of the theorem rather than the particulars of a gien problem.

Outcome 5: *Apply technology tools to solve problems* was assessed in Math 452, Numerical Methods II, in Winter 2016. There are four performance criteria for this PSLO.

a) Write appropriate code.
b) Provide proper documentation of code.
c) Presentation and output of results.
d) Validity of solutions via comparison or other means.

These criteria were measured by considering the third of the four major assignments on which their grade was based. The course used the Python programming language on the Anaconda software platform. The results are given in Table 3. Percents indicate the percentages of students performing at the given level for each criterion. There were four math majors in the course.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
Write code	0%	50%	50%
Document code	50%	50%	0%
Presentation	0%	50%	50%
Solution validity	0%	75%	25%

Table 3 Assessment results for Outcome 5.

Based on this data, we see that our students were reasonably good at **writing code**. The results would probably have been better except that this course used Python as its programming language, a language which the students had had little to no experience using before taking Math 451. **Program documentation**, while not very good, was not really emphasized in the course. Had it been, I feel the students would have responded.

Presentation was emphasized in the course, but the response was hit-or-miss. Students have a tendency to dump a large number of graphs and tables into their reports without much in the way of organization or theme. In the future it would be good to emphasize the need for a small number of well-constructed, well-explained, illustrative graphs.

Validity of solutions was also rather hit-or-miss. When explicitly told to compare a numerical result with a theoretical one, they usually performed well. When told to make numerical calculations of quantities that have a theoretical connection, but not explicitly told to make that connection, they did much less well. For example, in a problem involving a system of differential equations the students were told to find the fixed points and the eigenvalues of the Jacobian at those points. They were also told to integrate solutions near those fixed points and comment on the results. They did these things reasonably well. However, there connection between the eigenvalues and the behavior of the solutions was important, clear, and pretty much ignored by most students. It is important that we do better on this, as it is the difference between using technology to perform fairly rote tasks and using technology to understand mathematics.

Additional Assessment: Diverse Perspectives ESLO

The Mathematics Department met early in the Fall term 2015. At this meeting we determined that there are no courses in the Applied Mathematics Program that assess the ESLO on Diverse Perspectives. We plan to have further conversations about this ESLO in tandem with campus-wide efforts to reform GE.

V. Closing the loop --- Abstract reasoning was reassessed in Math 311, Winter 2015 and Winter 2016

Outcome 6: *Perform abstract mathematical reasoning* was previously assessed in Math 311, Real Analysis, in the winter of 2014. Because there were so few students enrolled in this course winter 2014, the department felt that this outcome should be reassessed. The enrollement was low again in Winter of 2015 (2 students), so the department decided to assess a third time. For the year 2015-16, *Perform abstract mathematical reasoning* was assessed in Math 311, Real Analysis, in the winter of 2016.

There are three performance criteria for this PSLO.

a) Construct the contra-positive of an if-then-statement.

b) Present a formal proof of the convergence of a sequence.
c) Present a formal proof of the limit of a function at a point.

These criteria were measured by three final exam problems. There were 9 students in the class and all of them are math majors. However, only 8 students were assessed since one student did not attend the final exam. The results are given in Table 4.

The first criterion was tested by presenting the student the famed **Bolzano-Weierstrass Theorem**. The Bolzano-Weierstrass theorem is an if-then-statement. The students were asked to state the contra-positive of this theorem. A response showed high proficiency if the student could construct the correct contra-positive statement. A response showed proficiency if the contra-positive was essentially a correct statement but showed some grammatical errors.

The second criterion was tested by presenting the students with a sequence function as a quotient. They were then asked to find the limit of this sequence using the formal definition. The student showed high proficiency if he could arrive at the correct answer by using the formal “epsilon-N” definition of limit. The student showed proficiency if he/she used the formal definition correctly but made an error at some point in the problem which led to a mistake.

The third criterion was tested by presenting the students with a linear function and its limit at a point. The students were then asked to present a formal delta-epsilon proof. A response showed high proficiency if the student chose an appropriate delta and showed algebraically that this bounded the function to within epsilon of its limit. A response showed proficiency if the student bounded the difference between the function and its limit, but did not clearly tie together epsilon and delta.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
Constructing Logical Statements	25% (2/8)		75% (6/8)
Proof of Convergence	50% (4/8)	37.5%(3/8)	12.5% (1/8)
Proof of Limit	37.5%(3/8)	37.5%(3/8)	25% (2/8)

Table 4. Assessment results for Outcome 6 results

This data shows that students did reasonable well when constructing a logical statement (contrapositive). However, the students performance on constructing a formal (and relatively simple) proof was not acceptable.

The Winter 2016 instructor for Math 311 (Jim Fischer) feels that students are reluctant to work at learning how to write proofs. There is too much information available online that allows students to avoid thinking about proofs and instead copy proofs or main ideas from internet resources. This strategy works fine when it comes to graded assignments, however when these same students are asked to construct (relatively simple) proofs in a testing environment, they are not able to do so.

The math major committee met to discuss what if any changes should be made to the program or to Math 311. We decided to bring the discussion to the department during convocation 2016. We will likely request that faculty assess writing mathematics in more courses (such as Math 111, 112, 25X). We are also thinking about adding some introduction to writing proofs to the Math 253 course. A summary of changes and closing the loop will be included in next year's program assessment report.

VI. Student Exit Surveys

The math major committee met Spring term 2016 to read and discuss student responses from the exit survey distributed in 2015-16. At the time of our meeting there were zero responses so we had no data to evaluate. The committee decided to look at exit survey responses during convocation 2016. A summary will be included in next year's program assessment report.

VII. Changes Resulting From Assessment

No changes at this time. However, the department may make or suggest changes after discussing some of the issues with respect to abstract reasoning SLO. This discussion will occur during convocation 2016. If there are any changes to make, they will be recorded in next year's program assessment report.

VIII. Summary of Student Learning

The faculty assessed two program student learning outcomes during the 2015-16 academic year and reassessed a third outcome. The faculty reviewed the results during a spring 2016 faculty meeting and had the following conclusions.

Outcome 2: *Apply mathematics to solve problems* was assessed in math 354, in Winter 2016. Students met all performance criteria and no further action is required at this time.

Outcome 5: *Apply technology tools to solve problems* was assessed in Math 452, Students met all performance criteria and no further action is required at this time.

Outcome 6: *Perform abstract mathematical reasoning* was previously assessed in Math 311, Real Analysis, in the winter of 2016. We felt that students did not perform satisfactorily with respect to writing proofs. The Math Major Committee, considered a few options for changes and we decided to open this discussion up to the entire department during convocation 2016.

Appendix A: Student Learning Outcomes/Curriculum Matrix

In the following table, an E indicates that outcome is emphasized in the course, an A means that it is addressed, and N/A indicates that the outcome is not addressed in the course.

Course	Student Learning Outcome						
	Computation	Graphing	Application	Communication	Technology	Abstract Reasoning	Independent Learning
322	E	A	E	A	NA	A	NA
327	A	NA	A	E	NA	E	A
354	E	NA	A	E	NA	A	E
421	E	E	A	E	A	A	A
422	E	E	A	E	A	A	A
423	E	E	A	E	A	A	A
452	A	E	E	E	E	A	E
453	A	E	E	E	E	A	A