Applied Mathematics Degree Program
Assessment Report 2013/14

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. According to Institutional Research, currently the program has 33 majors. The program graduated its first student in the Spring of 2008, six more students graduated in 2008/2009, an additional student graduated during the 2009/2010 year, five students graduated during (2010/2011), and four graduated during the year (2011/2012), six graduated during the year (2012/2013). We expect 5 students will graduate this year (2013/2014). The degree is too new at this point to be able to offer additional information on retention rates, numbers of graduates or employment rates and salaries.

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 2013 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	**'11-12**	**'12-13**	**'13-14**
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. 2013-14 Assessment Activities

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

Outcome 1: *Apply mathematical concepts and principles to perform symbolic computations* was assessed in Math 354 Multi-variable and Vector Calculus II, in the Winter of 2014. There are three performance criteria for this PSLO.

a) Set up and evaluate a multi-variable integral.
b) Apply a form of Stokes' theorem to convert between integrals.
c) Solve a problem related to conservative vector fields

These criteria were measured by exams and the results *for only the math majors* are given in Table 2. Percent indicates the percentage of students performing at the given level for each criterion. There were 3 math majors enrolled in Math 354 this term. Each was given the same three problems on a final exam. Jim Ballard has a copy of the problems given to the students and the data used to complete Table 2. Here is a description of the three problems.

Problem 1: Compute a surface integral over a parameterized surface.

Problem 2: Use Stokes's theorem to compute a double integral of a curl.

Problem 3: Verify that a vector field is conservative and find the potential function.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
(a)		66	34
(b)	66	34	
(c)	33	33	34

Table 2. Assessment results for Outcome 1.

The students in Math 354 performed strongly in the area of symbolic computation. The low score of 66% for criteria (b) resulted because two out of the three students did completed the problem but did not use Stoke's Theorem as the problem asked. The data suggests that our Junior/Senior students are performing at a high level in the area of symbolic computation.

Outcome 6: *Perform abstract mathematical reasoning* was previously assessed in Math 327, Discrete Mathematics, in the spring of 2011. For the year 2013-14, *Perform abstract mathematical reasoning* was assessed in Math 311, Real Analysis, in the winter of 2014. 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 final exam problems. All five students in the class were math majors. The results are given in Table 3.

The first criterion was tested by presenting the student with two if-then statements and asking the student to construct the contra-positive. The first statement was quite straight-forward, while the second was somewhat more subtle. A response indicated proficiency if the first statement was correct and the second having only minor errors. A response indicated high proficiency if the first statement was completely correct and the second showing only a very minor error.

The second criterion was tested by presenting the students with a recursively defined sequence and asking them to first prove that the sequence converges, and then calculate the actual limit. A response showed high proficiency if the student used induction to establish the sequence was monotone increasing and bounded, cited the monotone convergence theorem, and then calculated the actual limit. A response showed proficiency if one of these steps was either poorly done or omitted entirely, but the other two were essentially correct.

The third criterion was tested by presenting the students with a polynomial 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	1	1	3
Proof of Convergence	2	1	2
Proof of Limit	1	1	3

Table 3. Assessment results for Outcome 6 results

Additional Assessment: Critical Thinking and Problem Solving ISLO

During convocation the Math Department met to discuss how to assess the institutional learning outcome *Critical Thinking and Problem Solving* within our program. We started by trying to define what is critical thinking. We discussed several ideas that were presented in the talk *"Critical Thinking Within and Across Disciplines"* presented at this year's convocation by Matt Barker. Ultimately, the department unanimously agreed that we should find a definition of critical thinking that is most relevant to what we are teaching in our math classes. We agreed on the following definition that was found online at Dictionary.com:

Critical Thinking: the mental process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information to reach an answer or conclusion.

The department met fall term 2013 to determine how to use the above definition to construct an assessment plan for critical thinking. We chose to assess the ISLO on critical thinking in the course Math 452, Numerical Methods II during the Winter term 2014.

Critical Thinking – Math Department
Course: Math 452, Numerical Methods II

Assignment: Students will solve one linear ordinary differential equation (ODE) and one non-linear ODE, each by various numerical methods, and evaluate their results.

Performance Criteria:
1. State clearly what is to be accomplished (identification)
2. Discuss the nature of the specific equations (identification)
3. Describe the methods under consideration (identification)
4. Implement the methods (clarification)
5. Generate and present results (clarification)
    a) Solutions and convergence information
    b) Error analysis
6. Evaluate correctness of solutions (evaluation)
7. Determine the "best" method of solution to each problem, with justification for choices (evaluation)

Students were assessed for their critical thinking skills using an assigned, take-home, numerical problem where all the criteria designated above were evaluated. The first three tasks were grouped under the identification task below – students were graded as meeting proficiency standards if their scores were at least 2 out of 3, and below proficiency standards if they only earned 1 or no points out of 3 points possible for the identification task. Similarly for the clarification task. For evaluation, there were only two tasks, and students who earned two points out of two possible earned high proficiency, while those who earned 1 were classified as proficient. Those who earned no points at all were classified as not proficient. The breakdown for the student population who were math major in Math452 during Winter 2014 who were evaluated for this task is given below.

	Some/no Proficiency	Proficiency	High Proficiency
Identification	0	75	25
Clarification	13	25	62
Evaluation	0	44	56

Table 4. Critical thinking summary (results represent percent of student in each category).

V. Summary of Student Learning

The faculty assessed two program student learning outcomes and one institutional student learning outcome during the 2013-14 academic year. The faculty reviewed the results during a Spring 2014 program meeting and had the following conclusions.

Outcome 1: Apply mathematical concepts and principles to perform symbolic computations.

Students met all performance criteria and no further action is required at this time. The strength of our conclusion is limited by the low number (3) of math majors enrolled in Math 354.

Outcome 6: Perform abstract mathematical reasoning.

This is an area of difficulty for most students. The data indicates that the students' performance was adequate.

Institutional Outcome: Critical Thinking.

Based on this data, one area of weakness that was identified is in "clarification", specifically in discussing the nature of a given differential equation (linear vs. nonlinear) and how this affects the solution obtained as well as the choice of a numerical method chosen for its solution. Students performed well in the areas of "identification" and "evaluation". Students also performed well in the "subcategories" of Implementation and generation of results that are part of the "clarification" task.

VI. Changes Resulting From Assessment

The program committee felt that the students performed adequately in the abstract reasoning outcome. Due to the low number of students assessed, the committee decided to replicate the assessment next Winter in the same course (Math 311). We discussed the possibility that there may be too much time between when the students take the prerequisite (Math 327) and Real Analysis (Math 311). Due to scheduling constraints, it may be too late to add a section of Math 327 for the Fall term 2014. We will consider adding a section of Math 327 Fall 2015, depending partly on the assessment outcome from next Winter.

<u>Appendix A</u>: 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