Applied Mathematics Degree Program Assessment Report 2014/15

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, 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), six graduated during the year (2013/2014). We expect 5 students to graduate this year (2014/2015). As of Spring term 2015, there are a total of 40 Applied Mathematics Majors, 25 in Klamath Falls, 12 Software Duals, and 3 from Wilsonville. 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 Spring 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. 2014-15 Assessment Activities

Assessment of three learning outcomes was conducted during this academic year. A combined rate of proficiency and high proficiency of at least 60% is considered an minimum acceptable performance.

Outcome 3: *Create, use and analyze graphical representations of mathematical relationships* was assessed in Math 422, in the Winter of 2015. There are three performance criteria for this PSLO.

a) Graph the time dependent solution of the three dimensional heat equation.
b) Graph the solution of Laplace's equation in three dimensions.
c) Graph the time dependent solution of the three dimensional wave equation.

All 5 students in Math 422 during Fall 2015 were Applied Mathematics majors. The criteria were measured through technical report-projects. All students were expected to solve the problems anayically and create a Matlab code resulting in a graphical representation of the solution.

Problem 1 (a): Produce a graphical representation of the analytical solution to the following problem:

The heat equation inside a circular cylinder subject to the initial condition:
u(r,theta,z,0)=r^2z.
With boundary conditions u(r,theta,0,t) = u(r,theta,6,t) = u(4,theta,z,t)=0.
Let k=2.

Problem 2 (b): Produce a graphical representation of the analytical solution to the following problem:

Laplace's equation inside a circular cylinder subject to the boundary conditions:
u(r,theta,0)=(16-r^2)cos(2theta), u(r,theta,6)=u(4,theta,z)=0.

Problem 3 (c): Produce a graphical representation of the analytical solution to the following problem:

The wave equation inside a sphere of radius rho < 10 subject to the boundary condition:
u(10,theta,phi,t)=0.

With the initial conditions: u(rho,theta,phi,0)=-2(rho-5)^2+2 if 4 < rho < 6, and u(rho,theta,phi,0)=0 otherwise, and no initial velocity.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
(a)	0%	20%	80%
(b)	0%	0%	100%
(c)	0%	40%	60%

Table 2. Assessment results for Outcome 3.

For the first criteria, all of the students were successful in solving the problem but one of the five did not manage to work all the bugs out of their code and the graphical solution was off by a few constants.

For the second criteria, all of the students were able to perform flawlessly. The high proficiency students performed all the tasks needed to generate this graph – correct solution, correct code, and appropriate confirmation of the correct graph through the use of various principles that apply to this problem.

For the third criteria, all students but two earned high proficiency marks. Those who were just proficient were able to generate the correct analytical solution but failed to properly code up and create a working animation of a spherical wave inside a ball.

Based on this assessment exercise, our students met or exceeded our stated 60% performance minimum.

Outcome 4: *Communicate mathematical knowledge and understanding* was assessed in Math 422, in the Winter of 2015. There are three performance criteria for this PSLO.

a) Demonstrate the use of various solution techniques and explain how and why all solution scheems work.
b) Explain the relevant PDE's; both the governing equattions along with boundary and initial conditions and the expected and computed solutions.
c) Write a technical report regarding the two previous criteria and document all analytical and computational solutions.

The three criteria for outcome 4 were assessed in Math 422, Winter 2015 via technical reports. The first critera, explain how and why solution techniques work, was assessed in all technical reports. All students were highly proficient at this criteria on each of the reports. In the written reports I was able to assess this criteria at the level of a incorrect explanation, proficient explanation and an excellent explanation. Results for all assessment of criteria-one are shown in the table below.

The second criteria (explain relevant PDE problem) was assessed on both (three) in-class tests and two technical reports. None of the students failed any of the test qustions for this criteria (all were proficient), a few students gave improrper boundary and / or initial conditions on the in-class tests. The tests were difficult in this regard since limited time was a major factor. In the technical reports all of the students were able to give excellent explanations which demonstrated that they could (given time) properly set up and explain

(model) a giving situation with the proper partial differential equation and boundary and initial conditions.

The final criteria (technical report which included the first two criteria) was assessed two times for each student. No student turned in a final report that was less than proficient. Also the first reports assessed here were only assessed on the second/final draft. Each student knew that they would get the first report back and have two weeks to fix any mistakes and re-submit.

None of this takes away from the fact that the each of the final reports (which were not allowed a prior draft) for each student averaged over 30 pages of well documented, clearly communicated, and mathematically correct perfectly constructed technical reports. Many of the students did a great deal more than was asked for and included extra analysis and outside information (beyond what we did in the class). Scores ranged between 79 and 115 out of 100 points and I was literally shocked at the quality of work demonstrated by undergraduates.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
Solution Techniques	0%	0%	100%
Explain PDE's	0%	20%	80%
Write technical report.	0%	40%	60%

Table 2. Assessment results for Outcome 4.

Based on this assessment exercise, our students met or exceeded our stated 60% performance minimum.

Outcome 7: *Independent learning* was assessed in Math 354 Multi-variable and Vector Calculus II, during Winter term 2015. There are three performance criteria for this PSLO.

a) Determine or recognize an application of vector calculus.
b) Do some research regarding the application or problem.
c) Give a presentation that summarizes the applicaton or problem.

The Independent learning assessment was done in Math 354 winter term, 2015. The criteria (a) was measured by requiring the students to submit and abstract that summarizes their choice of application. The abstract was collected around mid-term.g Criteria (b) and (c) were measured by the quality of the presentation which included a list of references**.** There were 14 students enrolled in the class, 9 were math majors. .

Table 1 demonstrates the students' performance. The group performance is recorded as a percent indicating low proficiency, proficient, or highly proficient on each of the three assessment questions

	Student Performance		
Criterion	%-Some/no proficiency	%-Proficient	%-High Proficiency
Recognition of application	22	78	0
Research of application	22	78	0
Quality of Presentation	22	22	56

Table 1. Assessment results for Outcome 7.

For the first criteria, determine or recognize an application of one of the integral theorems, the group exceeded the mathematics department's stated 60% performance minimum. Of the 9 Math Majors, 7 students submitted a reasonable abstract that clearly indicated an application of vector calculus that was relevant to the course. One student failed to submit an abstract and one student was assessed as having "no proficiency" because s/he did not demonstrate how the research topic was related to vector calculus.

For the second criteria, do research on the application or problem, the group exceeded the stated 60% performance minimum. The students were either graded as Proficient for having stated references during their presentation or Not Proficient if they failed to list references. 7 out of the 9 students listed references within their presentations. The group therefore exceeds the department's stated minimium.

For the third criteria, quality of a presentation, students were given a rubric two weeks prior to their presentation. Their presentations were graded using the rubric and a point score for each presentation was converted to a percent. Students were determined to be Some or Not Proficient if their presentation score was under 70% and Highly Proficient if their score was over 90%. Two of the 9 students did a poor job on their presentation, they did not follow the instructions and clearly did not come to class prepared. However, 7 of the 9 students did a reasonable or very good job at researching and presenting a relevant application of vector calculus. The group therefore exceeds the department's stated minimium of 60% Proficient.

Based on this assessment exercise, our students met or exceeded our stated 60% performance minimum for Outcome 7.

V. Summary of Student Learning

The faculty assessed three program student learning during the 2014-15 academic year. The faculty reviewed the results during a spring 2015 faculty meeting and had the following conclusions.

Outcome 3: Create, use and analyze graphical representations of mathematical relationships.

Students met all performance criteria and no further action is required at this time.

Outcome 4: Communicate mathematical knowledge and understanding.

Students met all performance criteria and no further action is required at this time.

Outcome 7: Learn independently.

Students met all performance criteria and no further action is required at this time.

VI. Student Exit Surveys

The math major committee met Spring term 2015 to read and discuss student responses from the exit survey distributed in 2013, 2014. There were a total of 8 respondents, 4 from 2012 and 4 from 2013. The committee did not feel any action was necessary. The committee decided to review these 8 surveys again next year together with and any new surveys submitted in 2015.

VII. Changes Resulting From Assessment

No changes. However, it should be noted that a change suggested from 2011 Assessment regarding early collection of Abstract or Outline for a Paper or Presentation was employed this year for Outcome 7. Having early collection of an Abstract seems to help students to avoid procrastination and helps to ensure a reasonable choice of topic for their paper/presentation.

VIII. Closing the loop --- Abstract reasoning was reassessed in Math 311, Winter 2014

Outcome 6: *Perform abstract mathematical reasoning* was previously assessed in Math 311, Real Analysis, in the winter of 2014. For the year 2014-15, *Perform abstract mathematical reasoning* was assessed in Math 311, Real Analysis, in the winter of 2015. 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 various exam problems. There were two students in the class and both of them were math majors. The results are given in Table 3.

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 in part (a) of the question. In part (b) of the question the students were asked to prove this contra-positive statement. A response showed high proficiency if the student could construct the correct contra-positive statement. A response showed proficiency if the contra-positive had the same meaning as the original statement but showed 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 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 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
Proof of Convergence			2
Proof of Limit		1	1

Table 3. Assessment results for Outcome 2 results

Since the data only involves two students the committee felt that we should continue to assess this outcome next year. We will hold off on making any conclusions until we have more data to work with.

<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