Applied Mathematics Degree Program Assessment Report 2011/12

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 approximately five will graduate this year (2011/2012). 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 Winter 2012 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. 2011-12 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 421, in the Fall of 2011. There are three performance criteria for this PSLO.

a) Sketch a few typical characteristics.
b) Graph the solution to the 2D-Laplace equation.
c) Graph the solution for a fixed time for the solution wave equation.

All 8 students in Math 421 during Fall 2011 were Applied Mathematics majors. The criteria were measured through both homework assignments and exams. The problems assessing parts (a) and (c) above were given on an exam, while the problem assessing students' ability to graph the solution to a 2D Laplace equation was given on a homework assignment, mostly because students were expected to use some software to generate the graph. A Matlab code written for a different problem was available to all students and they were expected to modify this code or write their own to produce the graph.

Problem 1 (a): Consider the wave equation u_tt = 4 u_xx for x any real number and t>0. Initially u(x,0) = x, u_t(x,0)= sin(x).
Solve this problem using D'Alembert's solution. Sketch some typical characteristics.

Problem 2 (b): Solve Laplace's equation inside the quarter circle of radius 1, and 0 <= theta <= pi/2 subject to the boundary conditions u_tht(r,0) = 0, u_tht(r, pi/2) = 0 and u(1,theta) = 1+ exp(-theta). Sketch the solution in Matlab or another software, and include both your code and the graph with your solution. Interpret your graph in the context of this problem.

Problem 3 (c): Suppose that u(x,t) solves the wave equation, thus the solution has the form u(x,t) = F(x-ct) + G(x+ct). Sketch the solution u(x,t) for t = 0, 1, 2 seconds, given F(x) and G(x) below (pictures were provided on the exam). Assume the velocity c = 1.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
(a)	38%	24%	38%
(b)	37.5%	37.5%	25%
(c)	25%		75%

Table 2. Assessment results for Outcome 3.

For the first criteria, some of the weak proficiency was due (perhaps) to students not reading the instructions carefully enough to perform the task asked – there was no attempt to draw any characteristics at all. This was rectified in subsequent examinations by separating the instructions to a problem into parts, each asking for a single task. Those who scored at a proficient level had some minor errors, their graphs had time assume both positive and negative values, whereas x assumed the positive values only. Some of these students also did not label their axes properly, which is important in the evaluation of this particular skill. The remaining students who scored at a high proficiency level produced clear graphs, with appropriate labels and correct lines as the characteristics.

For the second criteria, the assessment looked carefully at a student's ability to generate the graph as well as assess whether the graph was correct by confirming the correct boundary data, as given in the problem and evidenced in the graph. Students were specifically asked to further assess if their graph was correct by visually confirming the max/min principle for Laplace's equation, as well as the mean value principle for this problem. This problem was assigned as homework.
Most of the students who were not proficient in this area did not attempt to generate the graph at all.
Since the graph necessitated a correct solution to the problem, which included the explicit computation of Fourier coefficients, some students obtained incorrect graphs due to their inability to carry on these computations correctly. Students were explicitly encouraged to use integral tables or software for various computations needed to generate the graph. Some students could not confirm the validity of their graphs through boundary data, max/min principles or mean value principles. These students earned a proficiency level assessment due to most of their work being correct but lacking few of these specifics. 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 not proficient either confused the left traveling solution with the right one, thus their graphs were switched, or they did not understand the piecewise nature of the initial data.

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 452, in the Winter of 2012. There are three performance criteria for this PSLO.

a) Use a variety of methods to explain how and why all algorithms work.
b) Explain the relevant ODE's; both the problem 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 452, Winter 2012 via three in-class tests and four technical reports. The first critera, explain how and why algorithms work, was assessed on the first two tests and also in all four reports. While a few students failed to adequetly explain algorithims on one or more of the tests, all students were at least proficient at this criteria on each of the four reports. In the written reports I was able to assess this criteria at the level of a proficient explanation and an excellent explanation. Results for all forms of assessment of criteria-one are shown in the table below.

The second criteria (explain relevant ODE problem and solutions) was also assessed on both (three) in-class tests and four technical reports. None of the students failed any of the test qustions for this criteria (all were proficient). In the technical reports about half of the students were able to give excellent explanations which demonstrated that they were not only able to find expected (analytical) and computed (numerical) solutions but also that they were able to use data to explain the differences (something I refused to help them do, but told them I would dock points if they failed to do).

The final criteria (technical report which included the first two criteria) was assessed four times for each student. No student turned in a final report that was less than proficient and by the fourth report all students turned in outstanding work that was excellent by any measure. Also each of the first three reports assessed here were only assessed on the second/final draft. Each student knew that they would get the first three reports 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 85 and 120 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
Explain algorithms	16%	27%	57%
Explain ODE’s	0%	44%	56%
Write technical report.	0%	36%	64%

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 2012. There are three performance criteria for this PSLO.

a) Determine or recognize an application of one of the integral theorems.
b) Research a paper regarding the application or problem.
c) Quantity and quality of resources used to demonstrate independent learning.

The Independent learning assessment was done in Math 354 winter term, 2012. The criteria were measured via an assigned research paper. Six students from the class submitted research papers. Of those that turned in the assessment material, two were Applied Mathematics majors, and four were engineering majors. One of the students did not submit a paper.

The class was given a hand-out explaining the research paper assignment and, at a later date, the assignment was discussed with the class during class time. The instructor did allow two of the students to do the assignment together, however these two were required to write a longer paper. The other students each wrote their own research paper.

Each student spoke with the instructor about the topic or topics s/he wished to research. From this conversation, and the topic the student chose for the research paper, the teacher assessed outcome "determine or recognize an application of one of the integral theorems," The term paper was also assessed for its application to one or more of the integral theorems and for the quality and quantity of the resources used to research the paper.

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	17	0	83
Research of application	17	50	33
Quantity and Quality of Resources	33	17	50

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. One student was assessed as having "no proficiency" because s/he did not demonstrate how the research topic was related to in integral application. The topic did have an integral application; however there was no indication that the student understood the application.

For the second criteria, research a paper regarding the application or problem, the group exceeded the stated 60% performance minimum. However, 50% of the group was rated as only proficient. Several of these papers had writing errors-demonstrating a lack of proof-reading. There were many spelling errors, many sentence construction errors, and demonstration of weak writing skills. The papers were not checked for originality. Some of the weak proficiency could be due to the lack of length in the research paper. The paper was only required to be three pages in length, and to be no more than 5 or 6 pages in length. Because of this length requirement several of the writers focused more on developing the mathematics rather than on the application of the problem.

For the third criteria, quantity and quality of resources used to demonstrate independent learning, only three of the six students demonstrated high proficiency. While the group met the criteria, most of the group selected material found via a web search (usually something from wikipedia), and none of the group indicated that some sources are better than others. However, one is not sure how this could be done in the assessment assignment.

The assessment indicates to this writer that the applied mathematics majors should have more “research paper” assignments during their junior and senior courses, and that these papers should be assessed and returned for re-writes as needed.

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

V. Summary of Student Learning

The faculty assessed two program student learning outcomes and two institutional student learning outcome during the 2010-11 academic year. The faculty reviewed the results during a spring 2011 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. Changes Resulting From Assessment

Institutional Outcome 1: *Effective oral, written and visual communication.*

Results were mixed. Going forward we will ask students to submit an abstract and two drafts prior to submission of the final written report. Students will be given a rubric outlining the areas to be assessed in the oral presentation.

Based on the results of this outcome, this year we re-evaluated our students for effective oral, written and visual communication in one of their required senior level courses, Math 421, during Fall 2011. Students were given 5 articles, by the instructor, and asked to rank two articles in order of their interest in further working on the topics explored in these articles. All students were asked, in addition, to submit two abstracts, one for each article that they were interested in working on. Based on these abstracts and their rankings of the articles, students were put in groups of two, and had the assigned task of preparing an oral presentation, along with a power point, on the topic of one of the articles assigned.

Students were asked to meet with the instructor to review their power point presentations before they were due to present in class. These were considered the drafts of their written presentations. The students also submitted their final drafts to the instructor. The students were given a rubric of what the instructor outlining the areas assessed for both the oral presentation and the written power point. The students in the audience were also engaged through the same rubric to give (anonymous) feedback to the presenters. The instructor did not consider this feedback as part of the grade of the students giving the presentation.

	Student Performance		
Criterion	Some/no proficiency	Proficient	High Proficiency
Oral Presentation			100%
Written Presentation		25%	75%
Visual Presentation		25%	75%

Table 4. Assessment results for Institutional Outcome 1 results.

All students performed at a proficient aor above proficient level. The additional input given by the instructor in the form of initial articles to work on, as well as requiring students to provide abstracts and drafts of their power point presentations enhanced the results of students's performances on this outcome.

<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