Applied Mathematics Degree Program

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 a few problems identifying our students because some of them are dual majors and do not need to declare a Mathematics advisor in order to receive permission to register for courses. We anticipate having our first two graduates in the spring of 2008.

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 able to do the following:

1. Apply mathematics and technology tools to solve problems.
2. Understand the use of mathematical tools and concepts in other fields.
3. Communicate, and work, with people of diverse backgrounds in individual and group settings, in an ethical and professional manner..
4. Critically analyze information and concepts to adapt to advances in knowledge and technology in the workplace.

Expected Student Learning Outcomes

Upon graduation, students will be able to

1. apply mathematical concepts and principles to perform symbolic computations
2. use modeling to solve problems
3. read and analyze quantitative information in various representations
4. interpret mathematical results
5. apply technology tools to solve problems
6. perform abstract mathematical reasoning
7. create mathematical models
8. learn independently
9. understand or apply the methods of scientific inquiry
10. work effectively in teams

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.

Data Collection/Assessment Schedule

The following table indicates the three year cycle (note that the fourth year is included to show where the cycle begins repeating) for assessing the learning outcomes.

	Academic Year Assessed			
Learning Outcomes	**'07-8**	**'08-9**	**'09-10**	**'10-11**
1. Apply mathematical concepts and principles to perform symbolic computations.	**X**			**X**
2. Read and analyze quantitative information in various representations			**X**	
3. Interpret mathematical results	**X**			**X**
4. Use modeling to solve problems		**X**		
5. Apply technology tools to solve problems		**X**		
6. Perform abstract mathematical reasoning	**X**			**X**
7. Create mathematical models			**X**	
8. Learn independently		**X**		
9. Understand or apply the methods of scientific inquiry			**X**	
10. Work effectively in teams		**X**		

Assessment of Student Learning Outcomes

Assessment of Program Learning Outcome 1, Fall 2007

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

Measures (Activities) Used

Direct Measure: Students in several sections each of Math 111 and Math 252, and one section of Math 321, were given one (Math 111 and Math 252) or two (Math 341) exam problems (meaning they were incorporated into regular class exams or final exams) that required students to apply mathematical concepts and principles to perform symbolic computations. *It should be noted that the questions specifically isolated on this outcome alone.* Student work was graded according to a rubric that was specific to the question asked (the rubric was common to all sections of a given course); points were awarded for correctly executing steps in solving the problem or problems. Copies of the problems and rubrics can be found in the Math Department assessment binder, kept by the department assessment coordinator.

Indirect Measure: Students in these same courses were given a questionnaire asking what they felt their ability level was in applying mathematical concepts and principles to perform symbolic computations, both in math classes and in courses in their major. They were also asked if they felt that their ability in applying mathematical concepts and principles to perform symbolic computations had improved while taking their current math course. A copy of the questionnaire can be found in the Math Department assessment binder, kept by the department assessment coordinator.

Analysis of Results/Strengths and Weaknesses:

Direct Measure: Student scores overall followed the usual distribution of "haves" and "have nots." That is (particularly with the Math 111 and 252 results), most of the students either did fairly well or fairly poorly, and few fell in the middle. For Math 111, 68% of the 41 students made significant errors, had little idea what to do, or both. On the other hand 26% of the Math 111 students received a score of 80% or better. Those percentages for Math 252 (56 students) were 41% and 39%, and for Math 321 (29 students) the percentages were 28% and 52%. Copies of the raw data can be found in the Math Department assessment binder, kept by the department assessment coordinator.

Indirect Measure: In Math 111, a slight majority (58%) of the 57 students felt their ability to apply mathematical concepts and principles to perform symbolic computations *in math courses* was good to excellent, and a few more (62%) felt their ability to apply mathematical concepts and principles to perform symbolic computations *in non- math courses* was good to excellent. For Math 252 (37 students) the figures were 68% and 78%, respectively, and for Math 321 (18 students) they were 83% and 89%.

In Math 111, 70% of the students felt that their ability to apply mathematical concepts and principles to perform symbolic computations had gotten better as a result of taking the course, and 12% felt their ability had gotten *much* better as a result of taking the course. The figures for Math 252 were 73% and 22%, and for 341 they were 56% and 33%. Copies of the raw data can be found in the Math Department assessment binder, kept by the department assessment coordinator.

Plans For Improvement

It is the feeling of at least some members of the Mathematics Department that the key to improvement in this area is for students to practice more. All members of the department are continually experimenting with ways to motivate students to practice more, on their own and in a meaningful way.

It should be noted that the data indicates that student performance for this outcome does improve for those students that continue on to take additional courses beyond Math 111, so it seems that progress is being made!

Assessment of Program Learning Outcome 4, Winter 2008

Outcome: Interpret mathematical results.

Measures (Activities) Used

Direct Measure: Data for this outcome was collected from four sections of Math 111 and one section each of Math 251, 321 and 361 during the winter term of 2008. In all cases students were given an exam question in which they had to interpret results of a mathematical computation or graph. They were awarded one point (satisfactory) or zero points (unsatisfactory) for each of two criteria. Those students who performed satisfactorily on both criteria were considered to have satisfied the outcome. Copies of the problems and rubrics can be found in the Math Department assessment binder, kept by the department assessment coordinator.

Analysis of Results/Strengths and Weaknesses

Direct Measure: Two of the sections of Math 111 used one exercise to assess this outcome, and two other sections used a different exercise. The percentage of students whose performance was proficient is given in the table below, by course/exercise.

M111 Exer. 1	M111 Exer. 2	Math 251	Math 321	Math 361
67%	83%	44%	77%	61%

As one can see, there range of proficiency rates varies by course a great deal. This is most likely a result of differences in the way that the tasks were framed within their respective examinations.

Plans For Improvement

We do not feel that anything in this data is conclusive about how we might improve instruction in this area, or whether improvement is really needed. Our plans for the future are to take more care in assessing in a more consistent manner across courses.

Assessment of Program Learning Outcome 6, Winter 2008

Outcome: Perform abstract mathematical reasoning.

Measures (Activities) Used

Direct Measure: Data for this outcome was collected from the Winter 2008 Math 327 class. One final exam exercise was created for each of five of the seven proposed criteria for this outcome. A grading rubric was created to assign each student a score of one to four in each criterion, with a score of 3 or 4 being proficient. Copies of the problems and rubric can be found in the Math Department assessment binder, kept by the department assessment coordinator.

Analysis of Results/Strengths and Weaknesses:

Direct Measure: Eight students took the final exam. Performance was strongest on Criterion 7, *Make conjectures based on concrete observations,* where 100% of the students demonstrated proficiency. The weakest area was Criterion 2, *Construct a proof,* in which only three of the eight (38%) of the students were proficient. This could probably have been predicted, as that is usually an area of difficulty for students. Another area of some difficulty was Criterion 5, *Construct examples or counterexamples,* with a 63% rate of proficiency.

Performance Criterion	Assessment Method	Measurement Scale	Score for Proficiency	Students at or Above Proficiency
Construct a proof	Final exam question	0,1,2 or 3	2 or 3	37.5%
State a definition	Final exam question	0,1,2 or 3	2 or 3	75%
Meets a definition?	Final exam question	0,1,2 or 3	2 or 3	87.5%
Construct example or counterexample	Final exam question	0,1,2 or 3	2 or 3	62.5%
Make a generalization	Final exam question	0,1,2 or 3	2 or 3	100%

Plans For Improvement

Performance was not assessed for two of the criteria for this outcome. Three department members with substantial experience teaching Math 327 discussed this omission and decided that those two criteria will be eliminated in the future. One of them asked students to perform something that they are not asked to do with any regularity (or at all) in the course, and the other one was deemed to be almost the same as one of the other criteria so it will be incorporated into that one.

Of the criteria that were assessed, student performance was good in three of them, with proficiency levels of 75%, 87.5% and 100%. Two others were weaker, with proficiency levels of 37.5% and 62.5%. The first of these, *Construct a proof* is universally known to be a difficulty for students, and this course is their first exposure to doing this. Historical experience of our colleagues across the country indicates that the performance observed is to be expected regardless of the strength of our efforts in this area. The second weakness was in the area of *Constructing examples or counterexamples*. To remediate in this area we will try to give more emphasis to this criterion in future offerings of this course.

Student Learning/Assessment Improvement Plan

Three program student learning outcomes were assessed this year:

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

For Outcome 1, results were not felt to be as good as we would like to see. It is felt that students need to spend more quality time on their own working with mathematical concepts. Members of the department have, and will continue to, experiment with ways to motivate students to spend this time. Several department members are currently using WeBWorK, an online homework system, and some data has been gathered relating to its use. That data can be found in the Math Department assessment binder, kept by the department assessment coordinator.

> **Outcome 4:** *Interpret mathematical results.*

Results for Outcome 4 were extremely varied. The overall feeling of the department is that student skills in this area are neither outstanding nor disappointing. It is clear that more care will need to be taken when assessing this in the future.

> **Outcome 6:** *Perform abstract mathematical reasoning.*

The sample of students used for Outcome 6 was fairly small, but we feel that the results have some use. Overall performance was adequate in stating definitions, determining whether an object meets a definition and making conjectures based on concrete observations. Performance was lacking in constructing examples or counterexamples and

in constructing proofs. We feel that progress can be made in the first of these two areas by giving it a bit more emphasis in class, assigned work and exams. As mentioned before, constructing proofs is an area of difficulty for students everywhere, and the performance we saw may not be able to be improved.

The area that we feel needs most attention at this point is further refinement and reorganization of our learning outcomes. In retrospect we think that Outcomes 1 and 4 above should actually be individual criteria under some broader outcomes. Outcome 6 seems to be fairly well-designed and will not need any revision. The department has determined a plan for revising our outcomes, and we will do that in a one-day retreat during the 2008 Fall Convocation. Greater consistency in assessing across courses and levels will receive greater attention in the future as well.

A further note may be in order. The number of students in the Applied Mathematics degree program is relatively small (10-20) and the individual students are difficult to track for several reasons. It is possible that none of the students whose performance was assessed are actually Applied Mathematics majors; we may wish in the future to try to determine which of the students assessed are majors. Informal observations and anecdotal evidence at this point seem to indicate that our majors are fairly proficient, at least in the area of mathematics. The level of sophistication in thinking we are seeing in students taking our most challenging courses is high. Two recent graduates who received math minors have been very successful in an Applied Physics graduate program at Oregon State University. One of them reported that MATLAB skills learned at OIT gave the two of them a huge advantage over classmates on one major class assignment, and the same student claimed to have had an easy time in a graduate probability course at PSU because of taking Math 465 at OIT. These things are encouraging!