Colorado State University – Pueblo Academic Program Assessment Report for AY 2012-2013 **Due: June 1, 2013**

Program: Mathematics BA/BS **Date:** June 5, 2013

Completed by: Frank Zizza

Assessment contributors (other faculty involved in this program's assessment): Professors Barnett, Funk, Lundberg

Please complete this form for each undergraduate, minor, certificate, and graduate program (e.g., B.A., B.S., M.S.) in your department. Please copy any addenda (e.g., rubrics) and paste them in this document, and return it to Erin Frew, erin.frew@colostate-pueblo.edu as an email attachment before June 1, 2013. You'll also find the form at the assessment website at http://www.colostate-pueblo.edu/Assessment/Resources/Pages/default.aspx. Thank you.

Introduction

Over the course of the 2012-2013 academic year, the faculty of the mathematics program decided to evaluate the program's SLOs with a team of faculty reviewing ungraded and unidentified final exams from the entry level mathematics course *Math 307 – An Introduction to Linear Algebra*, and from the capstone courses *Math 327 – Abstract Algebra* and *Math 421 – Advanced Calculus*. The plan was to evaluate the program's effectiveness in developing its students proficiencies in the SLOs identified in the program's assessment plan by comparing their early abilities in mathematical argumentation with their abilities at the conclusion of their degree program.

Students enrolled in Math 307 are most likely math majors that have successfully completed the entry level Calculus courses (Math 126, Math 224 and Math 207). These students should be computationally proficient with elementary Calculus application problems, but they have not yet been exposed to formal mathematical arguments or proofs; Math 307 provides the introduction. It was anticipated that students will still be in the development phase of constructing mathematical arguments even at the conclusion of Math 307.

Math 327 and 421 are capstone courses and the expectations are much higher. By the students' senior year, they have been exposed to two or three semesters of courses with problems of increasing difficulty and requiring more sophisticated and advanced techniques of argumentation and proof. Additionally there are the expectations that students will have developed increased confidence, maturity, application of rigor and aesthetic appreciation in creating and writing elegant mathematical arguments.

A team of four faculty, Professors Barnett, Funk, B. Lundberg and Zizza assessed exams from the aforementioned courses for which they were not the instructor of record. Each professor developed their own evaluation rubric for this exercise.

I. Program student learning outcomes (SLOs) assessed in this cycle, processes, results, and recommendations.

A. Which of the program SLOs were assessed during this cycle? **Please include the outcome(s) verbatim from the assessment plan.**	B. When was this SLO last assessed?	C. What method was used for assessing the SLO? **Please include a copy of any rubrics used in the assessment process.**	D. Who was assessed? Please fully describe the student group.	E. What is the expected achievement level and how many students should be at it?	**F. What were the results of the assessment?**	**G. What were the department's conclusions about student performance?**	H. What changes/improvements to the <u>program</u> are planned based on this assessment?
3. Students will create, analyze and use mathematical abstraction. They will understand and write formal mathematical arguments. They will appreciate the standards for mathematical rigor, elegance and beauty. 4. Students will produce and deliver effective oral and written presentations of mathematical material and ideas.	Never	Ungraded and unidentified copies of the students' final exams from each course were evaluated by 4 senior faculty members. Each evaluator developed their own rubric for the courses they evaluated. Their rubrics are included in the addendum.	All students enrolled in Math 307 Fall 2012, Math 307 Spring 2013, Math 327 Spring and 421. Students in Math 307 are beginning math majors. Math 327 and 421 are capstone courses.	Math 307 students are expected to be in the developmental stages for formulating written arguments and proofs. Students in Math 327 and 421 are expected to be proficient at the undergraduate level.	Individual faculty reports are included in the addenda. Briefly, students in the two Math 307 courses were mostly still in the developmental stages. Students in both Math 327 and Math 421 were ***exceptionally*** proficient in their writing and argumentation skills.	There is evidence the program is very successful in developing students' abilities to compose and express rigorous mathematical arguments. Math 307 results show the more computational and outline stages of the development of proof writing and composition abilities. Math 327 & 421 results show clearly that the program has brought most of its students to or beyond the level of proof writing ability targeted in the SLOs. There is strong evidence that the Math Program develops student confidence, maturity, rigor and aesthetic appreciation in creating and writing elegant and rigorous mathematical arguments.	1. A uniform rubric for evaluation of final exams will be created during the academic year 2013-2014, based on the three rubrics that were developed for this year. 2. It was agreed that keeping a portfolio of final exams for each student would provide the ability to track each student's growth. Beginning this fall semester, portfolios will be kept by the department for each student starting in Math 307.

Comments: Because as a department, we have not been able to agree on a way to measure students' ability to deliver oral presentations, for the time being we are removing that student outcome from the formal assessment plan. We continue to grapple with the problem as everyone does agree that it is an important and desirable outcome. The difficulties are logistical concerning how to have independent faculty available to assess students' oral presentations.

B. Follow-up (closing the loop) on results and activities from previous assessment cycles. In this section, please describe actions taken during this cycle that were based on, or implemented to address, the results of assessment from previous cycles.

A. What SLO(s) did you address? Please include the outcome(s) verbatim from the assessment plan.	B. When was this SLO last assessed?	C. What were the recommendations for change from the previous assessment?	D. Were the recommendations for change acted upon? If not, why?	E. What were the results of the changes? If the changes were not effective, what are the next steps or the new recommendations?
Students will have facility in the core mathematical content areas: calculus, algebra, and other additional topics. Students will formulate and solve problems using mathematics, working alone or with others at the three cognitive levels: routine problems, non-routine problems and applied problems. They will also be able to formulate and solve applied problems involving applications to other fields and problems involving real-world data.	Never	Programatical assessment of mathematics program's students' content knowledge is measured by their MFT scores. There was overall satisfication with the students' results, and as a consequence a positive program evaluation based on these SLOs. The statement of the SLO mentions facility in specific content areas. The MFT exam results reported were overall scores that aggregate the individual content areas. To provide an assessment of each course that delivers these content areas, the MFT scores can be broken down into sub-scores for each content area. There is an additional cost to the department for this service from the ETS, but it was decided to proceed with the investment to improve program assessment.		MFT scores will be analyzed by individual content areas, as opposed to only the cumulative scores we have been using in previous years. The changes will be effective beginning in December 2013 with the next round of MFT exams , and all subsequent rounds of exams.

Addenda

Program Assessment Report - Mathematics
Janet Heine Barnett
May 24, 2013

Objectives

The review activities described in this report pertain to the assessment of the Mathematics Program relative to Student Learning Outcomes 3 and 4 for mathematics majors:

3. Students will create, analyze and use mathematical abstraction. They will understand and write formal mathematical arguments. They will appreciate the standards for mathematical rigor, elegance and beauty.

4. Students will produce and deliver effective oral and written presentations of mathematical material and ideas.

More specifically, the objective of this review was to assess the program's effectiveness in developing student ability to write formal mathematical statements and rigorous mathematical proofs using correct mathematical terminology and symbolism.

Process

Selected questions from the Final Exams of the two linear algebra courses (Math 307) taught during AY2012-2013 were reviewed. Each student paper was placed in one of the following four scores:

E: Excellent (Exceeds expectations)
P: Proficient (Meets expectations)
D: Developing (Partially Proficient)
U: Unsatisfactory or Unable to Judge

A draft rubric created to provide more details concerning each of these categories appears on page 2 of this report.

Conclusions

Since Linear Algebra is one of the first courses in which students are expected to write formal statements and proofs, it was anticipated that the majority of students would be in the Developing category.

As summarized by the following table, this was the case for 15 student papers reviewed:

E	P	D	U
0	1	10	4

With regard to the four student papers assigned to the "U" category, it was difficult to determine the extent to which conditions of the testing situation itself (e.g., lack of time to complete) may have played a factor in the student's inability to complete a written proof that demonstrated partial proficiency.

Recommendations

The student papers reviewed during this assessment cycle provide evidence that the Program is succeeding in developing the student proficiencies defined by Student Learning Outcomes 3 and 4 at this relatively early stage of their mathematical development.

However, the importance of context in assessing student proof efforts became clear in developing the rubric on page 2. Given the complexities of proof writing, the Mathematics Program should consider expanding its assessment efforts to a full Proof portfolio for each student, rather than select problems from Final Examinations only.

Draft Rubric – Program Assessment (Janet Barnett, May 16, 2013)

Score	Description
E	**Excellent (Exceeds expectations)** The work meets criteria for "P" below, and in addition, goes beyond the criteria for "P" in **at least one (?) noteworthy way** such as: ❑ Context: non-routine proof written by the student as part of an in-class examination ❑ Context: challenging proof written by the student as part of a homework assignment or take-class examination: ❑ Novelty of approach used ❑ Clarify of exposition ❑ *Other – this portion of the rubric needs additional work*
P	**Proficient (Meets expectations)** The work was completed within one of the following contexts: ❑ a proof previously encountered in class, reproduced by the student as part of an in-class examination ❑ a "type" proof (e.g., subgroup proof, limit proof via) , written by the student as part of an in-class examination ❑ a routine proof of average difficult, written by the student as part of a homework assignment ❑ a routine proof of average difficult, written by the student as part of take-class examination: **and** satisfies all of the following criterion: ❑ Correct statement (using a complete sentence) of relevant definitions in either symbolic form or prose form (def) ❑ Correct statement of negations, contrapositives and converses of relevant statements (equiv) ❑ Correct use and introduction of quantifiers (quant) ❑ Appropriate references to definitions and/or prior results as justification within a problem solution or proof (just) ❑ A valid logical structure for the statement in question (valid) ❑ Complete sentences throughout proof, including a clear statement of assumption(s) and conclusion(s) (composition) ❑ Correct use of mathematical terminology (term) ❑ Correct use of mathematical symbolism (sym) ❑ Minimal number of errors in correct spelling (sp) and grammar (gr)
D	**Developing (Partially Proficient)** Although the work demonstrates a meaningful effort to develop a proof (or to write a definition, or to form negations / contrapositives / converses) within one of the contexts indicated under Proficient ("P) and also employs underlying mathematical ideas correctly, it does not yet demonstrate full proficiency ("P") and would require some revision or extension in order to reach that level. Some aspect(s) of the work may be incomplete or incorrect, or explanations may be incomplete or insufficiently detailed.
U	**Unsatisfactory or Unable to Judge** Lacking one or more criteria for score of "D"*;* for example, little or no evidence of work beyond given statement of theorem, evidence that major and important *mathematical* ideas have been overlooked, or that the proof has been misunderstood. This can also mean that the proof approach taken is unlikely to produce an adequate solution (i.e. on the wrong track).

Program Assessment Comments of Bruce N. Lundberg 5-16-2013

Selected questions from recent Math 307 and Math 421 final exams were reviewed. The intent of this review was to assess how successful the Program is in developing students' abilities to compose and express rigorous mathematical statements and proofs. Student responses were given a rating of N (No evidence), S (Structure of definition or proof in evidence), P(complete proof, including good structure, with at most minor errors, in evidence), PE (P plus an evident appreciation of elegance of argument and expression).

For the intermediate level course Math 307 (sophomore/junior), Fall 2012 Final Exam questions 1a&b and 4, and Spring 2013 Final Exam questions 6a&b and 13 were examined. Out of 17 student papers

0% attained at least 1 PE rating
29% attained at least 1 P rating but nothing higher
29% attained at least one S rating but nothing higher
41% attained no ratings higher than N

For the advanced level course Math 421 (senior), Fall 2012 Final Exam questions 1a&b and 2 (option a or were examined. Out of 9 student papers

78% attained at least 1 PE rating
11% attained at least 1 P rating but nothing higher
11% attained at least one S rating but nothing higher
0% attained no ratings higher than N

The following are evident from this data and my professional judgments based on my reading of student responses:

1. There is strong evidence the Math Program is very successful in developing students' abilities to compose and express rigorous mathematical statements and proofs. The Math 307 results show the more computational and outline stages of the development of proof writing and composition abilities. The Math 421 results show clearly that the program has brought most of its students to or beyond the level of proof writing ability targeted in Program outcomes.
2. There is strong evidence that the Math Program develops student confidence, maturity, rigor and aesthetic appreciation in creating and writing elegant and rigorous mathematical arguments.

Mathematics Program Assessment Comments of Darren Funk-Neubauer
May 23rd 2013

Selected questions from recent Math 307 (Linear Algebra) and Math 327 (Abstract Algebra) final exams were reviewed. The intent of this review was to assess how successful the Program is in developing students' abilities to compose and express rigorous mathematical definitions, statements and proofs. Each student response to each question reviewed was rated as either N, D, or E. A rating of N means the student wrote Nothing, Nonsense, or something which was Not relevant. A rating of D means what the student wrote was Decent, and the student is Developing their skills, but has not yet attained mastery. A rating of E means what the student wrote is Excellent, Elegant, and Efficient.

For the intermediate level course Math 307 (sophomore/junior level) the following was examined: Question 1 Parts a & b & c and Question 4 Parts a & b from the Fall 2012 Final Exam. Thus, each exam received a sequence of five N's, D's, and/or E's.
Out of 12 student papers
25% attained at least 2 E ratings
58% attained at least 2 D ratings and less than 2 E ratings
17% attained less than 2 D ratings and less than 2 E ratings.

For the advanced level course Math 327 (senior level) the following was examined: Question 3 Parts a & b and Question 5 Parts a & b & c from Part C from the Spring 2013 Final Exam. Thus, each exam received a sequence of five N's, D's, and/or E's.
Out of 12 student papers
58% attained at least 2 E ratings
33% attained at least 2 D ratings and less than 2 E ratings
9% attained less than 2 D ratings and less than 2 E ratings.

The above data provides evidence that as student progress through the Math Program's curriculum their ability to express mathematical definitions, statements and proofs improves. There is a noticeable difference in the quality of writing between the Math 307 exams and the Math 327 exams.

Based on my reading of the Math 307 exams I would urge all Math 307 instructors to pay extra special attention to teaching their students to correctly apply basic logic and to correctly use mathematical notation. Applying the basic principles of logic and using the correct notation are prerequisites to understanding the mathematical ideas. Students cannot be expected to improve their proof writing skills until they have first mastered basic logic and correct notation.