

Colorado State University – Pueblo Academic Program Assessment Report for AY 2012-2013

Due: June 1, 2015

Program: Mathematics BA/BS

Date: June 1, 2015

Completed by: Bruce N. Lundberg

Assessment contributors (other faculty involved in this program's assessment): Professors Barnett, Chacon, B. Lundberg, and Zizza

Introduction

For the 2014-2015 academic year, the faculty of the mathematics program decided to evaluate the program's SLOs, as was done in AY12-13. A team of faculty reviewed ungraded and unidentified final exams from the Sophomore-Junior level mathematics course *Math 307 – An Introduction to Linear Algebra*, and from the capstone courses *Math 427 – Abstract Algebra* and *Math 421 – Introduction to Analysis*. 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 largely or exclusively math majors that have successfully completed the freshman level Calculus sequence (Math 126, Math 224) and the freshman-sophomore level matrix and vector course (Math 207). These students should be computationally proficient with introductory Calculus application problems, but not yet exposed to formal mathematical arguments or proofs. Math 307 provides the program's principle introduction to reading and composing mathematical proofs. It was anticipated that students will still be in the development phase of constructing mathematical arguments even at the conclusion of Math 307.

Math 427 and 421 are capstone courses, with much higher expectations. By the students' senior year, they have been exposed to two or three semesters of courses with problems of increasing difficulty, requiring more sophisticated and advanced techniques of argumentation and proof. Additionally, there are the expectations in the capstone courses that students will have developed increased confidence, maturity, mathematical literacy and fluency, and greater intellectual rigor and aesthetic appreciation, as demonstrated by creating and writing elegant mathematical arguments.

A team of four faculty, Professors Barnett, Chacon, B. Lundberg and Zizza, assessed final exams from the aforementioned courses for which they were not the instructor of record. The rubrics used for the similar assessment activity in AY12-13 were distributed, discussed and edited in an effort toward greater precision, objectivity, calibration and comparability in assessment results for this type of exercise. The participating professors ended up using the circulated rubric with somewhat varying interpretations, symbols, and categories.

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.	AY 12-13	Ungraded and unidentified copies of the students' final exams from each course were evaluated by 4 senior faculty members. Each evaluator contributed and discussed the AY 12-13 rubrics, and helped develop a common rubric for the courses they evaluated. The new common rubric is included in the addendum.	All students enrolled in Math 307 Fall 2014, Math 307 Spring 2015, Spring 15 Math 427, and Fall 14 Math 421. Students in Math 307 are soph-jr math majors. Math 427 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 427 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 427 and Math 421 were exceptionally proficient in their writing and argumentation skills. The issue of differing proof styles and expectations among different professors received comment by some on the team.	There is evidence the program is very successful in developing students' abilities to compose and express rigorous mathematical arguments. Math 307 results again show the more outline stages of the development of proof and composition and writing abilities. Math 427 & 421 results show that the program has brought almost all of its 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. The new AY 14-15 uniform rubric for evaluation of final exams will be refined during the AY 15-16, based on the experience of using and discussing in this exercise. 2. The logistics of keeping portfolios of final exams for each student will be discussed and addressed. This improvement planned improvement was delayed due to staff cutbacks and teaching load increases in AY 14-15. 3. The assessment exercise and discussion showed the need for and current lack of time spent on conversation on teaching and curricular challenges and issues. Ways to foster such conversation collaboration, and to improve teaching morale, will be sought, and tried, and assessed.

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?
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.	AY 12-13	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. 3. 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.	1. Yes, see above. 2. Partially, due mainly to staff cutbacks and increased teaching loads and other committee work, and decreased morale. 3. Yes	1. The rubrics use for the similar assessment activity in AY12-13 were distributed, discussed and edited in an effort toward greater precision, objectivity, calibration and comparability in assessment results for this type of exercise. The participating professors used the circulated rubric with somewhat varying interpretations. 2. The logistics of keeping portfolios of final exams for each student will be discussed and addressed. This improvement planned improvement was delayed due to staff cutbacks and teaching load increases in AY 14-15. 3. During Fall 14, a pilot "Communicating Mathematics" seminar was created and run for 8 upper-level students to addresss the oral (and writing) aspects of this SLO. The seminar was effective, and appreciated by the students. Final presentations were attended and evaluated by some faculty not involved in creating and running the seminar. Department meeting discussions are planed for AY 15-16 on adopting this semiar as a regular course, and its use in assessing this and other program SLO's.

Comments:

The mathematics program continues to developing modifications to its remedial mathematics offerings. The curriculum for Math 099 is under review by a team of five faculty this summer (Summer 2015) and the course will be delivered in a new format starting Fall 2015 as planned.

A committee considering improvements in the Math 121: College Algebra course, text and online homework system used by most instructors, has met regularly during Spring 15, and into the summer. Meetings with publishers have also been held, various proposals of syllabus topics, texts, and homework have been drafted and discussed, and the wider program faculty have given their input. A decision on adopting a new homework system and text has been made in favor a McGraw-Hill text and homework system that promises to improve the curriculum, delivery, and initial assessment of student preparedness for the course. The pilot program using Supplemental Instruction, for certain students with borderline preparation, has been adopted with curricular arrangements submitted to formalized this with course and catalog changes. The change to College Algebra is more substantial, follows State of Colorado guidelines for the incorporation of Supplemental Academic Instruction, and requires action by the Curriculum and Academic Programs Board following the new course proposals.

Changes to Math 207-307 topics and text have been discussed in an ad-hoc committee Spring 15 and into the summer. A many texts and issues have been considered. A non-commercial text written by a professor at Metro State University, who is willing to adapt the text for our needs, has been considered and adopted for pilot usage in the Fall 15 Math 207 course. A new text and revised syllabus for the follow-on course Math 307 will be discussed and determined for adoption in the Spring 16 Math 307 offering.

All of these revisions have kept and will keep the departmental curriculum committees very busy We plan to engage in these important activities in the coming semesters. Ideas and plans for fostering more discussion and sharing of teaching challenges and practices, in the Department meetings and other fora, are being developed for the 2015-16 academic year.

Addenda Below: SLO Assessment Exercise Rubric and Individual Summary Reports

Rubric – Program Assessment

Score	Description
P	Proficient (Meets expectations) satisfies <u>all</u> of the following <u>criterion</u>: - o Correct statement (using a complete sentence) of relevant definitions in either symbolic form or prose form (def) - o Correct statement of negations, contrapositives and converses of relevant statements (equiv) - o Correct use and introduction of quantifiers (quant) - o Appropriate references to definitions and/or prior results as justification within a problem solution or proof (just) - o A valid logical structure for the statement in question (valid) - o Complete sentences throughout proof, including a clear statement of assumption(s) and conclusion(s) (composition) - o Correct use of mathematical terminology (term) - o Correct use of mathematical symbolism (sym) - o 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”) <u>and</u> 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 <i>mathematical</i> 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 5-20-2015

Selected questions from recent Math 307 final exams from Fall 2014 and Spring 2015 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

P -- Proficiency evident, complete proof, including good structure, with at most minor errors, in evidence.

D -- Developing ability in evidence, but not yet proficient.

U -- Unsatisfactory or Unable to judge

For the intermediate level course Math 307 (sophomore/junior), Spring 2015 Final Exam questions 3d and 5e from Part 2 were examined. Out of 10 student papers

20% (2) attained 2 P ratings

30% (3) attained at least 1 P rating

10% (1) attained at least one D rating but nothing higher

50% (5) attained no ratings higher than U

For the intermediate level course Math 307 (sophomore/junior), Fall 14 Final Exam questions 14a, 15a and 16a were examined. Out of 11 student papers

0% (2) attained 3 P ratings

18% (2) attained 2 P ratings

81% (3) attained at least 1 P rating

9% (1) attained at least one D rating but nothing higher

9% (1) attained no ratings higher than U

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

1. A significant fraction of students are proficient in composing and writing proofs at the end of Math 307, but the majority are still developing.
2. The style of proof writing varies from ordered statement-reason form, expository form (complete sentences...), and somewhat disordered but apparently complete expression of ideas.

Program Assessment Report - Mathematics

Janet Heine Barnett

May 20, 2015

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 for two courses taught during AY2012-2013 were reviewed:

- Math 307, Spring 2015 (10 students, 2 questions)
- Math 421, Fall 2014 (17 students, 4 questions)

For each student paper, the selected questions were assigned one of following four scores using the rubric on page 3 of this report.

E: Exceeds expectations

M: Meets expectations

P: Partially Proficient

D: Developing

U: Unsatisfactory or Unable to Judge

Findings for Math 307, Spring 2015 (10 students)

The following table shows the number (and percentage) of students for which the highest assigned score obtained on at least one proof fell in each category:

E	M	PP	D	U
0 (0%)	0 (0%)	3 (30%)	1 (10%)	6 (60%)

The following table shows the number (and percentage) of students for which all proofs reviewed met the indicated level or higher for all four proofs reviews.

$\geq M$	$\geq PP$	$\geq D$
0 (0%)	2 (20%)	2 (40%)

This shows that only 4 of the 10 students completed both proofs at developing or higher level.

Findings for Math 421, Fall 2014 (17 students)

The following table shows the number (and percentage) of students for which the highest assigned score obtained on at least one proof fell in each category:

E	M	PP	D	U
0 (0%)	9 (53%)	3 (17.5%)	3 (17.5%)	2 (12%)

The following table shows the number (and percentage) of students for which all proofs reviewed met the indicated level or higher for all four proofs reviews.

$\geq M$	$\geq PP$	$\geq D$
5 (29%)	4 (24%)	3 (17.5%)

This shows that 9 of the 17 students completed all four proofs at the partially proficient or higher level.

Discussion and Recommendations

1. With regard to the 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. Because none of the exams included a non-routine or challenging proof, it was also anticipated that no scores would reach the E level even in the more advanced class. The timed nature of a final exam also makes it impossible to gauge what students are able to do with proofs within a more authentic context. *In order to get a better reading of student proficiency with proof overall, the program should explore other ways to assess student proof-writing proficiency; this might include, for example, collecting samples of student homework, in addition to exams.*
2. 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. What would be expected is growth as student progress through their upper division courses, culminating in Math 327 and Math 421. The student papers reviewed during this assessment cycle provide evidence that the Program is succeeding in helping students to develop the proficiencies defined by Student Learning Outcomes 3 and 4 as they progress through the upper division courses required by the major. To gain more insight into what courses are contributing to the growth that occurs between taking Math 307 and the Math 327/Math 421, *the program should explore other ways to assess individual student growth with respect to proof-writing proficiency; this might include, for example, student work portfolios that included homework and exam samples. It would also be helpful for the program faculty to have a discussion concerning whether/how Math 307 might be differently structured or approached to better support student efforts with regard to proof and logic.*

Program Assessment Report – Dr. Paul Chacon

Math 307 11 students 4 problems examined Rated P (proficient) D (developing) U (not acceptable)

					PPD or higher
1	P	P	U	P	yes
2	D	D	U	U	no
3	U	P	U	P	no
4	D	P	P	U	yes
5	P	P	U	P	yes
6	U	P	D	U	no
7	U	P	D	P	yes
8	D	D	P	P	yes
9	P	P	D	P	yes
10	P	D	U	U	no
11	U	P	U	D	no

Number of at least PPD 6 of 11.

Number without U 2 of 11

Math 427 15 students 5 problems examined
rated P (proficient) D (developing) U (not acceptable)

						PPPD or higher
1	P	P	P	D	U	yes
2	P	P	P	P	U	yes
3	P	P	P	P	D	yes
4	P	D	P	P	P	yes
5	P	D	P	U	P	yes
6	P	P	P	P	D	yes
7	P	P	P	P	P	yes
8	P	P	P	D	P	yes
9	P	P	P	P	U	yes
10	P	U	P	U	U	no
11	P	P	U	D	D	no
12	D	P	D	U	P	no
13	D	P	P	U	U	yes
14	D	U	P	P	U	no
15	U	D	D	P	U	no

Number of at least PPPD 10 of 15.

Number without U 5 of 15

Math Program Assessment Report
Fall 2014 – Spring 2015
Frank Zizza

I was charged with performing a partial assessment of the Mathematics program based on anonymously identified copies of students' final examinations from Math 421 Introduction to Analysis, and Math 427 Introduction to Abstract Algebra. Problems were selected from the final examinations in each course that would permit an evaluation of each student's progress towards mastery of using mathematical abstractions and their ability to produce effective written presentations. Students written presentations were evaluated on a three point scale: P for Proficient, D for Developing and U for Unsatisfactory. My rubric, a slightly modified version of the one discussed by the committee as a whole, is attached.

Results from the Fall 2014 Section of Math 421 – Introduction to Analysis

Questions 1, 4, 8 and 11 from Dr. Bruce Lundberg's final exam were used.

	Question 1	Question 4	Question 8	Question 11
Students Proficient	11	10	9	8
Students Developing	2	2	1	3
Students Unsatisfactory	4	5	7	6

Students with at least 3 P's	9
Students with at exactly 2 P's	2
Students with at exactly 1 P	4
Students with no P's	2

In this course 65% of the students demonstrate proficiency on at least two of the selected questions and 88% of the students are proficient on at least one problem of the questions selected.

Results from the Spring 2015 Section of Math 427 – Introduction to Abstract Algebra

Questions 1a, 2a and 3a from Dr. Janet Barnett's final exam were used.

	Question 1a	Question 2a	Question 3a
Students Proficient	11	11	8
Students Developing	4	4	6
Students Unsatisfactory	0	0	1

Students with at least 2 P's	11
Students with at exactly 1 P	4
Students with no P's	0

In this course 73% of the students demonstrate proficiency on at least two of the selected questions and 100% of the students are proficient on at least one problem of the questions selected.

Conclusion: These two courses are the capstones of the Mathematics major program. By the end of their senior year, all students were showing Proficiency at an acceptable level. Based on the high percentages of students showing an acceptable proficiency level it is this evaluator's opinion that the program as a whole is very successful at training its graduates to produce abstract mathematics in clear written form.