# Assessment Report: Mathematics Learning Outcomes
# 2016-17

**Fall 2016 Assessment Results**

Assessment Conducted by: Ryan Grady, David Ayala

According to the description of the Mathematics Program Learning Outcomes and Assessment, 20 students were assessed for the following outcomes in M 333.

Students will produce rigorous proofs of results that arise in the context of linear algebra. Moreover, these proofs will use proper mathematical language, and meet standards of organization, coherence, logic, and style.

Based on two multiple part final exam questions, 13 of the 20 students adequately demonstrated their understanding at an acceptable level or better. Many students in M333 did not have sufficient background in mathematical proof writing. Further, some of these students struggled with implementing mathematical definitions and confused the role of example versus proof.

It is our recommendation that M242 become a pre-requisite for M333. This will allow students to more fully engage with the course content as opposed to being distracted by the basic mechanics of mathematical proofs.

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**Spring 2017 Assessment Results**

Assessment Conducted by: Kevin Wildrick, Lukas Geyer

According to the below description of Mathematics Program Learning Outcomes and Assessment, 12 students were assessed for Outcomes 1), 3), and 6) in M431:

> Outcome 1): Effectively communicate mathematical ideas by precisely formulating them in proper mathematical language.
>
> Outcome 3): Produce rigorous proofs of results that arise in the context of abstract algebra.
>
> Outcome 6): Write solutions to problems and proofs of results that meet rigorous standards based on content, organization, coherence, logical arguments, and style.

**Description of Assignment Assessed**

Two assignments were used in this assessment. The first is a month-long group project, the second is the final exam. A description of the project is attached. The final exam was a 110 minute cumulative evaluation to be completed without use of any reference materials or computational aids. It consisted of three types of activities: fill in the blank definitions of key concepts, true or false statement identification, and theorems to be proven.

**Assessment Results**

Of the four group projects submitted, two indicated acceptable performance on all of the outcomes, one indicated marginal performance on all outcomes, and one indicated unacceptable performance on all outcomes.

Of the twelve final exams, one indicated excellent performance on all outcomes, four demonstrated acceptable performance on all outcomes, six demonstrated marginal performance on all outcomes, and one demonstrated unacceptable performance on all outcomes. Of the marginal and unacceptable performances, one exam was by a non-mathematics major.

In total, this course did not meet the threshold.

**Recommendations**

The assignments indicate that the program has not supported the majority of students in developing the level of understanding necessary to meet these learning outcomes. Many students have not integrated material from M 242 (Methods of Proof) or M 333 (Linear Algebra) into their skill set. In particular, many students display discomfort with the notion of a mathematical definition, have difficulty in identifying the parts of a proof by induction, and have not internalized concepts such as injectivity or linearity. Another problematic point is the difference between a proof of a theorem and an example confirming the validity of the theorem.

We suggest that efforts be directed to the improvement of student learning in M 242 and M 333, the prerequisites to this course.

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## Program Learning Outcomes

Students should demonstrate the ability to:

1) Effectively communicate mathematical ideas by precisely formulating them in proper mathematical language (M 333, M 383, M 384, M 431).
2) Produce rigorous proofs of results that arise in the context of real analysis (M 383, M 384).
3) Produce rigorous proofs of results that arise in the context of abstract algebra (M 431).
4) Produce rigorous proofs of results that arise in the context of linear algebra (M 333).
5) Construct direct, indirect, and proofs by induction and determine the appropriateness of each type in a particular setting. Analyze and critique proofs with respect to logic and correctness. (M 333, M 383, M 384)
6) Write solutions to problems and proofs of results that meet rigorous standards based on content, organization, coherence, logical arguments, and style. (M333, M 383, M 384, M 431)

## Curriculum Map and Assessment Schedule

| | Outcomes | | | | | | | Assessment Schedule |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| M 333, Linear Algebra | X | | | X | X | X | | Even Fall Semesters |
| M 431, Abstract Algebra I | X | | X | | | X | | Odd spring semesters |
| M 383, Introduction to Analysis I | X | X | | | X | X | | Odd Fall Semesters |
| M 384, Introduction to Analysis II | X | X | | | X | X | | Even spring semesters |

## Rubric

| Learning Outcome | Unacceptable | Marginal | Acceptable | Excelle |
|---|---|---|---|---|
| *Effectively communicate mathematical ideas by precisely formulating them in proper mathematical language* | Terms are used improperly or key definitions are missing | Terms are properly used, but logical flow and organization do not lead to clear communication. | Terms are properly used, and flow is logical, though organization lacks attention to detail that would lead to a clearly communicated result. | The work is fu correct and co with the relev terms properl employed and that work, and mathematical are well-organ into a logical sequence. |
| *Produce rigorous proofs of results, in the indicated area or using the indicated method.* | The work is not logical and complete because either terms are used improperly or key ideas are missing or organization is unlikely to result in a correct proof even if a few more ideas are inserted. | The work is not correct and complete because key ideas are missing, but the terms are properly used and the work shows a type of organization that might work if the right ideas were inserted in the proper places. Also, the work is "marginal" if most of it leads toward a correct proof, but a false statement is inserted. | The work is almost correct with relevant terms used and ideas that work, but not well-organized; for example, with some steps out of order, or with something relatively minor incomplete. | The work is fu correct and co with the relev terms properl employed and that work, and steps well-org into a logical sequence. |
| *Write solutions to problems* | If the work is not correct and complete because either there are fundamental gaps in understanding the underlying mathematical methods or there are two or more significant errors in the computations. | The work is not correct and complete because a significant component of the analysis is missing or incorrect, but most of the components are present. | The work is almost correct with the appropriate methods employed but with a minor error or misunderstanding of one part of the computations. | The work is fu correct and co and displays fu understanding appropriate mathematical methods. |

## Threshold

*At least half of the majors in each of the courses are assessed as "excellent" or "acceptable" for all the learning outcomes.*