# Annual Program Assessment Report

Academic Year Assessed: 2021-2022
College: College of Letters and Science
Department: Mathematical Sciences
Submitted by: Elizabeth Burroughs, Department Head

Assessment reports are to be submitted annually by program/s. The report deadline is October 15th .

**Program(s) Assessed:**

**Indicate all majors, minors, certificates and/or options that are included in this assessment:**

| Majors/Minors/Certificate | Options |
|---|---|
| **Mathematics (Major)** | **Applied Math, Math, Math Teaching, Statistics** |
| **Mathematics (Minor)** | |
| **Statistics (Minor)** | |

## Annual Assessment Process (CHECK OFF LIST)

1. Data are collected as defined by Assessment Plan
   YES__X___ NO_____
2. Population or unbiased samples of collected assignments are scored by at least two faculty members using scoring rubrics to ensure inter-rater reliability.
   YES__X___ NO_____
3. Areas where the acceptable performance threshold has not been met are highlighted.
   YES__X___ NO_____ NA_____
4. Assessment scores were presented at a program/unit faculty meeting.
   YES__X___ NO_____
5. The faculty reviewed the assessment results, and responded accordingly (Check all appropriate lines)
   Gather additional data to verify or refute the result. __X___
   Identify potential curriculum changes to try to address the problem _____
   Change the acceptable performance threshold, reassess _____
   Choose a different assignment to assess the outcome _____
   Faculty may reconsider thresholds_____
   Evaluate the rubric to assure outcomes meet student skill level _____
   Use Bloom's Taxonomy to consider stronger learning outcomes _____
   Choose a different assignment to assess the outcome__X___

OTHER:

6. Does your report demonstrate changes made because of previous assessment results (closing the loop)? YES__X___ NO_____

# 1. Assessment Plan, Schedule and Data Source

| PROGRAM LEARNING OUTCOME | 2020-2021 | 2021-2022 | 2022-2023 | 2023-2024 | ***Data Source**** |
|---|---|---|---|---|---|
| 1. Students will demonstrate mathematical reasoning or statistical thinking | x | | x | | M 242 Signature Assignment |
| 2. Students will demonstrate effective mathematical or statistical communication | x | | x | | M 242 Signature Assignment |
| 3. Students will develop a range of appropriate mathematical or statistical methods for proving, problem solving, and modeling | | x | | x | M 384, M 329, and Stat 412 Signature Assignments |

The UPC members are Jack Dockery, Ryan Grady, Stacey Hancock, Jennie Luebeck, and Tianyu Zhang. The department head appointed a task force to assess individual courses: Tianyu Zhang and Ryan Grady to analyze data from M 384, Beth Burroughs and Jennie Luebeck to analyze data from M 329, and Katie Banner and Mark Greenwood to analyze data from STAT 412.

The task force submitted the results below to the UPC and the DH on September 27, 2022. It was compiled and reviewed by the UPC on September 28 and October 5. It was circulated among the faculty and discussed at the October 19 faculty meeting.

### b. What are your threshold values for which you demonstrate student achievement?

| Threshold Values | | |
|---|---|---|
| PROGRAM LEARNING OUTCOME | Threshold Value | Data Source |
| *1. Students will demonstrate mathematical reasoning or statistical thinking.* | *The threshold value for this outcome is for 70% of assessed students to score acceptable or proficient on the scoring rubric.* | *Not assessed this cycle.* |
| *2. Students will demonstrate effective mathematical or statistical communication.* | *The threshold value for this outcome is for 70% of assessed students to score acceptable or proficient on the scoring rubric.* | *Not assessed this cycle.* |
| 3. Students will develop a range of appropriate mathematical or statistical methods for proving, problem solving, and modeling. | The threshold value for this outcome is for 70% of assessed students to score acceptable or proficient on the scoring rubric. | M 384, M 329, and Stat 412 Signature Assignments |

# 2. What Was Done

**a) Was the completed assessment consistent with the plan provided?** YES__X__ NO____

**b) Please provide a rubric that demonstrates how your data was evaluated.**

**M 384:** Criteria for demonstrating understanding:

a. For problem 1, understand that the Fourier series for a function defined on $[-\pi , \pi]$ is $2\pi$ periodic.
b. For problem 1, correctly use the periodicity of the Fourier series to calculate its value at any given point.
c. For problem 2, understand that the norm of a normed linear space is induced by an inner product if and only if the norm satisfies the parallelogram law
d. For problem 2, correctly apply the parallelogram law in the discrete $l^p$ space to show that it is a Hilbert space if and only if $p = 2$

| **M 384 Rubric** | Unacceptable 1 | Acceptable 2 | Proficient 3 |
|---|---|---|---|
| Outcome 3:<br>Students will develop a range of appropriate mathematical or statistical methods for proving,<br>problem solving, and modeling. | Displays limited or inappropriate reasoning strategies in the statistical content focus.<br><br>*Missing more than 2 elements of (a) – (d) above* | Adequately displays reasoning<br>strategies in the statistical content focus.<br><br>*Correct in at least two of (a) – (b), but with issues in at least one of them* | Displays thorough and appropriate reasoning strategies in the statistical content focus.<br><br>*Correct in of ALL (a)-(d)* |

| **M329 Rubric** | Unacceptable 1 | Acceptable 2 | Proficient 3 |
|---|---|---|---|
| **Outcome 3:**<br>Students will develop a range of appropriate mathematical or statistical methods for proving, problem solving, and modeling | Displays limited or inappropriate proof, problem solving, or modeling strategies in the mathematical content focus.<br><br>Problem solving:<br>Student is not able to create a sketch – it is not fully dynamic and it uses advanced tools<br><br>Proof:<br>Student cannot prove | Adequately displays appropriate proof, problem solving, or modeling strategies in the mathematical content focus.<br><br>Problem solving:<br>Student is able to create a sketch, but either it is not fully dynamic OR it uses advanced tools instead of only compass and straightedge<br><br>Proof:<br>Student has not clearly stated which definition OR they use a naïve definition, such as "four congruent sides and four congruent angles" BUT produces an accurate proof | Displays thorough and appropriate proof, problem solving, or modeling strategies in the mathematical content focus.<br><br>Problem solving:<br>Student is able to create a sketch that is generic – it is fully dynamic and uses only compass and straightedge<br><br>Proof:<br>Student has clearly stated which definition of square they are using, and either they discuss/chose a minimal definition (eg., equiangular quadrilateral with two congruent adjacent sides.) OR they produce a proof nuanced for mathematical knowledge for teaching |

**STAT 412:** Criteria for demonstrating understanding. In at least 2 of the four problems the student does the following:

a. Distribution of the response is appropriate given the scenario (including matching component)
b. Link function matches choice of distribution (dependent on choice in (a), even if (a) is incorrect)
c. Systematic component accurately reflects the research question (i.e., is additive or interactive where appropriate)
d. All variables are defined completely

| **STAT 412 Rubric** | Unacceptable 1 | Acceptable 2 | Proficient 3 |
|---|---|---|---|
| Outcome 3: Students will develop a range of appropriate mathematical or statistical methods for proving, problem solving, and modeling. | Displays limited or inappropriate reasoning strategies in the statistical content focus.<br><br>*Missing more than 2 elements of (a) – (d) above in more than 2 problems. Specifically, missing on both (a)-(b) and (c)-(d)* | Adequately displays reasoning strategies in the statistical content focus.<br><br>*Consistently correct choice of (a) and (b), but issues with (c) and (d) OR visa-versa 2 or more of 4 problems.* | Displays thorough and appropriate reasoning strategies in the statistical content focus.<br><br>*Consistently correct choice of ALL (a)-(d) in 2 or more of 4 problems.* |

# 3. How Data Were Collected

### a) How were data collected? (Please include method of collection and sample size).

M 384: The signature assignment chosen was the final portfolio. Out of 28 enrolled students, the instructor of the course randomly identified 10 students (5 in the math option, 5 in the applied math option). For each student, the instructor collected one problem from each of two quizzes.

M 329: The two most recent instructors identified two problems that would allow assessment of this outcome. Task force members chose the problem that addressed both facets (problem solving and proving) and had complete student submissions. Of the 10 students enrolled in the course, 6 were math teaching majors; all 6 of these students were included in the sample.

STAT 412: The program assessment questions were on the final exam for STAT 412. The instructor of the course collected the exams and removed identifying information, including majors and minors of the students associated with each exam. There were 9 exams from students either majoring or minoring in Mathematics or Statistics.

In all cases, identifying information was removed and data were stored in a secure One Drive folder for the task force to access and assess.

**b) Explain the assessment process, and who participated in the analysis of the data. Include the signature assignment (for faculty review; delete before posting to the web because signature assignments may be reused on future exams).**

**M 384:** blinded student work was assessed on two problems:

- Problem 1

  Given function $f(x) = x$ defined on the domain $\pi \leq x \leq \pi$ and let $(Sf)(x)$ be the associated Fourier series. Evaluate $(Sf)(2+\pi)$.

- Problem 2

  Let $1 \leq p \leq \infty$, recall that $l^p$ consists of real sequences (indexed by $\mathbb{N}$) such that

  $$\sum_n |x_n|^p < \infty$$

  As you have seen, $l^p$ is a normed linear space (it's even complete) with respect to the norm

  $$||(x_n)||_p = \left( \sum_n |x_n|^p \right)^{1/p}$$

  Prove that the only $p$ for which $l^p$ is a Hilbert space is $p = 2$.

Tianyu Zhang independently applied the rubric and then discussed any borderline cases with Ryan Grady (the current instructor of M 384) until they reached consensus on student scores.

M 384: Of the 10 student submissions assessed: overall for Outcome 3, 90% scored at acceptable level (20% at proficient level).

**M 329:** blinded student work was assessed on two problems:

1. Create an arbitrary line segment AB and construct a square with AB as one of its sides, using only compass and straight edge tools in GeoGebra.
2. Prove that your construction process produces a square.

Jennie Luebeck and Elizabeth Burroughs analyzed the data independently, then met to discuss the 1 data point on which they did not initially agree, and they discussed in order to reach complete agreement.

M 329: Of the 6 student submissions assessed: 100% were acceptable (83% at proficient level) on Problem 1, 83% were acceptable (33% at proficient level) on Problem 2; overall for Outcome 3, 83% scored at acceptable level (33% at proficient level).

**STAT 412:** blinded student work was assessed on a 4-part question with each part representing a different research scenario. For each part, students were asked to:

- read the research scenario and associated research question
- choose an appropriate distribution for modeling the response variable

- write a linear or generalized linear model using appropriate mathematical notation that allowed the research question to be addressed, and
- correctly define all variables in their chosen model.

All exams were assessed independently by Katie Banner and Mark Greenwood. Discrepancies in assessment scores were discussed and resolved using the scoring rubric.

| |
|---|
| STAT 412: Of the 9 student submissions assessed: overall for Outcome 3, 89% scored at acceptable level (33% at proficient level). |

# 4. What Was Learned

**Based on the analysis of the data, and compared to the threshold values provided, what was learned from the assessment?**

### a) Areas of strength

**M 384:** The experience provided in M 384 during the Spring 2022 semester was sufficient to meet the threshold of at least 70% of students at acceptable or proficient. Overall, students had a solid grasp of understanding theorems and applying theorems to prove or solve particular problems and to prove or solve elementary statements.

**M 329:** The experiences provided in M 329 are sufficient to meet the threshold of at least 70% of students at acceptable or better. The course prepares more students to be proficient at mathematical problem solving than proving.

**STAT 412:** The experience provided in STAT 412 during the Spring 2022 semester was sufficient to meet the threshold of at least 70% of students at acceptable or proficient. Overall, students had a solid grasp of choosing appropriate distributions for the response variable in a statistical model (generalized linear model) or writing appropriate functions of explanatory variables (both continuous and categorical) to represent research questions of interest, but not always both.

### b) Areas that need improvement

**M 384:** Continue to focus on mathematical methods for proving and problem solving, with an aim to ensuring more students move beyond acceptability and achieve proficiency in their senior- and graduate-level coursework. Problem 2 indicated that throughout the M383/384 sequence, special attention should be paid to more intricate arguments, e.g., combining several relevant results, to build proficiency in mathematical argument.

**M 329:** Increase the focus on mathematical knowledge for teaching about proof. The problems chosen for assessment should provide the opportunity to examine how math-teaching majors demonstrate an acceptable level of mathematical problem solving, proving, and modeling as relate to teaching.

**STAT 412:** In STAT 412 and subsequent courses, continue to focus on statistical methods for proving, problem solving, and modeling, with an aim to ensuring more students move beyond acceptability and

achieve proficiency in their senior- level coursework. Specifically, only 33% of students had a strong grasp of choosing an appropriate probability distribution for modeling the response variable and also specifying the most appropriate linear model to address research questions of interest. Areas that require more focus are determining when interactions in models are needed and appropriately representing categorical variables in linear models as a set of indicator variables. These concepts are part of the curriculum in STAT 217 and STAT 411 and they should continue to be emphasized to prepare students to solidify understanding in STAT 412.

## 5. How We Responded

### a) Describe how "What Was Learned" was communicated to the department, or program faculty. Was there a forum for faculty to provide feedback and recommendations?

Reports from individual courses went through two rounds of discussion and synthesis within the task force. The report was then circulated among the faculty and discussed at the October 19 faculty meeting.

### b) Based on the faculty responses, will there any curricular or assessment changes (such as plans for measurable improvements, or realignment of learning outcomes)?

These data do not suggest that major changes are needed to the assessed curriculum or the assessment process. However, the evidence reminds us of the importance of maintaining commitment to the more advanced learning goals within these courses. Overall, we suggest rebalancing the attention given to proof, justification, and sense making. These mathematical practices should be emphasized in all three Mathematical Sciences degree programs.

**YES_____** **NO__X__**

**If yes, when will these changes be implemented?** Not applicable

### Please include which outcome is targeted, and how changes will be measured for improvement. If other criteria are used to recommend program changes (such as exit surveys, or employer satisfaction surveys) please explain how the responses are driving department, or program decisions.

At this time there are no additional criteria used for undergraduate program assessment. We are exploring the possibility of adding a student exit survey to the assessment process every other year. The Undergraduate Program Committee is exploring this option.

### c) When will the changes be next assessed?

These courses and Outcome 3 will be assessed again two years from now.

## 6. Program Action

**a) Based on assessment from previous years, can you demonstrate program level changes that have led to outcome improvements?**

We recently refined our program outcomes and realigned our assessment process. This was our first time using this instrument to assess Outcome 3. We found it to be an effective tool for data gathering, reflection, and discussion.

Submit report to programassessment@montana.edu by October 15 annually.