2017-18 AY Assessment Report
M.A. in Mathematics.

Department and Degree: Department of Mathematics. Master's of Arts in Mathematics
Assessment Coordinator: Oscar Vega.

1. **Learning outcomes assessed this year**

Direct Assessment.

We assessed two courses this AY: MATH 271 and MATH 220. MATH 271 is one of the two core courses in our program (the other one was assessed last year), and MATH 220 is a recently created course.

The goals and SLOs assessed this year were:

Goal B. Continue development of students' ability to read, understand, and write rigorous mathematical proofs.

B1. Students will read, understand, and be able to reconstruct rigorous proofs of classical theorems in algebra and analysis.

B2. Students will write advanced proofs in algebra and analysis.

Goal C. Provide students with opportunities to apply mathematical knowledge to solve theoretical and practical problems.

C1. Students will utilize advanced problem-solving skills.

Goal D. Continue development of students' communication skills, both written and oral for purposes of conveying mathematical information.

D1. Students will be able to explain their solutions and proofs both orally and in writing.

Indirect Assessment.

In this section, we usually look at the online exit surveys the graduate committee collected from the 2017-18 graduating class. However, this year we only graduated two students and only one of them responded to the survey. We do not think there is enough data this year to make any important decisions. We will combine this year's exit survey with next year's in next year's report.

2. **Assignments and/or surveys used to assess the outcomes and criteria/rubrics used for evaluation.**

   For the direct assessment of SLOs B1, B2, C1, and D1, we embedded questions in the final exams of two courses.

   B1. One embedded question on the MATH 271 final exam in Fall of 2017.
   One embedded question on the MATH 220 final exam in Spring of 2018.

   B2. One embedded question on the MATH 271 final exam in Fall of 2017.
   One embedded question on the MATH 220 final exam in Spring of 2018.

   C1. One embedded question on the MATH 220 final exam in Spring of 2018.

   D1. One embedded question on the MATH 271 final exam in Fall of 2017.

   For the indirect assessment, exit interviews and online exit surveys of students in the graduating class are typically used to capture students' feelings and thoughts about our program and department. However, this year we only graduated two students and so we do not consider we have enough data to make any claims at this point.

3. **Discoveries from data gathered**

   MATH 271:
   We assessed one section of this course in the Fall of 2017.

   Eight of the 9 students enrolled in the course took the final exam (the one missing student having withdrawn from the course). The final exam consisted of a 70% take-home problem-solving part and a 30% theoretical (oral) part with an optional opportunity to earn 5 extra credit points by answering additional random questions.

   SLO B1. The instructor thinks that a score of $7/10$ (70%) in this question would be satisfactory. However, he expects an $8/10$ (80%) average score.

   Students' scores were as follows: $6/10$, $7/10$ (2 students), $8/10$ (3 students), $10/10$ (2 students), for an average of $8/10$.

   SLO B2. The instructor thinks that a score of $7/10$ (70%) in this question would be satisfactory. However, he expects an $8/10$ (80%) average score.

   Students' scores were as follows: $2/10$, $5/10$, $7/10$, $8/10$ (2 students), $9/10$, $10/10$ (2 students), for an average of $7.375/10$.

SLO D1. The instructor thinks that a score of $5/10$ (50%) in this question would be satisfactory. However, he expects an average score of $6/10$ (60%) .

Students' scores were as follows: $4/10$, $5/10$ (3 students), $6/10$, $7/10$, $10/10$ (2 students), for an average of $6.5/10$.

Summary: The SLO's measured by the embedded questions are generally satisfied by the students. For SLO B1, seven of the eight students achieved a satisfactory outcome, and the average was as the instructor expected. For SLO B2, six of the eight students achieved a satisfactory outcome, but the average was somewhat below the instructor's expectations. Finally, for SLO D1, seven of the eight students achieved a satisfactory outcome and the average was slightly above the instructor's expectations.

Of these students, five earned an A in the course, and three earned a B. Of those earning an A, all but two met the instructor's expectations for SLO's B1, B2, and D1; one of the students earning an A exceeded the expectations for SLO's B1 and B2, but fell short on SLO D1 by 1 point.

Clearly, overall students are satisfying SLO's B1, B2, and D1 for this course. However, results were better for SLO's B1 and D1 than for SLO B2. Based on the results for the assessment of SLO B2 in AY 2016-2017, this is not surprising, since it requires the more advanced skill of developing strategies to write solutions and proofs; students need to put together a plan to apply important and complex theorems and identify intermediate steps or goals that may be useful toward a solution of the problem.

MATH 220:
We assessed one section of this course in the Spring of 2018.

All four students enrolled in the course took the final exam. The final exam consisted of a take-home test in which students had to answer eight out of ten questions. There was an optional opportunity to earn 20 extra credit points by answering more than eight questions.

SLO B1. The instructor thinks that a score of $6/10$ (60%) in this question would be satisfactory. However, he expects an $7/10$ (70%) average score.

Students' scores were as follows: $0/10$ (2 students chose not to answer the question), $4/10$, $6/10$, for an average of $5/10$ (counting only students who answered the question).

SLO B2. The instructor thinks that a score of $8/12$ (67%) in this question would be satisfactory. However, he expects an $10/12$ (83%) average score.

Students' scores were as follows: $9/12$, $12/12$ (3 students), for an average of $11.25/12$.

SLO C1. The instructor thinks that a score of $7/10$ (70%) in this question would be satisfactory. However, he expects a score of $8/10$ (80%) average score.

Students' scores were as follows: $4/10$ (2 students), $10/10$ (2 students), for an average of $7/10$.

Summary: The SLO's measured by the embedded questions are satisfied by the students, roughly, half of the time. For SLO B1, none of the four students achieved a satisfactory outcome (only two chose that question, though), and the average of those two students was below what the instructor expected. For SLO B2, all four students achieved a satisfactory outcome, and the average was above the instructor's expectations. Finally, for SLO C1, two of the four students achieved a satisfactory outcome and the average was slightly below the instructor's expectations.

Of these students, three earned an A in the course, and one a B. Of those earning an A, only one met the standard in all three questions (and met instructor's expectations in two; s/he fell short by one point in SLO B1). The student with a B did not meet any of the instructor's expectations (also, s/he did not answer the question for SLO B1 and did not even meet the standard in the question for SLO C1).

We can see that students are satisfying SLO B2, and the top half of the class also satisfies SLO C1. There seems to be work needed to get students to satisfy SLO B1, as either students chose not to address that question (they may have thought that the question was too difficult for them) or had scores below the standard. Interestingly, SLO B2 is the one in which students in MATH 271 did the worst.

4. **Changes made as a result of findings**

After analyzing the data obtained, we identified one issue that we believe should be addressed: we see that student assessments that are more uniform would be beneficial, not only to students but also for assessment purposes. We mean by lack of uniformity in student assessments that in both courses there are instances in which students do not get assessed in one SLO in the same way they did for others. For example, the question for SLO C1 in MATH 271 had a lower expectation than the ones chosen for the other two SLOs, and in MATH 220, the question assessing SLO B1 was optional. It would be good for instructors to make sure they are assessing all of the students in all SLOs and with similar degrees of difficulty.

The recommendation above was shared with our department in writing and then discussed at our inaugural departmental assessment meeting, which took place on October, 7th. After a long and interesting discussion, we agreed on the following statement, which we believe is applicable to all our courses, both graduate and undergraduate.

> "Instructors must make sure that they assess all the SLOs their course is supposed to cover. Instructors should find ways to get students to attempt questions that have been written to address specific SLOs."

The annual M.A. assessment report for AY 2016-2017 gave the following three recommendations:

- Each proof-based graduate course should require students to write complex proofs involving: (1) several steps and/or intermediate goals/lemmas, and (2) the devising of a plan that involves known results and the aforementioned intermediate goals. These problems could be given to students as short papers, or in-class assignments, take-home exams, etc.
- SLO B2 should be re-written using the language above.
- The graduate writing requirement should include, at least, (1) the statement of a major mathematical result and its proof (or a major mathematics education result and its background), and (2) the application of an argument/proof along the lines of the previous recommendations.

The graduate committee worked on re-writing our graduate requirement and project/theses rubrics using the language described above. We will also include this language in our new SOAP, which we will work on during the 2018-19 AY.

Also, the report recommended that:

> "Our program should work on preparing its students better in applications of mathematics, appreciation of mathematics' place in the world, and also on mathematical software literacy."

During the 2017-18 AY, the graduate committee added a software literacy policy to our graduate handbook, in which we state expectations of software/technology usage in graduate classes. We did not have any tangible products regarding the first part of the above recommendation (applications); we expect to take care of that while we transition from an M.A. into an M.S (planned to start in Fall 2019).

5. **Assessment activities to be conducted in the 2018-19 academic year.**

   (a) Assessment of the SLOs covered by MATH 232, MATH 263, MATH 223, AND MATH 251. This will be done, preferably, by embedding questions in exams, but for courses that are more project-based, we will find a way to assess the corresponding SLOs after consulting and planning with the corresponding instructors.

   (b) We will survey our graduating students to learn about their thoughts and feelings about our program. We will combine their responses with the little data we were able to gather this year.

   (c) Create forms and sample rubrics for the process of embedding questions in exams; we need more detailed information from instructors and more uniformity in the assessment of SLOs; having 'templates' should help.

(d) We will re-write the current SOAP to match the way our program runs now, and to fit better the currently-being-developed MS program. This includes studying SLOs for new courses, courses that have not been taught in some time, etc.

6. **Progress made on items from our last program review action plan**

Regarding the previous assessment report, and as mentioned before, we developed a rubric for assessment of projects/theses (and project/theses defenses). The project rubric was first used in Spring 2018. We also created a policy for the usage of technology in our courses.

During the 2016-17 AY, we had a site visit to review our programs. The visit occurred on Sept. 28th and 29th, 2016. The review panel consisted of Prof. Kim Morin, Theatre Arts, CSU Fresno, Dr. Saeed Attar, Professor of Chemistry, Director of Honors College, CSU Fresno, and Dr. Ivona Grzegorczyk, Professor and Chair, Department of Mathematics, California State University, Channel Islands.

The panel delivered several recommendations that were already discussed in last year's assessment report. Next we report on the items for which we reported *no progress* last year, and that are relevant to our Master's program.

A. Curriculum Improvements and Vision for the Future.

Recommendation 4. Faculty should discuss a long-term vision for the department.
*Last year's response.*We have had a couple of retreats, in Fall 2015 and Fall 2016, to discuss this. Besides the implementation of a BS in Mathematics, which includes a 'blended' program for students who want to teach at the High School level, no further actions have been taken. We have discussed the creation of a 4+1 program in the near future.

This year's response. We are in the process of changing the degree designation of our program from an M.A. to an M.S. This change will consist in a re-organization of our courses, creation of new ones and phasing out of others. We believe our new program will be more competitive, modern, and will give our student a high-standards education.

B. Supporting Faculty Research and Workload Issues.

Recommendation (Administration and the Department). Identify sources for long term funding so the program can offer release time or summer stipends to faculty engaging in research and grant-writing activities.
Last year's response. No progress.

This year's response. No progress.

C. Departmental Budget.

Recommendation. Identify College and University funds to be included in the departmental funding base for faculty scholarly activities and curriculum coordination.
Last year's response. No progress.

This year's response. No progress.

D. Improving technology use in mathematics courses.

Recommendation. Rethink delivery of the calculus, statistics, and upper division courses to include updated use of technology and current mathematical software.
Note: Although this recommendation is specific to undergraduate courses, we have also considered it for graduate courses.
Last Year's Response. No progress. Any advances on this regard have been made by individuals; our department does not have a plan for this contingency.

This year's response. The graduate committee wrote a new policy on the usage of technology in graduate courses; our next step is to incorporate these ideas in our new M.S. program and our new SOAP.

E. Supporting Undergraduate and Graduate Student Research.

Recommendation 1. Rethink the ways to involve undergraduate and graduate students into original research rewarding supervising faculty with adequate work load.
Last year's response. No progress on the 'reward' end. Our department's student research committee has created a simple system to identify students who want to engage in research and to match them with faculty willing, and able, to mentor them.
Also, students in our upcoming BS program will have to have a culminating experience, which will involve seminars and, in certain options, a research senior project.

This year's response. The undergraduate research committee has changed its name, and charge, to the *student research committee* with the idea of also support graduate student research. No progress on the 'reward' end, though.

Recommendation 2. Create funding for the department to support small courses for faculty student research projects.

Last year's response. No progress.

This year's response. No progress.

Recommendation 3. Explore the possibility to offer research courses, where full course load is given to faculty for working with small groups of students.
Last year's response. No progress.

This year's response. No progress.

F. Facilities.

Recommendation (Administration) 1. Try to locate all faculty and graduate student offices in closer proximity to the department.
Last year's response. Our Dean has provided three additional offices for our part time faculty to share. Even after this, our need for part time faculty and TA office space remains severe.

This year's response. No progress.

Recommendation (Administration) 2. Provide additional space that is equipped appropriately for best practices in teaching mathematics that will facilitate faculty/student collaboration and research activities.
Last year's response. No progress.

This year's response. No progress.

Recommendation (Administration) 3. Investigate the use of laptops to meet the computing needs of the faculty and students.
Last year's response. All full-time faculty have laptops provided by our college. There has been no progress regarding part-time faculty and students (including our TAs).

This year's response. No progress.

G. Involving Lecturers in Departmental Activities.

Recommendation 1. Include lecturers in programmatic issues relevant to the courses they teach (especially in committees on instruction and curriculum related to their teaching assignments).

Last year's response. No progress.

This year's response. Travis Kelm was an important part on the development of the re-design of MATH 260. He not only contributed in the selection of topics but also taught the class covering some of the new topics and typing material that was (and will be) used to create a set of lecture notes for this class. Travis also worked on the redesign of MATH 202, which is not currently being offered but that we plan to resuscitate in the near future. Other instructors worked on the re-design of undergraduate-level courses, see the assessment report for our B.A. for more details.

Recommendation 2. Allocate an additional appropriate space for the program designated to faculty-student collaborations and projects.
Last year's response. No progress.

This year's response. No progress.

H. Assessment and Student Learning Outcomes

Recommendation. The Student Learning Outcomes should include familiarity with current technology accepted by the mathematical community.
Last year's response. No progress. Any advances on this regard have been made by individuals; our department does not have a plan for this contingency.

This year's response. No progress. Any advances on this regard have been made by individuals; our department does not have a plan for this contingency.

We also report here on the progress made after the assessment committee suggestions in last year's assessment report.

1. Last year we reported that we did not have a plan to 'close the loop'. Since then, our department decided to hold a department meeting early in the Fall semester exclusively dedicated to the discussion of the annual assessment report and to making decisions about actions that would be taken to deal with the suggestions in the assessment report.

MATH 271, Assessment Rubric. Fall 2017

<u>SLO B1.</u> Prove

Theorem (Absolute Continuity of Lebesgue Integral).

Let (X, Σ, μ) be a measure space and a function $f : X \to \overline{\mathbb{R}}$ be Σ-measurable. Prove that, if $f \in L(X, \mu)$, then

$$\forall \epsilon > 0\ \exists \delta > 0\ \forall A \in \Sigma,\ \mu(A) < \delta :\ \int_A |f(x)|\ d\mu(x) < \epsilon.$$

Solution. Total of 10 points

- **Two points.** Choosing the indirect proof by *contradiction* and correctly formulating its premise.
- **Two points.** Correctly identifying a set sequence to be used.
- **One point.** Using the fact that

  $$\Sigma \ni A \mapsto \mu_f(A) := \int_A f\ d\mu\ in[0, \infty)$$

  is a *measure*.
- **Three points.** Using the *continuity of measure from above*.
- **Two points.** Arriving at a contradiction.

<u>SLO B2.</u> Let $1 \le p \le \infty$ and $f \in L_p(\mathbb{R})$. Prove that

$$\int_{-\infty}^{\infty} |f(x_t) - f(x)|^p\ dx\ \to 0,\ t \to 0$$

Solution. Total of 10 points

- **One point.** Noticing that the statement can be equivalently restated relative to p-*norm*.
- **Three points.** Using approximation by the classes represented by continuous functions with compact support in $L_p(\mathbb{R})$.
- **Three points.** Using the semiadditivity of p-*norm* and the change of variables for the Lebesgue integral.
- **Three points.** Reducing the problem to continuous functions with compact support and applying the *Lebesgue Dominated Convergence Theorem*.

SLO D1. Let (X, Σ, μ) be a measure space and

$$f, f_n : X \to [0, \infty),\ n \in \mathbb{N},$$

be such that $f, f_n \in (X, \Sigma, \mu)$, $n \in \mathbb{N}$, $f_n \to f \pmod{\mu}$, and

$$\int_X f_n \, d\mu \ \to \ \int_X f \, d\mu,\ n \to \infty$$

Prove that

$$\|f - f_n\|_1 := \int_X |f_n - f| \, d\mu \ \to \ 0,\ n \to \infty$$

Solution. Total of 10 points

- **Five points.** Using the definition of the Lebesgue integral to relate the integrals

$$\int_X [f_n - f] \, d\mu \text{ and } \int_X |f_n - f| \, d\mu.$$

- **Five points.** Applying the *Lebesgue Dominated Convergence Theorem*.

MATH 220, Assessment Rubric. Spring 2018

SLO B1. Show that if

$$2^k \sum_{i=0}^{d-2} \binom{n-1}{i} < 2^n$$

then there exists a binary linear $[n, k]$-code with minimum distance at least d. Deduce from this that $A_2(n, d) \geq 2^k$, where k is the largest integer satisfying the above inequality.

Solution. Total of 10 points

- Two points are given if the student merely recognizes this is related to the GV bound.
- Six points are given if the normal GV bound is used to prove the result; the GV bound does not give information about linear codes, but this is on the right track and so deserves partial credit. (Four points only if this proof has technical issues aside from assuming the code guaranteed by GV is not linear.)
- Eight points are given for a proof that attempts to follow the structure of the proof for the normal GV bound, modified to consider linear codes, but has some technical issues.
- Full 10 points for a rigorous proof modified from the proof of the normal GV bound.

SLO B2. Let C be a cyclic code of length n over $\mathbb{F}_q$ with generator polynomial $g(x)$ and idempotent generator $e(x)$. Let β be a primitive n-th root of unity. Prove the following:

1. $e(\beta^j) \in \{0, 1\}$ for $0 \leq j \leq n-1$.
2. For $0 \leq j \leq n-1$, we have that $e(\beta^j) = 0 \iff g(\beta^j) = 0$.
3. $\dim C = |\{0 \leq j \leq n-1 : g(\beta^j) \neq 0\}|$
4. $\dim C = |\{0 \leq j \leq n-1 : e(\beta^j) = 1\}|$

Solution. Total of 12 points
Each part was worth 3 points, graded as follows:

- One point for an honest attempt that was on the wrong track but incorporated relevant concepts in a coherent way.
- Two points for a solution that included a logical error or overlooked a relevant detail.
- Three points for a correct proof that addressed all cases and technicalities.

SLO C1. Prove that over a binary alphabet, if there exists an $(n, M, 2k)$-code then there exists an $(n, M, 2k)$-code with all codewords of even weight.

Solution. Total of 10 points

- Four points are given for assuming the zero word is in the original code (WLOG) and recognizing that it will be necessary to alter a single entry of each odd weight codeword.
- Six points are given if it is mentioned that the distance between an odd weight codeword and even weight codeword will in fact be $\geq 2k+1$.
- Eight points are given for recognizing that a single bit can be consistently flipped across all odd weight codewords, but having technical issues with proving that this resulting new code will have minimum distance $2k$.
- Ten points are given for a rigorous proof that details how to construct the new code, and also proves that the new code has the desired properties.