San Francisco State University

College of Science and Engineering

Department of Mathematics

Assessment Report

2010-2011

*** The collection of MSLO data was made possible by an engine created by Professor Arek Goetz.**

^ The mining of MSLO data was facilitated by computer codes written by Raymond Cavalcante.

▫ This 22 August, 2011 version was prepared by David Bao, chair and professor of Mathematics.

Degree Programs and Mission Statements

The Department of Mathematics is the center of mathematical teaching and scholarship at San Francisco State University. Its members specialize in pure and applied mathematics, statistics and mathematical education. The Department serves three communities. (1) The *students of SFSU*: through service courses in remedial mathematics, probability & statistics, and calculus; advanced classes for undergraduate and graduate majors in Mathematics, Applied Mathematics, Statistics, as well as students majoring in allied disciplines such as Computer Science, Engineering, Geology, and Physics. (2) The *Bay Area at-large*: through scientific collaborations with industry, educational projects such as the Math Circle, and externally funded joint initiatives with the SF Unified School District. (3) The world-wide community of *research mathematicians*: through peer-reviewed publications and research conferences.

1. BA in Mathematics

The Bachelor of Arts degree is offered for students with an interest in mathematics for its own sake. There are three concentrations: one for students who intend to pursue graduate studies in mathematics, another for students interested in a broad liberal arts education focused in mathematics as a language for critical thinking (with an eye towards Medicine or Law), and a third for those seeking a Single Subject Teaching Credential.

2. BS in Applied Mathematics

The Bachelor of Science degree in Applied Mathematics responds to the needs of business and industry for applied mathematical scientists. More broadly, the program serves students who enjoy mathematics *and* want to see how it is applied to industry, the physical sciences, and engineering. Specific areas of application include finance, biotechnology, data mining, operations research, systems analysis, super-computing, transmission and visualization of data, high energy physics, and astronomy.

3. BS in Statistics

The Bachelor of Science in Statistics is for students who are planning careers as statisticians in industry, business, government, or any sector in which decisions are often based on incomplete information. Statistics is essential to quantitative research in the biological, physical, and social sciences. The successful statistician has a firm command of mathematical methods, scientific methodology, computational protocol, and a repertoire of practical problems. To give the student both breadth and depth, and to introduce the student to a variety of fields where statistics may be applied, three emphases are offered: science, business, and economics.

4. MA in Mathematics

The Master of Arts in Mathematics is offered with the purpose of extending the students' experience in mathematics. The program prepares students for further graduate work, for careers in government or industry, for community college teaching, or for an enhanced competency in elementary or secondary school teaching.

Student Learning Objectives (SLOs) and curriculum assessed

1. BA Mathematics

	Student Learning Objectives (SLOs)	Assessed curriculum
1a	Students will have learned basic computer programming or the use of various softwares such as Mathematica and SAS.	Math 338 (Intro to SAS); level I.
1b	Students will be able to apply the skills from 1a to solve problems in linear programming, network analysis, and transportation models.	Math 430 (Operations Research: Deterministic Methods); level D.
1c	Students will be able to apply the skills from 1a to solve problems in matrix algebra, especially those that concern eigenvectors and eigenvalues.	Math 325 (Linear Algebra); level I.
1d	Students will be able to apply the skills from 1a to solve problems in ordinary differential equations, especially the investigation of numerical and graphical solutions of equations that are not solvable by symbolic methods.	Math 376 (Ordinary Differential Equations I); level D.
2a	Students will have learned how to guide their exploratory thinking when formulating and analyzing conjectures. They will have learned the rudimentary tools that are needed for constructing rigorous proofs; these tools include elementary logic and set theory, mathematical induction, relations, and functions. Students will also have learned how to articulate their arguments in sound mathematical English.	Math 301 (Exploration and Proof); level I.
2b	Students will be able to write proofs for statements in linear algebra (vector spaces, linear transformations, eigenvectors and eigenvalues, determinants) and in modern algebra (groups, rings, integral domains, and fields). Students will also have learned how to articulate their arguments in sound mathematical English.	Math 325 (Linear Algebra) and Math 335 (Modern Algebra I); both at level I.
2c	Students will be able to write proofs for statements concerning limits, continuity, differentiability, and integrability. They will have learned how to critically assess the proofs of some key results in hard analysis, such as the Bolzano-Weierstrass and Heine-Borel theorems. Students will also have learned how to articulate their arguments in sound mathematical English.	Math 370 (Real Analysis I); level D.
3a	Students will be able to present technical information clearly in a written format.	Math 350 (Geometry) Math 335 (Modern Algebra I) Math 370 (Real Analysis I) Capstone Special Project at levels I, I, D, D.
3b	Students will be able to present technical information clearly in an oral format.	Capstone Special Projects; poster sessions at conferences; student project showcases. All at level D.
4	Students will be able to use numerical analysis methods to solve problems that arise from the mathematical modeling of practical situations.	Math 400 (Numerical Analysis); level D.
5	Students will be able to achieve knowledge integration in both content and practice.	For the Teaching concentration: Math 475 (Capstone) and the Capstone Special Project
6	Students will be able to use technological tools to locate and retrieve scientific information and conduct literature searches.	Capstone Special Project; level D.

2. BS Applied Mathematics

	Student Learning Objectives (SLOs)	Assessed curriculum
1a	Students will have learned basic computer programming or the use of various softwares such as Mathematica and SAS.	Math 338 (Intro to SAS); level I.
1b	Students will be able to apply the skills from 1a to solve problems in linear programming, network analysis, and transportation models.	Math 430 (Operations Research: Deterministic Methods); level D.
1c	Students will be able to apply the skills from 1a to solve problems in matrix algebra, especially those that concern eigenvectors and eigenvalues.	Math 325 (Linear Algebra); level I.
1d	Students will be able to apply the skills from 1a to solve problems in ordinary differential equations, especially the investigation of numerical and graphical solutions of equations that are not solvable by symbolic methods.	Math 376 (Ordinary Differential Equations I); level D.
1e	Students will be able to use computer software to perform data and statistical analyses, compute confidence intervals and carry out hypothesis testing, and apply the Central Limit Theorem.	Math 324 (Probability and Statistics with Computing) and Math 340 (Probability and Statistics I); both at level D.
2a	Students will have learned how to guide their exploratory thinking when formulating and analyzing conjectures. They will have learned the rudimentary tools that are needed for constructing rigorous proofs; these tools include elementary logic and set theory, mathematical induction, relations, and functions. Students will also have learned how to articulate their arguments in sound mathematical English.	Math 301 (Exploration and Proof); level I.
2b	Students will be able to write proofs for statements in linear algebra (vector spaces, linear transformations, eigenvectors and eigenvalues, determinants) and in modern algebra (groups, rings, integral domains, and fields). Students will also have learned how to articulate their arguments in sound mathematical English.	Math 325 (Linear Algebra) and Math 335 (Modern Algebra I); both at level I.
2c	Students will be able to write proofs for statements concerning limits, continuity, differentiability, and integrability. They will have learned how to critically assess the proofs of some key results in hard analysis, such as the Bolzano-Weierstrass and Heine-Borel theorems. Students will also have learned how to articulate their arguments in sound mathematical English.	Math 370 (Real Analysis I); level D.
3a	Students will be able to present technical information clearly in a written format.	Math 696-697 (App Math Proj); level D.
3b	Students will be able to present technical information clearly in an oral format.	Math 696-697 (App Math Proj); poster sessions at conferences; student project showcases. All at level D.
4a	Students will be able to use numerical analysis methods to solve problems that arise from the mathematical modeling of practical situations.	Math 400 (Numerical Analysis); level D.
4b	Students will be able to formulate initial or boundary value problems for standard physical phenomena, perform separation of variables on the resulting partial differential equations, implement Sturm-Liouville theory, the heat kernel method, harmonic theory, and the wave propagation method.	Math 477 (Partial Differential Equations); level D.
5	Students will be able to achieve knowledge integration in both content and practice.	Math 696-697 (App Math Proj); level D.
6	Students will be able to use technological tools to locate and retrieve scientific information and conduct literature searches.	Math 696-697 (App Math Proj); level D.

3. BS Statistics

	Student Learning Objectives (SLOs)	Assessed curriculum
1a	Students will have learned basic computer programming or the use of various softwares such as Mathematica and SAS.	Math 338 (Intro to SAS); level I.
1b	Student will have learned basic computer programming.	CSC 209 or CSC 210; both at level I. ***Assessed by the CS dept***.
1c	Students will be able to identify, formulate, and solve problems concerning probability spaces, elementary combinatorics, random variables, independence, expected values, moment generating functions, selected probability distributions, limit theorems, and applications.	Math 340 (Probability and Statistics I); level D.
1d	Students will be able to identify, formulate, and solve problems concerning sampling distributions, estimation of parameters, hypothesis testing, goodness-of-fit tests, linear regression, and selected non-parametric methods.	Math 441 (Probability and Statistics II); level D.
1e	Students will be able to apply the skills from 1a to solve problems in matrix algebra, especially those that concern eigenvectors and eigenvalues.	Math 325 (Linear Algebra); level I.
1f	Students will be able to identify, formulate, and solve problems in multiple linear regression, analysis of variance for fixed and random effects and nested and crossed treatments. Students will also be able to implement experimental design, especially factorial designs.	Math 424 (Introduction to Linear Models); level D.
2a	Students will be able to present technical information clearly in a written format.	Math 424 (Introduction to Linear Models); Capstone Special Projects. All at level D.
2b	Students will be able to present technical information clearly in an oral format.	Math 424 (Introduction to Linear Models); Capstone Special Projects; poster presentations at student project showcases or conferences.. All at level D.
3	Students will be able to use technological tools for computation, to locate and retrieve scientific and technical information, and to conduct literature searches.	Math 338 (Introduction to SAS); level I.
4	Students will be able to model, with the help of statistics, complex real-world situations in a specific field of interest. Students will also be able to apply statistical principles and processes to analyze and to solve such real-world problems.	Capstone Special Projects

4. MA Mathematics

	Student Learning Objectives (SLOs)	Assessed curriculum
1a	Students will be able to correctly state definitions, prove theorems and develop counter-examples in advanced algebra (rings, modules, and fields). Students will also be able to apply this machinery to solve problems in related areas of mathematics and statistics.	Math 850 (Algebra); level D.
1b	Students will be able to correctly state definitions, prove theorems and develop counter-examples in analysis (metric spaces, compactness, Baire category, Lebesgue measure and Lebesgue integration). Students will also be able to apply this machinery to solve problems in related areas of mathematics and statistics.	Math 710 (Analysis I); level D.
2a	Students will be able to present technical information clearly in a written format.	Master's theses and all courses; level M. Written examinations and expository papers; level D.
2b	Students will be able to present technical information clearly in an oral format.	Thesis defense; presentation of the expository paper or other research work at seminars, student project showcases, or conferences.
3	Students will be able to use technological tools for computation (Mathematica, Maple), for locating and retrieving technical information and conducting literature searches (J-Store), and for typesetting their written documents (LaTeX).	Master's theses and expository papers; level M.
4	Students will have achieved a culminating experience of knowledge integration.	Master's theses, expository papers, and poster presentations at student project showcases or conferences.

Protocol for Assessment and Program Improvement

Each Student Learning Objective (SLO) is being addressed by one or more courses. For any such course, there are two types of metrics for assessment. Course grades collectively provide a crude metric, while splitting the SLO in question into a series of *Measurable Student Learning Outcomes* (MSLOs) leads to a family of more refined metrics.

A. Course grade as a crude metric for assessment.

Before assessing a given course and its underlying SLO, we shall first stipulate the range of grades that indicate student success. Students are said to have successfully completed an undergraduate course if their grades are C or higher. For graduate level courses, success is defined as having earned a grade of B or higher. Note that these standards are a tiny notch higher than what we traditionally mean by "passing" a course.

Next, the 25^{th}, 50^{th}, and 75^{th} percentiles of grades in the course being assessed, say Math X, will be computed.

Suppose Math Y is a formal or recommended prerequisite of Math X. We shall examine the grades earned by students who came into Math X with various grade ranges from the prerequisite Math Y. These will be compared to the grades earned by all students in Math X, whether they had been exposed to Math Y or not. The comparisons will lead to an opinion regarding the appropriateness of the prerequisite course(s).

For program improvement: Inappropriate prerequisites will be removed and possibly replaced by other candidate prerequisite(s).

B. Measurable Student Learning Outcomes as refined metrics for assessment.

The Student Learning Objective (SLO) addressed by Math X is comprised of a series of Measurable Student Learning Outcomes (MSLOs). Questions dedicated to the MSLOs are embedded into the final exam. Each MSLO is scored on a scale of 0-10. For each student, these scores are entered into an MSLO data collection engine, with the student's identity replaced by an almost unique watermark. Sample student solutions at 3 levels of quality (good, so-so, bad) are also intermittently archived for each MSLO.

The average score for each MSLO will be computed. Each such average gives an indication of how the course is faring in its intention to deliver one facet of the Student Learning Objective. *As the pedagogy evolves and the student population varies, these averages are expected to change.*

We shall stipulate what is meant by a weak performance on any given MSLO; usually, scores of 0-5 out of 10 are considered weak, but this range varies among MSLOs. Also, we shall revisit our range of grades that spell student success and refer to grades outside of this range as failures. For instance, if C or higher means success, then C- or below will be referred to as failures.

The failure rate of students with weak performance on each specific MSLO will be compared to the failure rate of all students in the course Math X. Specifically, given each MSLO, say MSLO Z, the following ratio is computed: the percentage of failure among students who performed ***weakly*** on MSLO Z is divided by the percentage of failure among ***all*** students of Math X. A ratio of 3, say, would mean that students who are weak on MSLO Z are three times as likely to fail Math X as the generic students of Math X. Thus this ratio is a computed risk index. The higher the ratio, the more relevance one should attach to MSLO Z as a risk indicator. Again, *as the pedagogy evolves and the student population varies, these indicators may change.*

For program improvement: The effort spent on teaching those high risk MSLOs will need to be re-aligned with the magnitude of the computed risks. In particular, future students who perform weakly on MSLOs that were deemed high risk in the past *may* benefit from closer supervision.

For assessing the SLOs that concern written and oral presentation of mathematics, the faculty recently designed the following rubric of MSLOs for data collection.

Scale of Scores: Poor = 0-2, Below Average = 3-4, Average = 5-6, Good = 7-8, Excellent = 9-10.

Criteria	Score	Comments
Written Presentation		
Clarity of Purpose: To what extent did the student articulate the goals and significance of the research/thesis?		
Information on Background: To what extent did the student understand/convey the background and history of the problem?		
Justification of Method: To what extent did the student present convincing arguments for his/her approach to the problem?		
Mathematical Correctness: To what extent are mathematical statements and algorithms proved/justified? Assess quality of the work.		
Writing Style: To what extent is the document grammatically correct, clearly organized, well-written, and engaging?		
Interpretation of Results: Did the student adequately summarize the implications of his/her results?		
Oral Presentation		
Clarity of Purpose: To what extent did the student articulate the goals and significance of the research?		
Organization: Did the presentation have clear logical flow? Were the transitions clear?		
Quality of Presentation Material: Were the slides and/or board work uncluttered, organized and legible? Were graphs, charts, tables, and other visual aids used effectively?		
Interaction with Audience: Did the student keep eye contact with the audience? Did the student hold the audience's attention during the presentation?		
Response to Questions: Did the student's answers adequately address the questions, and indicate a mastery of the subject matter?		
Timing: Did the presentation show an effective use of the available time, and start/end on time? If not, give a reason.		

Summary of Findings for Various Courses

The following table lists the items in the curriculum that need assessment, together with their underlying Student Learning Objectives (SLOs). The last column provides the status of these assessments.

Curriculum	BA Math SLOs	BS Applied Math SLOs	BS Stats SLOs	MA Math SLOs	Assessed in 2010-2011?
Math 301	**2a**	**2a**			Yes
Math 324		**1e**			Yes
Math 325	**1c; 2b**	**1c; 2b**	**1e**		Yes
Math 335	**2b; 3a**	**2b**			Yes
Math 338	**1a**	**1a**	**1a; 3**		Yes
Math 340		**1e**	**1c**		Yes
Math 350	**3a**				Yes
Math 370	**2c; 3a**	**2c**			Yes
Math 376	**1d**	**1d**			Yes
Math 400	**4**	**4a**			Yes
Math 424			**1f; 2a; 2b**		Insufficient data
Math 430	**1b**	**1b**			Insufficient data
Math 441			**1d**		Yes
Math 475	**5**				Yes
Math 477		**4b**			Yes
Math 696-697		**3a; 3b; 5; 6**			Using the newly designed rubric to collect data.
Math 710				**1b; 2a**	Yes
Math 850				**1a; 2a**	Yes
Capstone Special Project	**3a; 3b; 5; 6**		**2a; 2b; 4**		Using the newly designed rubric to collect data.
Theses and Expository Papers				**2a; 3; 4**	Using the newly designed rubric to collect data.
Defenses, and presentations at seminars, conferences, and showcases.	**3b**	**3b**	**2b**	**2b; 4**	Using the newly designed rubric to collect data.

* The underlined SLOs were inadequately addressed in last year's assessment report. Note that SLO **1b** of **BS Stats** is absent from the above table because it is to be assessed by the Computer Science department.

In the following pages, we summarize the findings of those assessments that have been carried out, course by course. As for the parts of the curriculum that have not been assessed for this report, either due to insufficient data or the fact that a rubric has only recently been designed, it will take time in order to collect enough data for a meaningful assessment. Preliminary findings to date are withheld for the sake of brevity.

MATH 301 (Exploration and Proof)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C
50th percentile	B
75th percentile	A-

Population and Sub-populations		**Percentage earning A in Math 301**	**Percentage earning B or higher in Math 301**	**Percentage earning C or higher in Math 301**
All Math 301 students		12%	37.5%	60.7%
Students in Math 301 with C or higher from Math 226		10.2%	28.8%	52.5%
Students in Math 301 with B- or higher from Math 226		13%	32.6%	52.2%
Students in Math 301 with A- or higher from Math 226		20%	36%	60%
Students in Math 301 with C or higher from Math 227		11.9%	30.5%	54.2%
Students in Math 301 with B- or higher from Math 227		15.9%	38.6%	59.1%
Students in Math 301 with A- or higher from Math 227		29.2%	54.2%	79.2%
Students in Math 301 with C or higher from Math 228		12%	40.1%	67.4%
Students in Math 301 with B- or higher from Math 228		19%	51.7%	74.1%

Conclusion: Math 226 is not a strong enough prerequisite for Math 301. Math 227 would be a marginally acceptable prerequisite. Math 228 should have been *the* prerequisite.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 301: course grade C- or below.
The failure rate in Math 301 was 25.7%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [understanding set notions]	6.29	0-5	1.32
2 [definition-axiom-theorem]	7.02	0-6	1.83
3 [writing correct proofs]	6.67	0-5	1.71
4 [basic number systems]	6.80	0-5	1.67
5 [function concepts]	5.67	0-4	1.28
6 [cardinality concepts]	5.49	0-4	1.13

Conclusion: Invest more effort in MSLO 2 and MSLO 3.

MATH 324 (Probability and Statistics with Computing)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C
50th percentile	B-
75th percentile	A-

Population and Sub-populations		**Percentage earning A in Math 324**	**Percentage earning B or higher in Math 324**	**Percentage earning C or higher in Math 324**
All Math 324 students		15%	41.9%	65.7%
Students in Math 324 with C or higher from Math 227		13.6%	43.7%	65.1%
Students in Math 324 with B- or higher from Math 227		21.7%	56.7%	78.3%
Students in Math 324 with C or higher from Math 124		16.7%	50%	66.7%
Students in Math 324 with B+ or higher from Math 124		33.3%	100%	100%

Conclusion: Math 227 is a reasonable prerequisite for Math 324. Math 124 or its equivalent should be added as a prerequisite.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 324: course grade C- or below.
The failure rate in Math 324 was 26.9%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [description of data]	8.78	0-8	1.71
2 [probability]	7.51	0-6	1.86
3 [random variables]	7.17	0-6	1.86
4 [distributions]	7.11	0-6	1.82
5 [estimation]	7.58	0-6	2.42
6 [hypothesis testing]	7.05	0-6	2.04
7 [regression]	6.63	0-5	2.57
8 [simulation]	8.40	0-7	2.42

Conclusion: Invest more effort in MSLOs 5, 6, 7, 8.

MATH 325 (Linear Algebra)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C
50th percentile	B
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 325**	**Percentage earning B or higher in Math 325**	**Percentage earning C or higher in Math 325**
All Math 325 students		23.2%	48.9%	71.1%
Students in Math 325 with C or higher from Math 227		16%	43.7%	68.1%
Students in Math 325 with B- or higher from Math 227		26%	57.5%	76.7%
Students in Math 325 with C or higher from Math 301		27.1%	58.1%	78.3%
Students in Math 325 with B or higher from Math 301		38.4%	71.2%	83.6%

Conclusion: Math 227 is a reasonable prerequisite for Math 325. Math 301, currently as a recommended course, would have been a strong prerequisite. However, Math 301 cannot be added as such because it is strictly a course for Math majors, while Math 325 serves a broad clientele of physical science and engineering majors.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 325: course grade C- or below.
The failure rate in Math 325 was 22.8%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [solving linear systems]	8.14	0-7	1.58
2 [computing inverse matrix]	9.05	0-8	1.67
3 [computing determinants]	8.55	0-7	1.49
4 [subspace test]	5.07	0-4	1.18
5 [subspace basis]	7.98	0-5	1.71
6 [matrix rep of linear transformation]	7.48	0-5	1.89
7 [eigenvalues and eigenvectors]	7.85	0-5	1.97
8 [diagonalization]	6.86	0-5	1.36

Conclusion: Invest more effort in MSLOs 5, 6, 7. MSLO 8 is quite important and deserves special attention, even though it did not come through as a high risk facet of the course (possibly because it was covered near the end of the semester and was not emphasized on the final exam).

MATH 335 (Modern Algebra I)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C-
50th percentile	C+
75th percentile	B+

Population and Sub-populations		**Percentage earning A in Math 335**	**Percentage earning B or higher in Math 335**	**Percentage earning C or higher in Math 335**
All Math 335 students		11.2%	32.1%	66.9%
Students in Math 335 with C or higher from Math 301		8.4%	30.5%	74.0%
Students in Math 335 with B or higher from Math 301		12.2%	43.8%	84.7%
Students in Math 335 with C or higher from Math 325		5.7%	24.3%	59.7%
Students in Math 335 with B+ or higher from Math 325		9.9%	33.3%	74.3%

Conclusion: Math 301 is a reasonable prerequisite for Math 335. Math 325, though not a good prerequisite, should nevertheless be retained because the matrix algebra acquired from Math 325 is a necessary tool in Math 335.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 335: course grade C- or below.
The failure rate in Math 335 was 28%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [recognizing groups]	5.61	0-4	2.11
2 [computing in groups]	5.85	0-4	1.64
3 [group isomorphisms]	5.05	0-4	1.61
4 [group coset partition]	5.24	0-4	1.79
5 [Lagrange's theorem]	5.29	0-4	1.64
6 [normal subgroups]	4.80	0-3	2.00
7 [recognizing rings]	3.21	0-3	1.71
8 [identifying ideals]	2.68	0-1	0.86
9 [ring coset partition]	5.16	0-4	1.00

Conclusion: Invest more effort in MSLOs 1, 6, 4, 7. MSLO 8, which the students least mastered, did not come through as a high risk facet of the course possibly because it was covered near the end of the semester and was not emphasized on the final exam.

MATH 338 (Introduction to SAS)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C
50th percentile	B
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 338**	**Percentage earning B or higher in Math 338**	**Percentage earning C or higher in Math 338**
All Math 338 students		29.6%	47.7%	62.5%
Students in Math 338 with B or higher from Math 124		66.7%	66.7%	100%
Students in Math 338 with a grade of A from Math 124		50%	50%	100%

Conclusion: In our database, there is no student in Math 338 with a Math 124 grade that is lower than B. The above table supports our belief that Math 124 (Elementary Statistics) or its equivalent is an appropriate prerequisite for Math 338.

Let us comment on a subtlety in that table. Since Math 124 is a GE QR course, students who literally took that course are almost certainly not going to take Math 338, which is intended for Math or Statistics majors. Instead, most students in Math 338 have had the equivalent of Math 124, but not Math 124 itself. So, the two sub-populations above are quite small, in which case it is not unusual for the cohort with B or higher from Math 124 to outperform the cohort with A from Math 124.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 338: course grade C- or below.
The failure rate in Math 338 was 28.4%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [inputting data]	8.00	0-7	2.68
2 [managing data]	7.90	0-7	2.29
3 [loops and conditions]	7.65	0-6	2.68
4 [presentation procedures]	7.65	0-6	2.68
5 [conf interval & testing procedures]	7.35	0-5	3.52
6 [categorical analysis procedures]	7.15	0-5	3.52
7 [GLM procedures]	7.00	0-5	2.89

Conclusion: Invest more effort in MSLOs 5, 6, 7.

MATH 340 (Probability and Statistics I)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C-
50th percentile	B-
75th percentile	A-

Population and Sub-populations		**Percentage earning A in Math 340**	**Percentage earning B or higher in Math 340**	**Percentage earning C or higher in Math 340**
All Math 340 students		15.5%	40.5%	60.8%
Students in Math 340 with C or higher from Math 228		8.3%	33.3%	58.3%
Students in Math 340 with B or higher from Math 228		12.5%	50%	68.8%
Students in Math 340 with B+ or higher from Math 228		22.2%	61.1%	83.3%

Conclusion: Math 228 is a reasonable prerequisite for Math 340.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 340: course grade C- or below.
The failure rate in Math 340 was 24.3%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [basic probabilities]	7.96	0-6	2.84
2 [combinatorics]	7.24	0-5	3.87
3 [Bayes theorem]	7.71	0-6	2.92
4 [distribution functions]	7.81	0-6	2.67
5 [joint distributions]	7.12	0-4	2.88
6 [special distributions]	7.69	0-5	2.47
7 [approximations]	7.78	0-5	3.70

Conclusion: Invest more effort in MSLOs 2, 7, 3, 5.

MATH 350 (Geometry)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C+
50th percentile	B-
75th percentile	B+

Population and Sub-populations		**Percentage earning A in Math 350**	**Percentage earning B or higher in Math 350**	**Percentage earning C or higher in Math 350**
All Math 350 students		6%	43.4%	83.1%
Students in Math 350 with C or higher from Math 228		9.8%	43.9%	92.7%
Students in Math 350 with B- or higher from Math 228		14.8%	55.6%	92.6%
Students in Math 350 with C or higher from Math 301		5.9%	45.1%	84.3%
Students in Math 350 with B or higher from Math 301		7.4%	55.6%	85.2%

Conclusion: Math 228 and Math 301 are appropriate prerequisites for Math 350.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 350: course grade C- or below.
The failure rate in Math 350 was 10.8%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [axiomatic systems]	5.52	0-4	2.49
2 [finite/incidence geometry]	6.13	0-5	1.29
3 [Euclid's elements]	6.65	0-5	1.29
4 [Euclidean geometry axioms]	4.00	0-3	3.97
5 [neutral geometry]	4.55	0-3	0.83
6 [Euclidean geometry]	4.89	0-4	1.01
7 [transformational geometry]	6.40	0-5	1.94
8 [non-Euclidean geometry]	5.67	0-4	1.29

Conclusion: Invest more effort in MSLOs 4, 1, 7. MSLO 8 is quite important and deserves special attention, even though it did not come through as a high risk facet of the course (possibly because it was covered near the end of the semester and was not emphasized on the final exam).

MATH 370 (Real Analysis I)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	B-
50th percentile	B
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 370**	**Percentage earning B or higher in Math 370**	**Percentage earning C or higher in Math 370**
All Math 370 students		27.8%	62.4%	79.7%
Students in Math 370 with C or higher from Math 228		23.5%	66.7%	86.3%
Students in Math 370 with B+ or higher from Math 228		33.3%	85.7%	95.2%
Students in Math 370 with C or higher from Math 301		24.2%	65.9%	80.2%
Students in Math 370 with B or higher from Math 301		38.9%	77.8%	85.2%

Conclusion: Math 228 and Math 301 are appropriate prerequisites for Math 370.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 370: course grade C- or below.
The failure rate in Math 370 was 16.5%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [real sequences]	6.24	0-5	2.84
2 [limits of functions]	7.07	0-5	1.69
3 [continuity]	3.35	0-2	0.79
4 [differentiability]	6.97	0-6	1.45
5 [Riemann integration]	7.60	0-6	1.93

Conclusion: Invest more effort in MSLOs 1, 5, 2.

It is possible that students who were weak on MSLO 3 spent more time preparing for MSLOs 1, 2, 4, 5 than other students, hence their failure rate in Math 370 was actually *lower* than the failure rate among all students in the course.

MATH 376 (Ordinary Differential Equations I)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C+
50th percentile	B+
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 376**	**Percentage earning B or higher in Math 376**	**Percentage earning C or higher in Math 376**
All Math 376 students		26.6%	56.9%	78%
Students in Math 376 with C or higher from Math 228		19.5%	52.9%	83.3%
Students in Math 376 with B or higher from Math 228		29.3%	66.9%	87.5%
Students in Math 376 with C or higher from Math 325		21.2%	57.6%	86.4%
Students in Math 376 with B or higher from Math 325		26.9%	68.4%	92.6%

Conclusion: Math 228 and Math 325 are appropriate prerequisites for Math 376.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 376: course grade C- or below.
The failure rate in Math 376 was 16.6%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [first order equations]	7.76	0-7	0.42
2 [first order models]	7.40	0-7	0.78
3 [separable equations]	7.58	0-6	2.71
4 [Euler's numerical method]	8.85	0-7	1.99
5 [second order linear equations]	6.05	0-5	1.57
6 [nonhomogeneous linear equations]	6.27	0-5	1.75
7 [mechanical vibrations]	7.25	0-7	0.78
8 [first order systems]	7.24	0-6	1.27
9 [exponentials and diagonalization]	8.35	0-8	1.02
10 [existence and uniqueness]	5.73	0-4	1.20
11 [series solutions]	7.41	0-6	3.01

Conclusion: Invest more effort in MSLOs 11, 3, 4, 6, 5.

It is possible that students who were weak on MSLOs 1, 2, 7 spent more time preparing for the rest of the MSLOs than other students, hence their failure rate in Math 376 was actually *lower* than the failure rate among all students in the course.

MATH 400 (Numerical Analsysis)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	B
50th percentile	B+
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 400**	**Percentage earning B or higher in Math 400**	**Percentage earning C or higher in Math 400**
All Math 400 students		20%	62.4%	70.6%
Students in Math 400 with C or higher from Math 228		18.2%	54.6%	68.2%
Students in Math 400 with B+ or higher from Math 228		40%	50%	70%
Students in Math 400 with C or higher from Math 325		20.5%	65.9%	77.3%
Students in Math 400 with B or higher from Math 325		21.6%	64.9%	75.7%

Conclusion: Math 228 is a weak prerequisite for Math 400. Math 325 is an appropriate prerequisite for Math 400.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 400: course grade C- or below.
The failure rate in Math 400 was 15.3%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [linear equations]	7.39	0-5	1.96
2 [interpolation]	8.11	0-6	1.37
3 [numerical integration]	6.43	0-5	0.46
4 [numerical differentiation]	8.14	0-7	1.44
5 [differential equations]	7.89	0-6	2.81
6 [solving nonlinear equations]	6.59	0-5	1.24
7 [approximation theory]	6.97	0-6	1.96

Conclusion: Invest more effort in MSLOs 5, 1, 7.

It is possible that students who were weak on MSLO 3 spent more time preparing for the rest of the MSLOs than other students, hence their failure rate in Math 400 was actually *lower* than the failure rate among all students in the course.

MATH 441 (Probability and Statistics II)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	C
50th percentile	B
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 441**	**Percentage earning B or higher in Math 441**	**Percentage earning C or higher in Math 441**
All Math 441 students		33.3%	47.6%	64.3%
Students in Math 441 with C or higher from Math 340		13%	34.8%	60.9%
Students in Math 441 with B or higher from Math 340		18.8%	43.8%	68.8%
Students in Math 441 with B+ or higher from Math 340		37.5%	62.5%	100%

Conclusion: Math 340 is a reasonable prerequisite for Math 441.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 441: course grade C- or below.
The failure rate in Math 441 was 23.8%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [mle and mme]	8.27	0-7	2.81
2 [confidence intervals]	8.21	0-7	3.28
3 [properties of estimators]	7.35	0-6	3.70
4 [hypothesis testing]	7.74	0-6	4.20
5 [goodness of fit]	7.68	0-6	4.20
6 [regression-covariance-correlation]	7.50	0-6	4.20

Conclusion: Invest more effort in MSLOs 6, 5, 4, 3, 2, or practically the entire course!

MATH 475 (Capstone Course for Secondary Teachers)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	B-
50th percentile	B
75th percentile	A-

Population and Sub-populations		**Percentage earning A in Math 475**	**Percentage earning B or higher in Math 475**	**Percentage earning C or higher in Math 475**
All Math 475 students		21.2%	65.4%	84.6%
Students in Math 475 with C or higher from Math 335		20%	74.3%	85.7%
Students in Math 475 with B or higher from Math 335		36.4%	72.7%	90.9%
Students in Math 475 with C or higher from Math 370		25.8%	71%	93.6%
Students in Math 475 with B or higher from Math 370		24%	76%	96%

Conclusion: Math 335 and Math 370 are appropriate prerequisites for Math 475.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 475: course grade C- or below.
The failure rate in Math 475 was 9.6%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [find big ideas]	7.53	0-6	3.43
2 [use multiple methods]	7.78	0-6	3.95
3 [develop with rigor]	7.46	0-6	3.12
4 [develop for students]	7.47	0-6	1.87
5 [analyze student thinking]	6.82	0-6	5.20
6 [describe theoretical perspectives]	n/a	n/a	n/a
7 [find rich extensions]	7.78	0-6	1.77

Conclusion: Invest more effort in MSLOs 5, 2, 1, 3. MSLO 6 was not assessed.

MATH 477 (Partial Differential Equations)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	C or higher
25th percentile	B+
50th percentile	A
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 477**	**Percentage earning B or higher in Math 477**	**Percentage earning C or higher in Math 477**
All Math 477 students		50%	80%	83.3%
Students in Math 477 with C or higher from Math 376		40%	73.3%	80%
Students in Math 477 with B or higher from Math 376		41.7%	83.3%	91.7%
Students in Math 477 with A- or higher from Math 376		45.5%	81.8%	90.9%

Conclusion: Math 376 is a reasonable prerequisite for Math 477.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 477: course grade C- or below.
The failure rate in Math 477 was 6.7%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [first order equations]	n/a	n/a	n/a
2 [Fourier series]	9.17	0-8	3.00
3 [boundary value problems]	8.58	0-7	0(!)
4 [heat equation]	9.04	0-8	2.55
5 [wave equation]	9.11	0-8	4.95
6 [Laplace's equation]	8.89	0-7	3.75

Conclusion: Invest more effort in MSLOs 5, 6, 2, 4, practically the entire course!

MSLO 3 was not by itself emphasized on the final exam, even though it is present as an integral facet of MSLOs 4, 5, 6. This is how we can make sense of the fact that its risk index was zero.

MATH 710 (Analysis I)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	B or higher
25th percentile	B+
50th percentile	A-
75th percentile	A

Population and Sub-populations		**Percentage earning A in Math 710**	**Percentage earning B or higher in Math 710**	**Percentage earning C or higher in Math 710**
All Math 710 students		36.7%	82.7%	90.3%
Students in Math 710 with C or higher from Math 470		41.8%	91.1%	94.9%
Students in Math 710 with B or higher from Math 470		43.3%	95.5%	100%

Conclusion: Math 470 or its equivalent is a strong prerequisite for Math 710.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 710: course grade B- or below.
The failure rate in Math 710 was 8.6%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [metric spaces]	7.09	0-6	2.43
2 [Lebesgue measure]	7.39	0-5	2.32
3 [integration and convergence]	7.87	0-4	3.13
4 [differentiation]	8.32	0-6	2.32

Conclusion: Invest more effort in all the MSLOs, because they are all critically important to the future studies of the graduate student.

MATH 850 (Graduate Algebra)

A. Course grade as a crude metric for assessment.

	Course grade
Criterion of success	B or higher
25th percentile	B
50th percentile	B+
75th percentile	A-

Population and Sub-populations		**Percentage earning A in Math 850**	**Percentage earning B or higher in Math 850**	**Percentage earning C or higher in Math 850**
All Math 850 students		33.3%	47.6%	64.3%
Students in Math 850 with C or higher from Math 435		16.3%	83.7%	95.4%
Students in Math 850 with B or higher from Math 435		25%	96.4%	100%
Students in Math 850 with A- or higher from Math 435		33.3%	95.2%	100%

Conclusion: Math 435 or its equivalent is a reasonable prerequisite for Math 850.

B. MSLOs as refined metrics for assessment.

Criterion of failure in Math 850: course grade B- or below.
The failure rate in Math 850 was 13.1%.

The Risk Index for MSLO Z is defined as the failure rate among students who performed weakly on MSLO Z, divided by the failure rate among all students in the course.

MSLO	**Avg. score (0-10)**	**Range for weak scores**	**Risk Index**
1 [describing orbits]	5.42	0-3	1.30
2 [constructing groups]	4.43	0-3	1.45
3 [constructing rings]	5.26	0-4	1.60
4 [decomposing modules]	4.69	0-3	1.14
5 [checking exactness]	7.27	0-6	1.98
6 [finding generators]	4.75	0-3	1.22
7 [characterizing ideals]	4.10	0-3	2.44

Conclusion: Invest more effort in MSLOs 7 and 5.