Academic Program

Plan for Assessment of Student Learning Outcomes

Department of Mathematics and Statistics
College of Arts and Sciences
The University of New Mexico

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Academic Programs of Study[1] covered in this document:

- B.S. Mathematics, Applied Mathematics Concentration
- B.S. Mathematics, Mathematics Education Concentration
- B.S. Mathematics, Mathematics of Computation Concentration
- B.S. Mathematics, Pure Mathematics Concentration
- B.S. Statistics

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[1] Academic Program of Study is defined as an approved course of study leading to a certificate or degree reflected on a UNM transcript. A graduate-level program of study typically includes a capstone experience (e.g. thesis, dissertation, professional paper or project, comprehensive exam, etc.).

Contents

A B.S. Mathematics, Applied Mathematics Concentration **3**
A.1 Broad Program Goals & Measurable Student Learning Outcomes 3
A.2 Assessment of Student Learning Three-Year Plan 4

B B.S. Mathematics, Mathematics Education Concentration **8**
B.1 Broad Program Goals & Measurable Student Learning Outcomes 8
B.2 Assessment of Student Learning Three-Year Plan 9

C B.S. Mathematics, Mathematics of Computation Concentration **13**
C.1 Broad Program Goals & Measurable Student Learning Outcomes 13
C.2 Assessment of Student Learning Three-Year Plan 14

D B.S. Mathematics, Pure Mathematics Concentration **18**
D.1 Broad Program Goals & Measurable Student Learning Outcomes 18
D.2 Assessment of Student Learning Three-Year Plan 19

E B.S. Statistics **22**
E.1 Broad Program Goals & Measurable Student Learning Outcomes 22
E.2 Assessment of Student Learning Three-Year Plan 22

F Exit Survey **26**

A B.S. Mathematics, Applied Mathematics Concentration

A.1 Broad Program Goals & Measurable Student Learning Outcomes

A.1.1 Broad Program Learning Goals for this Degree/Certificate Program

Upon graduation the students of the Applied Mathematics concentration will have the following competencies:

A. Mathematics knowledge

- Demonstrate understanding of the foundations of calculus and linear algebra.
- Demonstrate the ability to think logically and critically. Specifically the student will be able to differentiate assumptions from conclusions, and be able to construct logical arguments.

B. Problem solving skills

- Demonstrate how to formulate, analyze, and solve problems in applied mathematics both through analytical and computational techniques.
- Demonstrate scientific judgment and the ability to apply mathematics to problems in other fields.

C. Employment and technical skills

- Translate the undergraduate degree into a viable career path or graduate degree.
- Demonstrate oral and written communication skills.

A.1.2 List of Student Learning Outcomes (SLOs) for this Degree/Certificate Program

A.1 Effectively perform essential computations in linear algebra, including solving linear systems, computing the eigenvalues of a matrix, and determining linear independence.

A.2 Compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

A.3 Construct rigorous proofs.

B.1 Use techniques from calculus to design analytical and numerical methods to solve applied problems, and understand the accuracy and limitations of the methods.

B.2 Understand simple differential equations models and their applicability.

B.3 Use numerical techniques, and judge their accuracy, for solving mathematical problems.

C.1 Demonstrate sufficient preparation for courses in differential equations, numerical analysis, complex analysis, and real analysis at the graduate level.

C.2 Communicate well, orally and in writing, in an applied mathematics context.

UNM Goals	Knowledge	Skills	Responsibility
A.1	X	X	
A.2	X	X	
A.3	X	X	
B.1	X	X	
B.2	X	X	
B.3	X	X	
C.1	X	X	
C.2	X	X	

A.2 Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes and report annually and to measure all program outcomes at least once over a three-year review cycle.

A.2.1 Timeline for Assessment

In the table below, briefly describe the timeframe over which your unit will conduct the assessment of learning outcomes selected for the three-year plan. List when outcomes will be assessed and which semester/year the results will be discussed and used to improve student learning (e.g., discussed with program faculty, interdepartmental faculty, advisory boards, students, etc.)

Year/Semester	Assessment Activities
Year 1, Fall	Accumulate data in MATH 321 and 401. This assesses SLOs A.1-3.
Year 1, Spring	Accumulate data in MATH 316 and 375. Administer exit surveys to graduating class. This assesses SLOs A.1, B.1-3 and C. 1-2.
Year 2, Fall	Accumulate data in MATH 316 and 321. This assesses SLOs A.1, B.2 and C. 2.
Year 2, Spring	Accumulate data in MATH 375 and 401. Administer exit surveys to graduating class. This assesses SLOs A.1-3, B.1,3 and C. 1.
Year 3, Fall	Accumulate data in MATH 316 and 401. This assesses SLOs A.1-3, B.2.
Year 3, Spring	Accumulate data in MATH 321 and 375. Administer exit surveys to graduating class. This assesses SLOs A.1, B.1,3 and C. 1-2.

A.2.2 How will learning outcomes be assessed?

1. What:

   (a) *For each SLO, briefly describe the means of assessment, i.e., what samples of evidence of learning will be gathered or measures used to assess students' accomplishment of the learning outcomes in the three- year plan?*

   Learning outcomes A.1-3 and B.1-3 will be assessed directly by instructors of critical courses in the major: MATH 316, 321, 375, and 401. These courses give an introduction to several of the foundational areas in modern applied mathematics: linear algebra, calculus, differential equations, and numerical analysis. Instructors will pose questions on exams that target each of the learning outcomes. They will then record the data and prepare a report at the end of the semester to be submitted to the undergraduate committee. The students in these classes come from a spectrum of majors in mathematics, statistics, and the sciences. The reports will assess the performance of the class as a whole and of the students within each major.

   Learning outcomes C.1-2 will be assessed indirectly in Math 375. This course is required of all applied mathematics majors. This course has complex homework / project assignments that will be used to assess outcomes C. 1-2. The instructor prepared reports in MATH 375 will contain an additional component that gives the percentage of students who are prepared for graduate school and can demonstrate effective written communication.

   Learning outcomes A.1-3, B.1-3, and C.1-2 will be assessed indirectly by surveying students at two stages. One will be an exit survey given to the graduating class. The other will be given at the end the semester in MATH 316, 321, 375 or 401, depending on the semester. For each survey, questions will ask students to self assess their achievement in these SLOs. The survey given to the graduating class will additionally target their experience within the program and future plans after graduation. Data will be collected on the future plans of graduates as part of the annual report.

   (b) *Indicate whether each measure is* ***direct*** *or* ***indirect****. If you are unsure, contact* `assessmentas@unm.edu` *for clarification. You should have* ***both direct and indirect measures*** *and at* ***least half of the assessment methods/measures program wide will be direct*** *measures of student learning.*

   The instructor reports are direct measures of assessment, except for the portions of the MATH 375 report focusing on preparedness for graduate school. The exit surveys are indirect.

(c) *Briefly describe the **criteria for success** related to each direct or indirect measures of assessment. What is the program's performance target (e.g., is an acceptable or better performance by 60% of students on a given measure acceptable to the program faculty)? If scoring rubrics are used to define qualitative criteria and measure performance, include them as appendices.*

Instructors will determine the level of success on graded problems by following a rubric. Since grading scales vary amongst instructors, success will not be quantified simply by reporting raw scores.

If less than 60% of the students are performing at a satisfactory level (or better), the undergraduate committee, in consultation with the faculty, will formulate a plan for improving the course curriculum and procedures in a manner to boost student success.

The undergraduate committee will accumulate the data from exit surveys and report on career paths of the graduates. It is expected that students will be able to successfully apply to graduate school or find employment after graduation.

2. Who: *State explicitly whether the program's assessment will include evidence from all students in the program or a sample. Address the validity of any proposed sample of students. Please note that you are recommended to sample all students in your program; however, sampling approx. 20% of the student population is acceptable if the course's total student population (or student enrollment) exceeds 99 in an academic year. A valid explanation should be provided for samples that are less than 20% of the total student population.*

The direct assessment measures will sample the population of applied math majors in any given semester, namely those students in MATH 316, 321, 375, and 401. These courses are required of all applied math majors. Hence the sample in each semester will be representative of the pool of majors in the department. As a byproduct, the performance of other concentrations and majors will also be assessed.

A.2.3 What is the unit's process to analyze/interpret assessment data and use results to improve student learning?

Briefly describe:

1. *who will participate in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations).*
2. *the process for consideration of the implications of assessment for change:*
    a. *to assessment mechanisms themselves,*

b. *to curriculum design,*

c. *to pedagogy*
...in the interest of improving student learning.

3. *How, when, and to whom will recommendations be communicated?*

Each semester, class reports will be prepared by those teaching MATH 316, 321, 375, and 401. Reports will then be sent to the undergraduate committee who prepare a yearly report which analyzes and interprets this data. At the end of each school year, the undergraduate committee will distribute a survey to the graduating seniors, then summarize the results in the report.

Once a yearly report has been completed, copies will be distributed to the faculty as a whole. A portion of a faculty meeting will then be dedicated to discussing the report, giving faculty an opportunity to recommend avenues for improvement in the assessment mechanisms, curriculum design, and pedagogy.

B B.S. Mathematics, Mathematics Education Concentration

B.1 Broad Program Goals & Measurable Student Learning Outcomes

B.1.1 Broad Program Learning Goals for this Degree/Certificate Program

Upon graduation the students of the Mathematics Education concentration will attain:

A. Mathematics knowledge.

- Demonstrate understanding of the foundations of calculus and linear algebra.
- Demonstrate the ability to think logically and critically. Specifically the student will be able to differentiate assumptions from conclusions, and be able to construct logical arguments.

B. An advanced perspective of high school level mathematics.

C. Employment and technical skills.

- Translate the undergraduate degree into a viable career path or graduate degree.
- Demonstrate communication skills (oral and written).

B.1.2 List of Student Learning Outcomes (SLOs) for this Degree/Certificate Program

A.1 Compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

A.2 Understand the role of definitions, axioms, and theorems in mathematical work. Recognize whether or not an argument is a valid proof. Produce viable proofs on your own with an appreciation of careful use of language.

B.1 Demonstrate an understanding of algebraic structures and, in particular, an algebraic viewpoint of the real number system.

B.2 Demonstrate an understanding of different models of geometry, both Euclidean and non-Euclidean. In particular, understand the real numbers and the cartesian plane geometrically.

B.3 Understand and develop an appreciation for how mathematics and statistics can be applied to real-world phenomena. Demonstrate problem solving skills.

B.4 Demonstrate an understanding of the importance that functions play in connecting topics across the high school curriculum.

C.1 Demonstrate sufficient preparation in higher level mathematics to become successful high school math teachers.

C.2 Demonstrate effective written mathematical communication.

UNM Goals	Knowledge	Skills	Responsibility
A.1	X	X	
A.2	X	X	
B.1	X	X	
B.2	X	X	
B.3	X	X	
B.4	X	X	
C.1	X	X	
C.2	X	X	

B.2 Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes and report annually and to measure all program outcomes at least once over a three-year review cycle.

B.2.1 Timeline for Assessment

In the table below, briefly describe the timeframe over which your unit will conduct the assessment of learning outcomes selected for the three-year plan. List when outcomes will be assessed and which semester/year the results will be discussed and used to improve student learning (e.g., discussed with program faculty, interdepartmental faculty, advisory boards, students, etc.)

Year/Semester	Assessment Activities
Year 1, Fall	Accumulate data in MATH 322 and 401 and STAT 345 through reports and exit surveys. This assesses SLOs A.1-2, B.1, B.3-4.
Years 1, Spring	Accumulate data in MATH 306 and 327 and STAT 345 through reports and exit surveys. Administer exit surveys to graduating class. This assesses SLOs A.2, B.2-4, C.1-2.
Year 2, Fall	Accumulate data in MATH 322 and STAT 345 through reports and exit surveys. This assesses SLOs A.2, B.1, B.3-4.
Years 2, Spring	Accumulate data in MATH 306 and 401 and STAT 345 through reports and exit surveys. Administer exit surveys to graduating class. This assesses SLOs A.1-2, B.2-4, C.1-2.
Year 3, Fall	Accumulate data in MATH 327 and 401 and STAT 345 through reports and exit surveys. This assesses SLOs A.1-2, B.3-4.
Years 3, Spring	Accumulate data in MATH 306 and 327 and STAT 345 through reports and exit surveys. Administer exit surveys to graduating class. This assesses SLOs A.2, B.2-4, C.1-2.

B.2.2 How will learning outcomes be assessed?

1. What:

   (a) *For each SLO, briefly describe the means of assessment, i.e., what samples of evidence of learning will be gathered or measures used to assess students' accomplishment of the learning outcomes in the three- year plan?*

   Learning outcomes A.1-2 and B.1-4 will be assessed directly by instructors of critical courses in the major: MATH 306, 322, 327, 401, and STAT 345. The math courses give a rigorous, proof-based introduction to several of the foundational areas in modern mathematics: algebra, calculus, discrete structures and geometry. The statistics course gives an introduction to probability and statistics inference for science and engineering students. Instructors will pose questions on exams that target each of the learning outcomes. They will then record the data and prepare a report at the end of the semester to be submitted to the undergraduate committee. The students in these classes come from a spectrum of majors in mathematics, statistics, and the sciences. The reports will thus discuss the performance of the class as a whole and of the students within each major.

   Learning outcomes C.1-2 will be assessed indirectly in MATH 306. This course is a rigorous course in axiomatic and transformational geometry and is required of all mathematics education majors. The reports in MATH 306 will contain an additional component that gives the percentage of students who are prepared for teaching at the high school level and can demonstrate effective written communication.

   Learning outcomes A.1-2, B.1-4, and C.1-2 will be assessed indirectly by surveying students at two stages. One will be an exit survey given to the graduating class. The other will be given at the end the semester in MATH 306, 322, 327, 401, or STAT 345, depending on the semester. For each survey, questions will ask students to self assess their achievement in these SLOs. The survey given to the graduating class will additionally target their experience within the program and future plans after graduation. Data will be collected on the future plans of graduates as part of the annual report.

   (b) *Indicate whether each measure is* ***direct*** *or* ***indirect****. If you are unsure, contact* `assessmentas@unm.edu` *for clarification. You should have* ***both direct and indirect measures*** *and at* ***least half of the assessment methods/measures program wide will be direct*** *measures of student learning.*

   The instructor reports are direct measures of assessment, except for the portions of the Math 306 report focusing on preparedness for teaching mathematics at

the high school level. The exit surveys are indirect.

(c) *Briefly describe the **criteria for success** related to each direct or indirect measures of assessment. What is the program's performance target (e.g., is an acceptable or better performance by 60% of students on a given measure acceptable to the program faculty)? If scoring rubrics are used to define qualitative criteria and measure performance, include them as appendices.*

Instructors will determine the level of success on graded problems by following a rubric. Since grading scales vary amongst instructors, success will not be quantified simply by reporting raw scores.

If less than 60% of the students are performing at a satisfactory level (or better), the undergraduate committee, in consultation with the faculty, will formulate a plan for improving the course curriculum and procedures in a manner to boost student success.

The undergraduate committee will accumulate the data from exit surveys and report on career paths of the graduates. It is expected that students will be able to successfully apply to graduate school or find employment after graduation.

2. Who: *State explicitly whether the program's assessment will include evidence from all students in the program or a sample. Address the validity of any proposed sample of students. Please note that you are recommended to sample all students in your program; however, sampling approx. 20% of the student population is acceptable if the course's total student population (or student enrollment) exceeds 99 in an academic year. A valid explanation should be provided for samples that are less than 20% of the total student population.*

The direct assessment measures will sample the population of math education majors in any given semester, namely those students in the classes mentioned in each semester of the three year plan. These courses are required of all math education majors. Hence the sample in each semester expects to be representative of the pool of majors in the department. As a byproduct, the performance of other concentrations and majors will also be assessed.

B.2.3 What is the unit's process to analyze/interpret assessment data and use results to improve student learning?

Briefly describe:

1. *who will participate in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations).*

2. *the process for consideration of the implications of assessment for change:*

    a. *to assessment mechanisms themselves,*

    b. *to curriculum design,*

    c. *to pedagogy*
    ...in the interest of improving student learning.

3. *How, when, and to whom will recommendations be communicated?*

Each semester, course reports will be prepared by those teaching MATH 306, 322, 327, or 401 and STAT 345. Course reports will then be sent to the undergraduate committee who prepare a yearly report which analyzes and interprets this data. At the end of each school year, the undergraduate committee will distribute a survey to the graduating seniors, then summarize the results in the report.

Once a yearly report has been completed, copies will be distributed to the faculty as a whole. A portion of a faculty meeting will then be dedicated to discussing the report, giving faculty an opportunity to recommend avenues for improvement in the assessment mechanisms, curriculum design, and pedagogy.

C B.S. Mathematics, Mathematics of Computation Concentration

C.1 Broad Program Goals & Measurable Student Learning Outcomes

C.1.1 Broad Program Learning Goals for this Degree/Certificate Program

Upon graduation the students of the Mathematics of Computation concentration will have the following competencies:

A. Mathematics knowledge

- Demonstrate understanding of the foundations of calculus and linear algebra.
- Demonstrate the ability to think logically and critically. Specifically the student will be able to differentiate assumptions from conclusions, and be able to construct logical arguments.

B. Problem solving skills

- Demonstrate how to formulate, analyze, and solve problems in applied mathematics both through analytical and computational techniques.
- Demonstrate how to efficiently use various computing platforms to implement computational algorithms.
- Demonstrate scientific judgment and the ability to apply mathematics to problems in other fields.

C. Employment and technical skills

- Translate the undergraduate degree into a viable career path or graduate degree.
- Demonstrate oral and written communication skills.

C.1.2 List of Student Learning Outcomes (SLOs) for this Degree/Certificate Program

A.1 Effectively perform essential computations in linear algebra, including solving linear systems, computing the eigenvalues of a matrix, and determining linear independence.

A.2 Compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

B.1 Use techniques from calculus to design analytical and numerical methods to solve applied problems, and understand the accuracy and limitations of the methods.

B.2 Use numerical techniques, and judge their accuracy, for solving mathematical problems.

B.3 Implement computational algorithms on, and be able to use shared and distributed memory parallel computing platforms.

C.1 Demonstrate the proficiency in scientific computing needed for graduate programs and/or careers in science and engineering.

C.2 Communicate well, orally and in writing, in an computational mathematics context.

UNM Goals	Knowledge	Skills	Responsibility
A.1	X	X	
A.2	X	X	
A.3	X	X	
B.1	X	X	
B.2	X	X	
B.3	X	X	
C.1	X	X	
C.2	X	X	

C.2 Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes and report annually and to measure all program outcomes at least once over a three-year review cycle.

C.2.1 Timeline for Assessment

In the table below, briefly describe the timeframe over which your unit will conduct the assessment of learning outcomes selected for the three-year plan. List when outcomes will be assessed and which semester/year the results will be discussed and used to improve student learning (e.g., discussed with program faculty, interdepartmental faculty, advisory boards, students, etc.)

Year/Semester	Assessment Activities
Year 1, Fall	Accumulate data in MATH 321, 464, and 471. This assesses SLOs A.1-2 and B.3.
Year 1, Spring	Accumulate data in MATH 375. Administer exit surveys to graduating class. This assesses SLOs B.1-2 and C.1-2.
Year 2, Fall	Accumulate data in MATH 321, 464, and 471. This assesses SLOs A.1-2 and B.3.
Year 2, Spring	Accumulate data in MATH 375. Administer exit surveys to graduating class. This assesses SLOs B. 1-2 and C.1.
Year 3, Fall	Accumulate data in MATH 464 and 471. This assesses SLOs A.1-2, B.3.
Year 3, Spring	Accumulate data in MATH 321 and 375. Administer exit surveys to graduating class. This assesses SLOs A.1, B.1-2 and C. 1-2.

C.2.2 How will learning outcomes be assessed?

1. What:

   (a) *For each SLO, briefly describe the means of assessment, i.e., what samples of evidence of learning will be gathered or measures used to assess students' accomplishment of the learning outcomes in the three- year plan?*

   Learning outcomes A.1-2 and B.1-3 will be assessed directly by instructors of critical courses in the major: MATH 321, 375, 464 and 471. These courses give an introduction to several of the foundational areas in modern computational mathematics: algebra, calculus, differential equations, numerical analysis and parallel computing. Instructors will pose questions on exams and homework that target each of the learning outcomes. They will then record the data and prepare a report at the end of the semester to be submitted to the undergraduate committee. The students in these classes come from a spectrum of majors in mathematics, statistics, and the sciences. The reports will assess the performance of the class as a whole and of the students within each major.

   Learning outcomes C.1-2 will be assessed indirectly in Math 375. This course is required of all mathematics of computation majors. This course has complex homework / project assignments that will be used to assess outcomes C. 1-2. The instructor prepared reports in MATH 375 will contain an additional component that gives the percentage of students who are prepared for graduate school and can demonstrate effective written communication.

   Learning outcomes A.1-2, B.1-3, and C.1-2 will be assessed indirectly by surveying students at two stages. One will be an exit survey given to the graduating class. The other will be given at the end the semester in MATH 321, 375, 464 or 471, depending on the semester. For each survey, questions will ask students to self assess their achievement in these SLOs. The survey given to the graduating class will additionally target their experience within the program and future plans after graduation. Data will be collected on the future plans of graduates as part of the annual report.

   (b) *Indicate whether each measure is* ***direct*** *or* ***indirect****. If you are unsure, contact* `assessmentas@unm.edu` *for clarification. You should have* ***both direct and indirect measures*** *and at* ***least half of the assessment methods/measures program wide will be direct*** *measures of student learning.*

   The instructor reports are direct measures of assessment, except for the portions of the MATH 375 report focusing on preparedness for graduate school. The exit surveys are indirect.

(c) *Briefly describe the **criteria for success** related to each direct or indirect measures of assessment. What is the program's performance target (e.g., is an acceptable or better performance by 60% of students on a given measure acceptable to the program faculty)? If scoring rubrics are used to define qualitative criteria and measure performance, include them as appendices.*

Instructors will determine the level of success on graded problems by following a rubric. Since grading scales vary amongst instructors, success will not be quantified simply by reporting raw scores.

If less than 60% of the students are performing at a satisfactory level (or better), the undergraduate committee, in consultation with the faculty, will formulate a plan for improving the course curriculum and procedures in a manner to boost student success.

The undergraduate committee will accumulate the data from exit surveys and report on career paths of the graduates. It is expected that students will be able to successfully apply to graduate school or find employment after graduation.

2. Who: *State explicitly whether the program's assessment will include evidence from all students in the program or a sample. Address the validity of any proposed sample of students. Please note that you are recommended to sample all students in your program; however, sampling approx. 20% of the student population is acceptable if the course's total student population (or student enrollment) exceeds 99 in an academic year. A valid explanation should be provided for samples that are less than 20% of the total student population.*

The direct assessment measures will sample the population of mathematics of computation majors in any given semester, namely those students in MATH 321, 375, 464 and 471. These courses are required of all mathematics of computation majors. Hence the sample in each semester will be representative of the pool of majors in the department. As a byproduct, the performance of other concentrations and majors will also be assessed.

C.2.3 What is the unit's process to analyze/interpret assessment data and use results to improve student learning?

Briefly describe:

1. *who will participate in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations).*

2. *the process for consideration of the implications of assessment for change:*

a. *to assessment mechanisms themselves,*

b. *to curriculum design,*

c. *to pedagogy*
...in the interest of improving student learning.

3. *How, when, and to whom will recommendations be communicated?*

Each semester, class reports will be prepared by those teaching MATH 321, 375, 464 and 471. Reports will then be sent to the undergraduate committee who prepare a yearly report which analyzes and interprets this data. At the end of each school year, the undergraduate committee will distribute a survey to the graduating seniors, then summarize the results in the report.

Once a yearly report has been completed, copies will be distributed to the faculty as a whole. A portion of a faculty meeting will then be dedicated to discussing the report, giving faculty an opportunity to recommend avenues for improvement in the assessment mechanisms, curriculum design, and pedagogy.

D B.S. Mathematics, Pure Mathematics Concentration

D.1 Broad Program Goals & Measurable Student Learning Outcomes

D.1.1 Broad Program Learning Goals for this Degree/Certificate Program

Upon graduation the students of the Pure concentration will have the following competencies:

A. Demonstrate proficiency in calculus and linear algebra, as well as areas of modern, proof-based mathematics.

B. Demonstrate the ability to think logically and critically. Specifically, the student will be able to differentiate assumptions from conclusions, and be able to construct logical arguments.

C. Translate the undergraduate degree into a viable career path or graduate school.

D.1.2 List of Student Learning Outcomes (SLOs) for this Degree/Certificate Program

A.1 Perform essential computations in linear algebra, including solving linear systems, computing the eigenvalues of a matrix, and determining linear independence.

A.2 Compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

B.1 Write rigorous and well written proofs which show comprehension of formal mathematical definitions, recognize hypotheses, and form logical conclusions.

B.2 Work with the fundamentals of logic, including mathematical statements and their converses and contrapositives.

B.3 Construct counterexamples to mathematical statements and understand the importance of hypotheses.

C.1 Demonstrate sufficient preparation for courses in real and complex analysis, algebra, topology, and geometry at the graduate level.

C.2 Demonstrate effective written mathematical communication.

UNM Goals	Knowledge	Skills	Responsibility
A.1	X	X	
A.2	X	X	
B.1	X	X	
B.2	X	X	
B.3	X	X	
C.1	X	X	
C.2	X	X	

D.2 Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes and report annually and to measure all program outcomes at least once over a three-year review cycle.

D.2.1 Timeline for Assessment

In the table below, briefly describe the timeframe over which your unit will conduct the assessment of learning outcomes selected for the three-year plan. List when outcomes will be assessed and which semester/year the results will be discussed and used to improve student learning (e.g., discussed with program faculty, interdepartmental faculty, advisory boards, students, etc.)

Year/Semester	Assessment Activities
Year 1, Fall	Accumulate data in MATH 321, 322, and 401 through reports and exit surveys. This assesses SLOs A.2, B.1-3.
Year 1, Spring	Accumulate data in MATH 327 and 402 through reports and exit surveys. Administer exit surveys to graduating class. This assesses SLOs A.2, B.1-3 and C. 1-2.
Year 2, Fall	Accumulate data in MATH 321 and 322 through reports and exit surveys. This assesses SLOs A.1, B.1-3.
Year 2, Spring	Accumulate data in MATH 401 and 402 through reports and exit surveys. Administer exit surveys to graduating class. This assesses SLOs A.2, B.1-3 and C. 1-2.
Year 3, Fall	Accumulate data in MATH 327 and 401 through reports and exit surveys. This assesses SLOs A.2, B.1-3.
Year 3, Spring	Accumulate data in MATH 321, 327 and 402 through reports and exit surveys. Administer exit surveys to graduating class. This assesses SLOs A.1-2, B.1-3 and C. 1-2.

D.2.2 How will learning outcomes be assessed?

1. <u>What:</u>

   (a) *For each SLO, briefly describe the means of assessment, i.e., what samples of evidence of learning will be gathered or measures used to assess students' accomplishment of the learning outcomes in the three- year plan?*

   Learning outcomes A.1-2 and B.1-3 will be assessed directly by instructors of critical courses in the major: MATH 321, 322, 327, 401, and 402. These courses give a rigorous, proof-based introduction to several of the foundational areas in modern mathematics: algebra, calculus, and discrete structures. Instructors will pose questions on exams that target each of the learning outcomes. They will then record the data and prepare a report at the end of the semester to be submitted to the undergraduate committee. The students in these classes come from

a spectrum of majors in mathematics, statistics, and the sciences. The reports will thus discuss the performance of the class as a whole and of the students within each major.

Learning outcomes C.1-2 will be assessed indirectly in Math 402. This course is the second semester of the advanced calculus sequence and required of all pure math majors. The reports in Math 402 will contain an additional component that gives the percentage of students who are prepared for graduate school and can demonstrate effective written communication.

Learning outcomes A.1-2, B.1-3, and C.1-2 will be assessed indirectly by surveying students at two stages. One will be an exit survey given to the graduating class. The other will be given at the end the semester in Math 321, 322, 327, 401, or 402, depending on the semester. For each survey, questions will ask students to self assess their achievement in these SLOs. The survey given to the graduating class will additionally target their experience within the program and future plans after graduation. Data will be collected on the future plans of graduates as part of the annual report.

(b) *Indicate whether each measure is* ***direct*** *or* ***indirect****. If you are unsure, contact* `assessmentas@unm.edu` *for clarification. You should have* ***both direct and indirect measures*** *and at* ***least half of the assessment methods/measures program wide will be direct*** *measures of student learning.*

The instructor reports are direct measures of assessment, except for the portions of the Math 402 report focusing on preparedness for graduate school. The exit surveys are indirect.

(c) *Briefly describe the* ***criteria for success*** *related to each direct or indirect measures of assessment. What is the program's performance target (e.g., is an acceptable or better performance by 60% of students on a given measure acceptable to the program faculty)? If scoring rubrics are used to define qualitative criteria and measure performance, include them as appendices.*

Instructors will determine the level of success on graded problems by following a rubric. Since grading scales vary amongst instructors, success will not be quantified simply by reporting raw scores.

If less than 60% of the students are performing at a satisfactory level (or better), the undergraduate committee, in consultation with the faculty, will formulate a plan for improving the course curriculum and procedures in a manner to boost student success.

The undergraduate committee will accumulate the data from exit surveys and report on career paths of the graduates. It is expected that students will be able to successfully apply to graduate school or find employment after graduation.

2. Who: *State explicitly whether the program's assessment will include evidence from all students in the program or a sample. Address the validity of any proposed sample of students. Please note that you are recommended to sample all students in your program; however, sampling approx. 20% of the student population is acceptable if the course's total student population (or student enrollment) exceeds 99 in an academic year. A valid explanation should be provided for samples that are less than 20% of the total student population.*

   The direct assessment measures will sample the population of pure majors in any given semester, namely those students in MATH 321, 322, 327, 401, and 402. These courses are required of all pure math majors. Hence the sample in each semester will be representative of the pool of majors in the department. As a byproduct, the performance of other concentrations and majors will also be assessed.

D.2.3 What is the unit's process to analyze/interpret assessment data and use results to improve student learning?

Briefly describe:

1. *who will participate in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations).*
2. *the process for consideration of the implications of assessment for change:*
   a. *to assessment mechanisms themselves,*
   b. *to curriculum design,*
   c. *to pedagogy*
   ...in the interest of improving student learning.
3. *How, when, and to whom will recommendations be communicated?*

Each semester, class reports will be prepared by those teaching MATH 321, 322, 327, 401, and 402. Reports will then be sent to the undergraduate committee who prepare a yearly report which analyzes and interprets this data. At the end of each school year, the undergraduate committee will distribute a survey to the graduating seniors, then summarize the results in the report.

Once a yearly report has been completed, copies will be distributed to the faculty as a whole. A portion of a faculty meeting will then be dedicated to discussing the report, giving faculty an opportunity to recommend avenues for improvement in the assessment mechanisms, curriculum design, and pedagogy.

E B.S. Statistics

E.1 Broad Program Goals & Measurable Student Learning Outcomes

E.1.1 Broad Program Learning Goals for this Degree/Certificate Program

Upon graduation the students of the Statistics concentration will have the following competencies:

A. Proficiency in probability and statistical theory and methods.

B. Ability to manipulate and visualize data and to compute standard statistical summaries.

C. Skill in applying fundamental mathematical techniques.

E.1.2 List of Student Learning Outcomes (SLOs) for this Degree/Certificate Program

A.1 Correctly analyze and interpret the results from standard designed experiments, sample surveys, and observational studies, understand the limitations of the procedures and the appropriate scope of conclusions.

B.1 Implement basic computer science skills needed for statistics, including a) data management tools, and b) use of a statistical software package for standard analyses.

B.2 Demonstrate competence in data management, summarizing, and plotting using a high-level statistical programming language (such as R, SAS, or Stata).

C.1 Demonstrate knowledge of basic mathematical skills needed for statistics, including a) probability and statistical theory, b) calculus foundations, c) symbolic and abstract thinking, and d) linear algebra.

C.2 Solve probability problems, with discrete and continuous univariate random variables, and apply the Central Limit Theorem.

UNM Goals	Knowledge	Skills	Responsibility
A.1	X	X	
B.1	X	X	
B.2	X	X	
C.1	X	X	
C.2	X	X	

E.2 Assessment of Student Learning Three-Year Plan

All programs are expected to measure some outcomes and report annually and to measure all program outcomes at least once over a three-year review cycle.

E.2.1 Timeline for Assessment

In the table below, briefly describe the timeframe over which your unit will conduct the assessment of learning outcomes selected for the three-year plan. List when outcomes will be assessed and which semester/year the results will be discussed and used to improve student learning (e.g., discussed with program faculty, interdepartmental faculty, advisory boards, students, etc.)

Year/Semester	Assessment Activities	SLOs
Year 1, Fall	Accumulate data in STAT 345 and STAT 427 through reports and exit surveys.	B.1-2, C.1-2
Year 1, Spring	Accumulate data in STAT 345 and STAT 428 through reports and exit surveys. Administer exit surveys to graduating class.	A.1, B.1-2, C.1-2
Year 2, Fall	Accumulate data in STAT 345 and STAT 440 through reports and exit surveys.	B.1-2, C.1-2
Year 2, Spring	Accumulate data in STAT 345 and STAT 445 through reports and exit surveys. Administer exit surveys to graduating class.	A.1, B.1-2, C.1-2
Year 3, Fall	Accumulate data in STAT 345, STAT 427, and STAT 440 through reports and exit surveys.	B.1-2, C.1-2
Year 3, Spring	Accumulate data in STAT 345, STAT 428, and STAT 445 through reports and exit surveys. Administer exit surveys to graduating class.	A.1, B.1-2, C.1-2

E.2.2 How will learning outcomes be assessed?

1. <u>What:</u>

   (a) *For each SLO, briefly describe the means of assessment, i.e., what samples of evidence of learning will be gathered or measures used to assess students' accomplishment of the learning outcomes in the three- year plan?*

   Learning outcomes A.1 and B.1-2 will be assessed directly by instructors of critical courses in the major: STAT 427, 428, 440, and 445. These courses give both theoretical and applied treatments of ANOVA and Regression. Instructors will pose questions on assignments (in-class, homework, or exams) that target each of the learning outcomes. They will then record the data and prepare a report at the end of the semester to be submitted to the undergraduate committee. The students in these classes come from a spectrum of majors in statistics, the sciences, public policy, and social sciences. The reports will thus discuss the performance of the class as a whole and of the students within each major.

Learning outcomes C.1-2 will be assessed directly in STAT 345. This probability course is required of stat majors, but many students from engineering also take it.

All learning outcomes will be assessed indirectly by surveying students at two stages. One will be an exit survey given to the graduating class. The other will be given at the end the semester in the classes being evaluated, depending on the semester. For each survey, questions will ask students to self assess their achievement in these SLOs. The survey given to the graduating class will additionally target their experience within the program and future plans after graduation. Data will be collected on the future plans of graduates as part of the annual report.

(b) *Indicate whether each measure is* ***direct*** *or* ***indirect****. If you are unsure, contact* `assessmentas@unm.edu` *for clarification. You should have* ***both direct and indirect measures*** *and at* ***least half of the assessment methods/measures program wide will be direct*** *measures of student learning.*

The instructor reports are direct measures of assessment. The exit surveys are indirect.

(c) *Briefly describe the* ***criteria for success*** *related to each direct or indirect measures of assessment. What is the program's performance target (e.g., is an acceptable or better performance by 60% of students on a given measure acceptable to the program faculty)? If scoring rubrics are used to define qualitative criteria and measure performance, include them as appendices.*

Instructors will determine the level of success on graded problems by following a rubric. Since grading scales vary amongst instructors, when there are multiple graders success will not be quantified simply by reporting raw scores.

If less than 60% of the students are performing at a satisfactory level (or better), the undergraduate committee, in consultation with the faculty, will formulate a plan for improving the course curriculum and procedures in a manner to boost student success.

The undergraduate committee will accumulate the data from exit surveys and report on career paths of the graduates. It is expected that students will be able to successfully apply to graduate school or find employment after graduation.

2. Who: *State explicitly whether the program's assessment will include evidence from all students in the program or a sample. Address the validity of any proposed sample of students. Please note that you are recommended to sample all students in your program; however, sampling approx. 20% of the student population is acceptable if the*

course's total student population (or student enrollment) exceeds 99 in an academic year. A valid explanation should be provided for samples that are less than 20% of the total student population.

The direct assessment measures will sample the population of statistics majors in any given semester, namely those students in the courses being assessed in Section E.2.1. These courses are required of all statistics majors. Hence, over time, we expect each student will be evaluated at multiple points in their program.

E.2.3 What is the unit's process to analyze/interpret assessment data and use results to improve student learning?

Briefly describe:

1. *who will participate in the assessment process (the gathering of evidence, the analysis/interpretation, recommendations).*
2. *the process for consideration of the implications of assessment for change:*
   a. *to assessment mechanisms themselves,*
   b. *to curriculum design,*
   c. *to pedagogy*
   ...in the interest of improving student learning.
3. *How, when, and to whom will recommendations be communicated?*

Each semester, class reports will be prepared by those teaching the courses being assessed in Section E.2.1. Reports will then be sent to the undergraduate committee who prepare a yearly report which analyzes and interprets this data. At the end of each school year, the undergraduate committee will distribute a survey to the graduating seniors, then summarize the results in the report.

Once a yearly report has been completed, copies will be distributed to the faculty as a whole. A portion of a faculty meeting will then be dedicated to discussing the report, giving faculty an opportunity to recommend avenues for improvement in the assessment mechanisms, curriculum design, and pedagogy.

F Exit Survey

This is a draft example of an exit survey consisting of three primary questions.
0. Circle your program

- Applied Mathematics
- Computational Mathematics
- Mathematical Education
- Pure Mathematics
- Statistics

1. How well did you achieve each of the following departmental student learning outcomes for your program?

For your program only, evaluate each learning outcome using this rating scale:
5 = extremely well, 4 = very well, 3 = adequately well, 2 = not very well, 1 = not at all

Applied Mathematics

_____ A.1 Be able to effectively perform essential computations in linear algebra, including solving linear systems and computing the eigenvalues of a matrix.

_____ A.2 Be able to compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

_____ A.3 Be able to construct rigorous proofs.

_____ B.1 Be able to use techniques from calculus, such as Taylor's approximation, to approximate derivatives, integrals and to solve scalar equations.

_____ B.2 Be able to understand simple differential equations models and their applicability.

_____ B.3 Be able to use numerical techniques, and judge their accuracy, for solving mathematical problems.

_____ C.1 Demonstrate sufficient preparation for courses in differential equations, numerical analysis, complex analysis, and real analysis at the graduate level.

_____ C.2 Communicate well, orally and in writing, in an applied mathematics context.

Mathematics Education

_____ A.1 Students will be able to compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

_____ A.2 Understand the role of definitions and proofs in mathematical work; be able to produce viable proofs on your own with an appreciation of careful use of language; and recognize whether a proof is valid or not.

_____ B.1 Demonstrate an understanding of algebraic structures and, in particular, an algebraic viewpoint of the real number system.

_____ B.2 Demonstrate an understanding of different models of geometry, both Euclidean and non-Euclidean. In particular, understand the real numbers and the Cartesian plane geometrically.

_____ B.3 Understand and develop an appreciation for how mathematics and statistics can be applied to real-world phenomena. Demonstrate problem solving skills.

_____ B.4 Demonstrate an understanding of the importance that functions play in connecting topics across the high school curriculum.

_____ C.1 Students will have sufficient preparation in higher level mathematics to become successful high school math teachers.

_____ C.2 Students will demonstrate effective written mathematical communication

Mathematics of Computation

_____ A.1 Be able to effectively perform essential computations in linear algebra, including solving linear systems, computing the eigenvalues of a matrix, and determining linear independence.

_____ A.2 Be able to compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

_____ B.1 Be able to use techniques from calculus, such as Taylor's approximation, to approximate derivatives, integrals and to solve scalar equations.

_____ B.2 Be able to use numerical techniques, and judge their accuracy, for solving mathematical problems.

_____ B.3 Be able to implement computational algorithms on, and be able to use shared and distributed memory parallel computational platforms.

_____ C.1 Demonstrate the proficiency in scientific computing needed for graduate programs and/or careers in science and engineering.

_____ C.2 Communicate well, orally and in writing, in an applied mathematics context.

Pure Mathematics

_____ A.1 Students will be able to effectively perform essential computations in linear algebra, including solving linear systems, computing the eigenvalues of a matrix, and determining linear independence.

_____ A.2 Students will be able to compute limits and derivatives using their definitions, and use the fundamental theorem of calculus to compute definite and indefinite integrals.

_____ B.1 Students will be able to write rigorous and well written proofs which show comprehension of formal mathematical definitions, recognize hypotheses, and form logical conclusions.

_____ B.2 Students will be able to work with the fundamentals of logic, including mathematical statements and their converses and contrapositives.

_____ B.3 Students will be able to construct counterexamples to mathematical statements and understand the importance of hypotheses.

_____ C.1 Students will have sufficient preparation for courses in real and complex analysis, algebra, topology, and geometry at the graduate level.

_____ C.2 Students will demonstrate effective written mathematical communication.

Statistics

_____ A.1 Be able to correctly apply, analyze, and interpret the results from standard designed experiments, sample surveys, and observational studies, understanding the limitations of the procedures and the appropriate scope of conclusions.

_____ B.1 Implement basic computer science skills needed for statistics, including a) data management tools, b) basic programming algorithms and logic, c) use of a statistical software package for standard analyses.

_____ B.2 Demonstrate competence in data management, summarizing, and plotting using a high-level statistical programming language (such as R, SAS, or Stata) and reproducible research tools (such as knitr).

_____ C.1 Demonstrate their knowledge of basic mathematical skills needed for statistics, including a) probability and statistical theory, b) calculus foundations, c) symbolic and abstract thinking, and d) linear algebra.

_____ C.2 Solve probability problems in finite sample spaces, with discrete and continuous univariate random variables, and apply the Central Limit Theorem.

2. What aspects of your education in this program helped you with your learning, and why were they helpful? For example, use of technology, instructor feedback, group work, opportunity to present work in front of others, course sequence, etc.

3. What might the department do differently that would help you learn more effectively, and why would these actions help? Please be as specific as possible; this is your opportunity to improve the program.

4. In hindsight, would you change anything about the order in which you took certain courses? If so, why?

Thank you for your valuable feedback.