Bachelor's Degree in Mathematics
Assessment of Student Learning Program
Kansas State University

A. College, Department, and Date of This Submission

College: Arts and Sciences
Department: Mathematics
Date of Submission: Nov. 1, 2004

B. Contact Person(s) for the Assessment Plans

Louis Pigno, Department Head
Thomas Muenzenberger, Director of Undergraduate Instruction

C. Program – degree, minor, or certification

B.S./B.A. in Mathematics

D. Assessment of Student Learning Three-Year Plan

1. **Student Learning Outcome(s)**
   In the next three years we will focus our assessments on the following student learning outcomes:

   R-2: Students will be able to compose and explain mathematical proofs and counterexamples; make logical inferences.

   K-1: Students will know the standard facts and algorithms of calculus and differential equations.

   K-4 Students will know the standard facts and algorithms of a specialized area of mathematics at a basic level (as defined by the student and the student's advisor).

   Special rationale for selecting these learning outcomes
   We divided our SLOs into "Knowledge" outcomes K-1 through K-4 and "Reasoning" outcomes R-1 through R-4, and wanted to focus initially on at least one of each type of outcome. We feel R-2 goes to the heart of mathematics and should be the first priority in assessment. Having chosen one "reasoning" outcome, we choose two different "knowledge" outcomes to provide a broad base of experience for developing future assessments of our other outcomes.

   Relationship to K-State SLO

Program SLOs	Knowledge	Critical Thinking	Comm.	Diversity	Integrity	Program SLO is conceptually different from K-State SLOs
R-2	X	X	X			
K-1	X					
K-4	X	X	X			

2. **How will the learning outcomes be assessed? What groups will be included in the assessment?**

R-2

- This learning outcome will be assessed in upper division mathematics courses. Majors take a minimum of six such classes. All students enrolled in these courses will be assessed. Instructors in these courses will designate two proof problems on assignments/exams to evaluate for program assessment. In order to provide consistent scoring, the curriculum committee has developed a rubric for grading proofs (attached). This rubric is being tested and validated in Math 506, Math 560, and Math 572 this year, and will be extended to other upper division courses once validation is complete (hopefully next year). Instructors will mark problems according to the rubric for program assessment, though they are not required to use the rubric for grading in their courses. [Multiple direct measures]
- Several of the performance measures used for K-4 will also reflect the ability to write proofs. We do not yet know what percentage of students will complete each individual performance, so we cannot at this time determine what percentage of students will be surveyed in this fashion. [Multiple direct measures]
- Majors will be asked during their exit interviews whether they believe they understand how to compose and explain proofs and what examples or reasons they have to support their belief. All graduating seniors are invited for such interviews and over 90% participate. [Indirect measure]

K-1

- Math 240, Elementary Differential Equations, serves as the capstone course for the calculus sequence. Students taking this course are assigned to complete 19-20 computerized assignments demonstrating their skill in calculus and differential equations (most differential equations are solved by reducing them to calculus problems) during the semester. Success of math majors on these problems will be recorded. The department currently has a federally-funded project to validate this instrument with respect to success in later courses and to develop appropriate statistics for reporting success. A similar system is being developed for other calculus courses that will enable us to track growth in knowledge over time in the program. Math 240 is a required course and over 90% of majors take the course

on campus and so will complete the computerized assessments. [Multiple direct measures]

- Several of the performance measures used for K-4 will also reflect the ability to write proofs. We do not yet know what percentage of students will complete each individual performance, so we cannot at this time determine what percentage of students will be surveyed in this fashion. [Multiple direct measures]
- Majors will be asked during exit interviews whether they believe they have a knowledge of basic calculus and differential equations and what examples or reasons they have to support their belief. All graduating seniors are invited for such interviews and over 90% participate. [Indirect measure]

K-4

- Advisors will be responsible for selecting a performance assessment (if available) for whether students have met this student learning outcome. Because students take a mathematics degree as preparation for a wide range of careers, many different measures will be appropriate in different circumstances. A list of nine different possible assessments that have been used in the past is attached, but other measures may be suitable in the future. Based on student files from the past several years, it appears over 50% of our students complete such a direct assessment. [Multiple direct measures]
- Majors will be asked during exit interviews whether they believe know the standard facts and algorithms of a specialized area of mathematics at a basic level and what examples or reasons they have to support their belief. All graduating seniors are invited for such interviews and over 90% participate. [Indirect measure]
- Placement data and alumni surveys will follow up on performance in selected area after graduation. [This will involve both direct and indirect measures for different students]

3. When will these outcomes be assessed? When and in what format will the result of the assessment be discussed?

The department curriculum committee will have primary responsibility for managing the assessment program.

- The undergraduate secretary will collect rubrics for assessing R-2 from upper division math instructors at the end of each semester.
- The online homework coordinator will provide data from computerized assignments in Math 240 each April.
- Advisors will work with advisees to select performance assessments and advisors will report performance assessment results for advisees each April.
- The undergraduate secretary will arrange exit interviews and collect placement data and alumni surveys each year.

Timeline for three-year plan

December 2004:	Collect rubric data from Math 572
Spring 2005:	Exit interviews Collect placement data Online homework coordinator and his research team complete validation of online assessments.
April 2005:	Collect online homework data from Math 240 Collect performance assessments from advisors Director of Undergraduate Instruction reviews exit interview and survey data.
May 2005:	Collect rubric data from Math 506, 560.
May 2005:	Curriculum committee reviews baseline data • Approves or revises rubric for proofs • Approve or revise targets for online assessments. • Select appropriate target scores for performance assessments as needed.
August 2005:	Rubric shared with upper division instructors
Fall 2005:	Exit interviews.
December 2005:	Collect rubric data from upper division math courses
Spring 2006:	Exit interviews Collect placement data
April 2006:	Collect online homework data from Math 240 Collect performance assessments from advisors Director of Undergraduate Instruction reviews exit interview and survey data.
May 2006:	Collect rubric data from upper division math courses
May 2006:	Curriculum committee reviews data • Identifies where assessment techniques are working well and poorly and revises techniques as needed (e.g. check inter-rater reliability of rubric data). • Identifies areas of concern regarding student learning.

Fall 2006:	Exit interviews. Curriculum committee discusses approaches for handling any areas of concern.
December 2006:	Collect rubric data from upper division math courses
Spring 2007:	Exit interviews Collect placement data
April 2007:	Collect online homework data from Math 240 Collect performance assessments from advisors Director of Undergraduate Instruction reviews exit interview and survey data.
May 2007:	Collect rubric data from upper division math courses
May 2007:	Curriculum committee reviews data • Identifies where assessment techniques are working well and poorly and revises techniques as needed. • Check areas of concern. Prepare plan to address any concerns that are consistent for two years of data.
Fall 2007:	Curriculum committee shares plans to address areas of concern with faculty. Proposals discussed, modified, and (perhaps) approved.

4. Historically, the director of undergraduate instruction has reviewed all assessment data, including student comments expressed in exit interview, and has brought any areas of concern to the curriculum committee. In addition, any faculty member in the department may suggest ideas or concerns for the curriculum committee to consider. The committee then provides recommendations to the faculty that are accepted (or not) at scheduled faculty meetings. Several changes aimed at improving student learning (e.g. an expanded actuarial program, advanced help sessions) have been implemented in the past decade from this model. With the new assessment plan we will have a more rigorous and formalized method of collecting and analyzing data, but will keep the same process for improvement as it seems to be working well.

Rubric For Grading Proofs

Interpretation of Problem

0 – Unacceptable	1 – Basic	2 – Acceptable
Incorrect interpretation of problem. A major misinterpretation of what is given or what is to be shown.	Correct but incomplete interpretation of the problem. May overlook significant details in the statement of the problem. Might be stated for indirect proof but a direct proof is given or vice-versa.	Correct statement with the hypothesis (given) and conclusion (to show) clearly stated.

Correctness of Proof (4 points)

0 –Unacceptable	1 – Poor	2 – Basic	3 – Acceptable	4 – Exemplary
Mainly incorrect consequences improperly deduced from the given. Little or no sense of how to prove the result.	Unconnected, mostly true statements properly deduced from the given. Listing facts without a sense of how to link them to get a correct proof. May just jump to the conclusion without justification.	Statements linked into a reasonable (though perhaps misguided) attempt to prove the theorem. The proof may be left incomplete or may depend upon a major unjustified leap.	A correct approach to proving the theorem is attempted. Some statements may be unjustified or improperly justified, but errors are minor and could be fixed without substantially changing the proof.	A correct and complete proof is given. Some irrelevant information may be included, particularly on timed work where the student is unable to polish up the presentation.

If a proof should have two parts, each part is graded separately. If the problem is misstated in a way to significantly change the proof, then the correctness score may also be reduced (since what is written is not a correct proof of what is supposed to be shown).

Title of Academic Program: Mathematics
Department/Unit: Department of Mathematics
Type of Degree: Bachelor's in Mathematics
Student Learning Outcome: Mathematical Knowledge and Mathematical Reasoning

Learning outcome K-4 will be assessed by asking that each of our majors achieve one of the following direct measures of student learning:

"How" will these learning outcomes be assessed?	Direct measure of student learning
Participate in an internship or research experience.	capstone experience or course
Rank sufficiently high* in a Putnam Mathematical Competition.	juried review of project
Rank sufficiently high* in a Mathematical Contest in Modeling (MCM).	juried review of project
Pass a CAS/SOA actuarial exam.	professional exam
Pass EDSEC 586 Teaching Participation in the Secondary School and Professional Development Seminar (12 hour KSU course).	capstone experience or course
Rank sufficiently high* on the Graduate Record Exam (GRE) Mathematics Test.	standardized test
Rank sufficiently high* on the Mathematics II Major Field Achievement Test (MFAT) over calculus, algebra, and additional topics.	standardized test
Present or publish a paper.	capstone experience or course
Receive a national award such as a Goldwater Scholarship	juried review of project

* The required rank will be decided by the Department of Mathematics Curriculum Committee.

These learning outcomes will also be assessed by the following indirect measures of student learning: exit interviews, student surveys, alumni surveys, job placement data, and graduate school admission data.

Master Degree in Mathematics
Assessment of Student Learning Plan
Kansas State University

A. College, Department, and Date

College: Arts and Sciences
Department: Mathematics
Date: Nov. 1, 2004

B. Contact Person(s) for the Assessment Plans

Louis Pigno, Department Head
Pietro Poggi-Corradini, Director of Graduate Studies

C. Degree Program

Master of Science in Mathematics

D. Assessment of Student Learning Three-Year Plan

1. **Student Learning Outcome(s)**

In the next three years we will focus our assessments on the following student learning outcomes:

K-1: Students will know the standard theorems and techniques of undergraduate mathematics.
K-4: Students will know the standard theorems and techniques of a specialized area of mathematics at an advanced level (as defined by the student and the student's committee).

Special rationale for selecting these learning outcomes

Our Masters Program SLOs are divided into two categories: "Knowledge" (K-1 through K-4) and "Reasoning" (R-1 through R-5). Among the knowledge SLOs K-1 is the most important one, because all others depend on it. The choice of K-4 is motivated, on the one hand, by it's rich relationship with all university-wide SLOs, and on the other hand by it's intrinsic importance for identifying prospective Ph.D. students.

Relationship to K-State Student Learning Outcomes

	University-wide SLOs (Graduate Programs)			Program SLO is conceptually different from university SLOs
Program SLOs	Knowledge	Skills	Attitudes and Professional Conduct	
K-1	X			
K-4	X	X	X	

Three-year timeline

Fall 2004	Collect data from Master's defenses.
January 2005	Collect data from Counseling Exams; Collect data from Qualifying Exams.
February 2005	GPAC discusses academic progress and makes recommendations to graduate students and their academic advisors.
March 2005	Faculty Meeting to discuss students with poor academic performance.
May 2005	Collect data from Master's defenses.; GPAC evaluates the assessment process, and necessary revisions, including rubric/curriculum changes. Baseline data (K-1) is analyzed.
August 2005	Collect data from Counseling Exams; Collect data from Qualifying Exams.
December 2005	Collect data from Master's defenses.
January 2006	Collect data from Counseling Exams; Collect data from Qualifying Exams.
February 2006	GPAC discusses academic progress and makes recommendations to graduate students and their academic advisors.
March 2006	Faculty Meeting to discuss students with poor academic performance;
May 2006	Collect data from Master's defenses; GPAC evaluates the K-1 assessment results for 1st year graduate students, and identifies areas of concern regarding student learning.
August 2006	Collect data from Counseling Exams; Collect data from Qualifying Exams.
December 2006	Collect data from Master's defenses.
January 2007	Collect data from Counseling Exams; Collect data from Qualifying Exams.
February 2007	GPAC discusses academic progress and makes recommendations to graduate students and their academic advisors.
March 2007	Faculty Meeting to discuss students with poor academic performance.
May 2007	Collect data from Master's defenses; GPAC evaluates the K-1 assessment results for 2nd year graduate students, and identifies areas of concern regarding student learning.
August 2007	Collect data from Counseling Exams. Collect data from Qualifying Exams.
Fall 2007	Collect data from Master's defenses; GPAC evaluates the K-1 assessment results for 3rd year graduate students; GPAC and the Department Head analyze the assessment process, and prepare a new assessment plan.

K-State Undergraduate Mathematics Program
Student Learning Outcomes by Major Courses

Courses / Outcomes	K-1	K-2	K-3	K-4	R-1	R-2	R-3	R-4	R-5
MATH 220	X				X				X
MATH 221	X				X				X
MATH 222	X				X				X
MATH 240	X				X			X	X
MATH 499 B	X	X	X	X	X	X	X	X	X
MATH 500		X		X	X			X	
MATH 501		X		X	X			X	
MATH 506				X	X	X	X	X	X
MATH 510				X	X	X	X	X	X
MATH 511			X	X	X	X	X	X	X
MATH 512			X	X	X	X	X	X	X
MATH 515			X	X	X	X	X	X	X
MATH 520		X		X	X	X	X	X	X
MATH 521		X		X	X	X	X	X	X
MATH 540	X	X		X	X	X		X	X
MATH 551			X	X	X	X		X	X
MATH 560				X	X	X	X	X	X
MATH 570				X	X	X	X	X	X
MATH 572				X	X	X	X	X	X
MATH 591				X	X	X	X	X	X
MATH 630		X		X	X	X	X	X	X
MATH 632	X	X		X	X	X	X	X	X
MATH 633	X	X		X	X	X	X	X	X
MATH 634	X	X		X	X	X	X	X	X
MATH 655		X		X	X	X	X	X	X
MATH 670				X	X	X	X	X	X

K-1	calculus and differential equations;
K-2	advanced analysis, including the theoretical justification of the basic rules of calculus;
K-3	abstract algebra, including the basic properties of groups, rings, and fields;
K-4	a specialized area of mathematics at a basic level (as defined by the student's advisor);
R-1	define and explain mathematical concepts;
R-2	compose and explain mathematical proofs and counterexamples; make logical inferences;
R-3	propose conjectures, generalizations, and mathematical questions;
R-4	solve non-routine mathematical problems;
R-5	read, discuss, and write mathematics.

Student Learning Outcomes

The Bachelor's degree in Mathematics

Mathematical Knowledge

Students will know the standard facts and algorithms of

- K - 1. calculus and differential equations
- K - 2. advanced analysis, including the theoretical justification of the basic rules of calculus
- K - 3. abstract algebra, including the basic properties of groups, rings, and fields
- K - 4. a specialized area of mathematics at a basic level (as defined by the student and the student's advisor)

Mathematical Reasoning

Students will be able to

- R - 1. define and explain mathematical concepts.
- R - 2. compose and explain mathematical proofs and counter examples; make logical inferences
- R - 3. propose conjectures, generalizations, and mathematical questions
- R - 4. solve non-routine mathematical problems
- R - 5. read, discuss, and write mathematics

For this degree, outcomes will be assessed at the **basic** level, characterized by an ability to explain and reproduce concepts and mathematical arguments developed in classes and readings and the ability to apply these ideas to new situations that are similar in broad outlines to previously encountered situations.

The Master's degree in Mathematics

Mathematical Knowledge

Students will know the standard theorems and techniques of

- K - 1. undergraduate mathematics,
- K - 2. advanced analysis, including properties of metric spaces, Riemann integration and functions of several variables,
- K - 3. abstract algebra, including homomorphism theorems, Galois theory, and vector spaces, and
- K - 4. a specialized area of mathematics at an advanced level (as defined by the student and the student's committee).

Mathematical Reasoning

Students will be able to

- R - 1. define and explain mathematical concepts
- R - 2. compose and explain mathematical proofs and counterexamples; make logical inferences
- R - 3. propose conjectures, generalizations, and mathematical questions
- R - 4. solve non-routine mathematical problems
- R - 5. read, discuss, and write mathematics

For this degree, outcomes will be assessed at the **advanced** level, characterized by an ability to explain and reproduce mathematical concepts and arguments introduced in classes and readings, but with a possible expectation of further development by the student, and the ability to apply these ideas to new situations that may be dissimilar to previously encountered applications.

The Ph.D. degree in Mathematics

Mathematical Knowledge

Students will know the standard theorems and techniques of

K - 1. masters level mathematics,
K - 2. real and complex analysis, including Lebesgue theory and analytic function theory,
K - 3. higher algebra, including structure theorems,
K - 4. geometry/topology, including point-set topology, homotopy and homology theory, and differentiable manifolds, and
K - 5. a specialized area of mathematics at an expert level (as defined by the student and the student's committee).

The areas of differential equations or applied mathematics may be substituted for one of K-2, K-3, or K-4. For more details on the specific topics of mathematical knowledge required for the Ph.D., see the qualifying exam syllabi on the mathematics department web site.

Mathematical Reasoning

Students will be able to

R - 1. define and explain mathematical concepts
R - 2. compose and explain mathematical proofs and counterexamples; make logical inferences
R - 3. propose conjectures, generalizations, and mathematical questions
R - 4. solve non-routine mathematical problems
R - 5. read, discuss, and write mathematics

For this degree, outcomes will be assessed at the **expert** level, characterized by an ability to create original and significant mathematics.