

Mathematics Program 2011 Assessment Report

I. INTRODUCTION

The Mathematics Program in the College of Arts & Sciences at Trinity Washington University was established in the 1900s and has since been serving the entire undergraduate population at the college. Currently, the program is comprised of two tenured and one untenured full-time faculty and three math specialists trained in the area of developmental mathematics. All students are required to take at least one mathematics course during their four years at the college. Our introductory math courses serve a very broad group of students and a majority of them at this level are learning mathematics as an adjunct to another discipline in which they will major. It comes as no surprise, therefore, that the students in these courses vary greatly in their interest and ability in mathematics. Some of them enter the college with minimum level of preparation in algebra and arithmetic. To this end, the program is offering Introductory Algebra, Intermediate Algebra and Pre-Calculus courses as preparatory courses to the main Calculus sequence.

In addition, the program serves a student population seeking to obtain a bachelor's degree in mathematics. An undergraduate student who wishes to major in mathematics must make this choice in her sophomore year. She then makes the transition from the problem solving approach of the calculus courses to the more abstract thinking approach of the advanced math courses. The program offers two tracks for majors: pure mathematics and mathematics education. Students opting for the pure math track are trained for graduate school and professional positions in government, business, and industry. Majors in this area adopt a theoretical or applied focus through their selection of electives ranging from number theory and history of mathematics to mathematical modeling and differential equations. The mathematics education track prepares students for teaching secondary level mathematics. In conjunction with Trinity's Education Program, majors pursue a five year program leading to the Master of Arts in Teaching degree.

The program developed its assessment plan during the 2009- 2010 academic year. The faculty in the program was asked to make suggestions about how to describe what we are trying to do and ways to measure our success. The questions broadly addressed the three issues: 1) What should a student enrolled in mathematics courses learn during her four years here at Trinity, 2) What are the learning methods that the student should be exposed to in order to gain the necessary mathematical skills, and 3) What are the tools to be used to assess whether a student has learned those skills.

The format of this report is to describe the goals and objectives of the program, describe the assessment tools used, describe the analysis of the data obtained and finally, describe any plans for change that the program has already made or will be making in the future because of the assessment.

II. PROGRAM-LEVEL GOALS (derived from its Mission)

Mission Statement

Trinity's mathematics program is designed to help students acquire the necessary mathematical knowledge and skills that will serve as a foundation for careers and further study in mathematics and science, nursing, education and the liberal arts. Our mathematics courses develop the student's analytical and problem solving abilities while learning to appreciate the beauty, value and power of mathematics in the real world. Students learn how to use strong communication skills to support and defend their positions mathematically; skills that are necessary in today's society. Our advanced math courses provide our mathematics majors the opportunity to work with abstract and profound mathematical ideas, giving them a solid background to pursue graduate study. The program also strives to provide appropriate courses that serve the needs of other programs within the college, emphasizing the integration of mathematical knowledge with the student's interest and area of study in the liberal arts.

The curriculum offered by the Mathematics Program enables students to acquire the mathematical knowledge, skills, and values that characterize liberal learning.

Goals:

- I. Introduce students to mathematics as an important area of human thought (All General Education Mathematics Courses).
- II. Offer a broad selection of mathematics courses that can be tailored to diverse student and college needs supporting the study of liberal arts (Intermediate Algebra, Mathematical Problem Solving, Foundations of Mathematics, Pre-Calculus, Mathematics for Allied Health).
- III. Help students appreciate the beauty and scope of mathematics and statistics (Foundations of Mathematics and Introduction to Statistics).
- IV. Provide a foundation for critical thinking by developing skills in logic and problem solving (Mathematical Problem Solving, Foundations of Mathematics).

The Program recognizes the ethical dimensions of problem solving and promotes the principles of equity, justice, and honor.

Goals:

- V. Encourage students to investigate the complexity and diversity of the human experience while learning to communicate with mathematics (Introduction to Statistics, Statistical Inference).
- VI. Develop in students the ideas of thinking independently, critically and creatively when developing their number sense (Introduction to Abstract Mathematics, Abstract Algebra).

The Program is committed to empowering women by emphasizing in its course offerings the integration of liberal learning with professional preparation.

Goals:

- VII. Give students the mathematical knowledge necessary to pursue a degree in education (Mathematics Problem Solving, Foundations of Mathematics, Introduction to Statistics, History of Mathematics).
- VIII. To prepare students for careers in business, government, social sciences and industry (Pre-Calculus, Calculus I, Introduction to Statistics, Statistical Inference).
- IX. To provide a solid foundation of mathematical skills to students studying nursing and the allied health professions (Mathematics for Allied Health, Foundations of Mathematics, Introduction to Statistics).
- X. Provide a strong base in mathematics enabling math and science majors the opportunities for further study (All Mathematics Upper Level Courses).

III. ASSESSMENT PROCEDURES

The program developed objectives to meet the above goals and identified the courses that would meet these objectives. A worksheet aligning the mathematics program goals with course objectives and with courses is included in the appendix.

Assessment strategies used by the math instructors in the courses offered by the program are based on the student learning outcomes, the course content, the pedagogical methods in the classroom and the specific purpose of evaluation. These strategies include quizzes, homework assignments, in-class tests, final exams, oral presentations, computer projects, brief writing assignments and written thesis. These various course embedded assessment practices used by the instructors have proven to be valuable in assessing student achievement. Students differ in their perception, skills and thinking styles. It is crucial therefore to give students the opportunity to demonstrate their individual potential. Many students come into our courses feeling anxious about mathematics and a single type of assessment may frustrate many of them. Using a variety of sources such as written work including quizzes, tests, homework, oral presentations, group discussions or a combination of these gives us the advantage of continuously monitoring student's understanding of the concepts presented to them. These tools measure whether the students have acquired certain process and content related knowledge. The assessment methods mentioned above and specific learning objectives assessed by them are given below:

- Student's ability to solve problems- methods: small group discussions, evaluation of tests, homework assignments
- Student's ability to communicate-methods: computer simulation exercises, evaluation of the clarity, precision and appropriate use of mathematical terms and symbols in written work
- Student's ability to conceptualize-methods: real-life problem solving exercises and written project reports

- Student's mathematical attitude- methods: evaluation of class participation, observations focusing on how the student asks and answers questions in class and oral presentations

IV. DATA

Course embedded assessment was used as the assessment tool during the Fall 2010 semester by Drs. Chiang, Luse and Ramamurti to collect data from the following courses to measure student competencies: MATH 109 (Sections 1, 5 & 6), MATH 110 (Sections 1 & 3), MATH 123, MATH 125, MATH 210, MATH 301 and MATH 431. All three faculty members administered two in-class exams during the fall 2010 semester and these instruments were used to collect evidence about the extent to which we are meeting our goals. A copy of the instrument including the course objectives tested on the exam and the data collected is included in the appendix for each of the above courses.

V. ANALYSIS

MATH 123: PreCalculus

Observations on data collected from Test 1

The data collected on student performance in Test 1 show the following,

- (i) 63% of students in the class scored below 65% on the 'find the domain for functions defined by formulas' objective.
- (ii) 79% of students in the class scored below 65% on the 'find the domain for functions defined by graphs' objective.
- (iii) 53% of students in the class scored below 65% on the 'evaluate functions at given domain values and simplify expressions' objective.
- (iv) 58% of students in the class scored below 65% on the **'find the slope from the equation of a line and sketch its graph' objective.**
- (v) 58% of students in the class scored below 65% on the **'find the maximum or minimum value of the function' objective.**

Response to the observations

Observations (i) and (ii) clearly show that a majority of students were not competent in the skill of identifying domains of functions. We addressed this issue in the subsequent spring 2011 semester by making modifications in both the pedagogy and the assessment strategy. We created worksheets of domain problems that were worked on together in the class and developed an extra quiz based solely on these problems to test student confidence. Observations (iii) and (iv) show that more than half the class was not sufficiently skilled in algebra to simplify expressions and modify linear equations to find the slope. We addressed this issue by talking to the math specialist teaching the algebra classes and agreed to devote a little extra time on these two concepts in the introductory algebra class. We responded to observation (v) by assigning a few more problems related to applications of functions on the homework so that students practice more on the two different ways of computing the maximum and minimum value of a function.

Observations on data collected from Test 2

Students performed better overall on the second test than the first. Expectations were not met on only two of the eight course objectives. The data show

(i) 53% of students in the class scored below 65% on the **'find the inverse of the function'** objective.

(ii) 89% of students in the class scored below 65% on the 'Use the trigonometric function definitions and core identities to verify a given identity' objective.

Response to the observations

Based on the success of the changes we made in response to the data analysis on Test 1 we expect to make a similar modification in the pedagogy and assessment strategy to address student competency in the two concept areas of 'inverse of a function' and 'verification of trigonometric identities.' Discussions are underway in the program on the benefits of potentially using an additional online resource such as MyMathLab in the future for the Precalculus course.

MATH 109: Foundations of Mathematics

The same two tests with small changes in some of the problem data was administered to all three sections.

Observations on data collected from Test 1

A majority of students in all three sections showed above average competency in all six objectives. Overall students performed better on the topic of 'sets' than the topic of 'logic'.

Response to the observations

We don't plan on making significant changes to the existing course content that was covered in this test, pedagogy or assessment strategy in Math 109.

Observations on data collected from Test 2

Students from all three sections performed at a lower level on the second test than the first. The data show the following,

(i) 52% of Section 1 students in the class scored below 65% on the **'use the savings plan formula to calculate the regular payments needed for planning ahead'** objective.

(ii) 61% of Section 1 students in the class scored below 65% on the **'compute the total and annual returns on described investments'** objective.

(iii) 96% of Section 1 students and 75% of Section 5 students scored below 65% on the 'use the loan payment formula to calculate how much of the total payment goes to principal and how much to interest' objective.

Response to the observations

Test 2 covers material on 'finance' and this topic involves a lot of computation. We expect the students to have a good 'number sense'. We are looking into the MyMathLab resource to see if these topics are covered in depth there and if it would be beneficial to the students to have the resource in addition to the textbook. The lower performance of students in the section 1 class compared to the performance in the other two sections

could perhaps be also attributed to a larger section 1 class. This class had 27 students compared to the 12 students in each of the section 5 and section 6 classes.

MATH 110: Introduction to Statistics

Section 3:

The data show a consistent performance by the students on both the exams possibly indicating that there is a uniform level of difficulty of the topics covered through the semester. Here are the specifics.

Observations on data collected from Exam I

More than half the class (61%) earned a C or above on the first exam. 30% of students earned a passing grade below C. 9% failed the exam. Most of the students were competent in all except one of the nine objectives tested, the data showing,

52% of students in the class scored below 60% on the question testing the ‘Discuss/identify distribution shapes and the relationship between sample and population’ and ‘Summarize, organize, tabulate, and graph statistical data’ objective.

Observations on data collected from Exam II

Half the class (50%) earned a C or above on the second exam. 44% of students earned a passing grade below C. 6% failed the exam. Most students met all the objectives tested.

Section 1:

Observations on data collected from Exam I

An analysis of the data show that at least 63% of the students met or exceeded expectations on all the course objectives tested.

Observations on data collected from Exam II

There is a clear indication that at least 52% of the students in the class did not meet expectations on the questions testing the “learn basics of probability theory” objective.

Response to the observations

The program is satisfied with the course content and the objectives. Discussions are underway on the classroom pedagogy. Dr. Chiang is undertaking a study on the pros and cons of potentially switching to MyStatLab as an additional online resource for students in this class. Currently, the program teaches the MATH 110 students the basics of the SPSS statistical software. Based on the results of his study, we anticipate some changes to the pedagogy in the coming year.

MATH 125: Calculus I

Observations on data collected from Exam I

A majority of students (67% or higher) met or exceeded expectations on the objectives testing the calculus concepts but the data also indicate an area of concern: 11 – 33% of the students did not meet the “Demonstrate solid knowledge and skills of Pre-Calculus/Algebra” objective.

Observations on data collected from Exam II

A majority of students (63% or higher) met or exceeded expectations on all but one of the course objectives tested on this exam. The data show 50% or more did not meet the “Apply derivatives to geometry and sciences” objective.

Response to the observations

The data show a consistent performance on both exams. The program is satisfied with the course content and the objectives. More needs to be done in the area of ‘applications’. We will have conversations on this in the next few months.

MATH 210: Statistical Inference

Observations on data collected from Exam I

More than half the class (67%) earned a C or above on the first exam. 24% of students earned a passing grade below C. 9% failed the exam. Most of the students were competent in all except one of the six objectives tested, the data showing,

67% of students in the class scored below 70% on the question testing the ‘Work with a sampling distribution in order to determine the percentage of samples having a specified attribute’ objective.

Observations on data collected from Exam II

More than half the class (67%) earned a C or above on the second exam. 19% of students earned a passing grade below C. 14% failed the exam. Most of the students were competent in all except two of the seven objectives tested, the data showing,

(i) 67% of students in the class scored below 70% on the ‘find P-values which could be used to make a decision in a hypothesis test’ objective.

(ii) 71% of students in the class scored below 70% on the question testing their ability to use the one proportion z-test addressing the “Perform and analyze a variety of statistical inference procedures” objective.

Response to the observations

The data show a consistent performance by a majority of the students on both exams. The failure rate increased slightly on the second exam when the level of difficulty of the concepts covered increased. The program is satisfied with the course content and the objectives. Perhaps more needs to be done in increasing the skill level of all students in the area of ‘decision making’. We will have conversations on this in the next few months.

MATH 301: Linear Algebra

This is an upper level math course for the majors. Five students enrolled in the class in the fall 2010 semester. The data show the following,

(i) 50% of students did not meet expectations (had incorrect answers) on questions 2 and 10 on the exam based on the “Perform matrix algebra, including operations, inverse matrices, determinants” objective.

(ii) 80% of students did not meet expectations (had incorrect answers) on question 3 that addressed the “Perform matrix algebra, including operations, inverse matrices, determinants” objective.

Response to the observations

This course is offered every two years. The program will reexamine this data and analysis when we offer this course again.

MATH 431: Real Analysis

This is a course specifically tailored for math majors who wish to go on to graduate school. In the fall 2010 semester, 3 students enrolled in this course.

Observations on data collected from Exam I

Two of the three students earned a B- or above. One student failed this exam. One-third of the class earned 60% or below on questions 1 and 3 addressing the “Understand/use the field, order, and completeness properties of the real numbers to prove facts about the real numbers”, “Learn to read mathematical results and proofs as well as formulate her own proof to various problems” and the “Gain knowledge of the axioms of real numbers” objectives.

Observations on data collected from Exam II

Only two of the three enrolled students took this exam (the one student who failed the first exam did not show up for this one.) Both earned a B- or above on this exam. The data show the following,

(i) 50% of the class did not meet expectations (scored 60% or below) on question 2 addressing the “Make use of/understand results concerning convergence or divergence of sequences” and the “Learn to read mathematical results and proofs as well as formulate her own proof to various problems” objectives.

(ii) 50% of the class did not meet expectations (scored 60% or below) on question 4 addressing the “Make use of/understand the definition of a Cauchy sequence” and the “Learn to read mathematical results and proofs as well as formulate her own proof to various problems” objectives.

(iii) 50% of the class did not meet expectations (scored 60% or below) on question 6 addressing the “Learn to read mathematical results and proofs as well as formulate her own proof to various problems” and the “Gain knowledge of the definition of the limit of a function at a point” objectives.

Response to the observations

This course is offered every two years. The program will reexamine this data and analysis when we offer this course again.

VI. CONCLUSION

The mathematics program has made good progress in its assessment activities in the past year. Based on the data and analysis, the program has already undertaken efforts to strengthen the Introductory & Intermediate Algebra courses by introducing additional course objectives into these foundational courses, objectives that repeat itself in the next level of PreCalculus and Calculus sequence of courses. The argument made in support of this is that the more the students hear these concepts and objectives being repeated, the more competent they become in exceeding expectations on these. We are also switching to new textbooks for the Algebra and PreCalculus courses, books that focus more on the concepts that students did not grasp completely as indicated in the analysis of the assessment data.

For the statistical sequence of courses, as mentioned above, the program is conducting a study on how effectively the statistical software SPSS is being used in the MATH 110 and MATH 210 courses. Will the students in MATH 110 benefit from using an additional

online resource such as MyStatLab? The study will answer this question as well. Based on the results of the study we anticipate discussions on these issues in the summer of 2011 and changes to be made to these courses in the fall 2011 semester.

The program will continue to collect and reexamine the data obtained from the assessment of the foundations of mathematics and the upper level math courses. There will be no immediate changes to either the course content or the pedagogy in these courses. Drs. Chiang and Luse are on leave during the spring 2011 semester. We will continue our conversations on assessment when they return.

