

## Assessment of Course in Mathematics and Statistics for General Education Category 4: Mathematical/Logical Reasoning

### Methodology

Dr. Jonathan Harper and Mr. Michael Haskins conducted an assessment of general education courses offered by the Department of Mathematics and Statistics during the Fall semester of the 2007-2008 academic year. Student work was sampled from the following classes: Math 110, 112, 113, 115, 121, 180, 181, 201, and Stat 154. Final examinations of approximately 10% of the students who completed these courses were reviewed. These students were chosen by those whose identification numbers ended in five. 195 students were in this group and 2320 of the 3543 test questions asked were reviewed.

Each question was classified in several ways in order to assess the objective/outcomes for Category Four. A problem was determined to be an historical application of a mathematical system if it was a more traditional topic common to similar courses in past generations. Examples include rational functions, basic trigonometric functions, arithmetic sequences, mean and variance of simple data sets. A problem was determined to be a contemporary application of a mathematical system if it has a more recent emphasis such as logarithmic functions, exponential functions, inverse trigonometric functions, geometric sequences, matrices, and statistics with probability distributions. Further categorization was made to separate identification problems from description problems. A problem in which the mathematical abstraction was given was considered to be a problem focused on identifying a mathematical system. In contrast, a word problem requiring a student to develop the mathematical symbolism would be considered a description problem.

The test problems were divided into four subsets, ranging from problems requiring simple manipulations to problems requiring higher-order problem-solving strategies and modeling strategies. These subsets were defined as follows: (1) problems requiring symbolic manipulation for essentially one step to derive the solution, (2) problems requiring symbolic manipulation for multiple steps to derive the solution, (3) problems requiring a modeling approach to derive the mathematical system needed for the solution, and (4) problems requiring a higher-order problem-solving strategy where the results of one procedure are used as input to another procedure needed to derive the solution. Each problem was scored on separate percentage scales pertaining to objective/outcomes two and three. First, the student's solution was evaluated to measure the quality of the presentation in written mathematically narrative form. Organization and logical ordering were components of this evaluation. Second, the student's solution was evaluated to determine if it constituted a valid mathematical argument, describing the parts of a valid proof for the problem.

### Results

On average a student in one of the above courses was asked to solve approximately 18 problems. Of the tests that were reviewed, 54.1% of the questions required students to be able to identify an historical application of a mathematical system, 12.8% required students to be able to identify a contemporary application of a mathematical system, 22.1% required students to be able to describe a component of an historical application of a mathematical system, and 6.3% required students to be able to describe a component of a contemporary application of a mathematical system. The remaining 4.6% of the questions were multiple-choice.

The following percentages represent the quality of the written explanations given by an average student for each of the four question subsets. The average student was 72.4% successful in presenting a written mathematically narrative form for a problem requiring symbolic manipulation for essentially one step to derive the solution. The average student was 73.3% successful in presenting a written mathematically narrative form for a problem requiring symbolic manipulation for multiple steps to derive the solution. The average student was 60.5% successful in presenting a written mathematically narrative form for a problem requiring a modeling approach to derive the mathematical system needed for the solution. The average student was 67.2% successful in presenting a written mathematically narrative form for a problem requiring a higher-order problem-solving strategy where the results of one procedure are used as input to another procedure needed to derive the solution. The average student was 68.6% successful in presenting a written mathematically narrative form on all questions.

Percentages were assigned for each student assessing the validity of their mathematical argument or proof. The following results present the average student's success rate on each of the four categories. The average student was 72.7% successful in presenting a valid solution for a problem requiring symbolic manipulation for essentially one step to derive the solution. The average student was 70.4% successful in presenting a valid solution for a problem requiring symbolic manipulation for multiple steps to derive the solution. The average student was 60.3% successful in presenting a valid solution for a problem requiring a modeling approach to derive the mathematical system needed for the solution. The average student was 63.2% successful in presenting a valid solution for a problem requiring a higher-order problem-solving strategy where the results of one procedure are used as input to another procedure needed to derive the solution. The average student was 67.3% successful in presenting a valid solution on all questions.

## **Conclusions**

Based on the results of this review, the average student is satisfying the first objective/outcome in Category Four (Mathematical/Logical Reasoning) of the General Education requirements. On average students were required to identify and describe both historical and contemporary applications of mathematical systems. However, the percentage of identification questions comprised the majority of the questions asked. An increase in the proportion of description questions would strengthen objective/outcome #1. The disparity between the percentages of historical problems versus contemporary problems is of less concern since all mathematical and logical applications have merit today and in the future.

Students showed some mastery of the second and third objective/outcomes in Category Four. An average student was 68.6% successful in presenting a written mathematically narrative form indicating that students are able to express mathematical ideas in writing. An average student was 67.3% successful in presenting a valid mathematical solution indicating that students are able to explain a valid mathematical argument. There is room for improvement but these results indicate achievement close to the minimum realistic goal of 70% set forth by the department.

Objective/outcome #4 uncovers the weakest point in the average student's performance. Students were less able on average to present well written and valid solutions to the questions in subsets three and four which required applying higher-order problem-solving techniques. These types of problems are more difficult since it requires more holistic thought rather than applying a mechanical process. More emphasis should be placed in this area to significantly improve performance.