

Quantitative Reasoning Assessment
Department of Mathematics and Computer Science
Spring 2006 – Fall 2006

The Department of Mathematical Sciences requires that students demonstrate they have acquired the skills to understand and solve problems given in quantitative terms. More specifically, students completing the general education requirement in mathematics should have the skills to:

- (*Conceptual Understanding*) - Identify a problem given in quantitative terms and demonstrate conceptual understanding of the problem;
- (*Strategy*) - Develop and carry out an appropriate strategy to solve the problem; and
- (*Communication*) - Effectively communicate the solution of the problem, including a demonstrated understanding that the solution reached is reasonable.

These skills comport with the College's stated goal that "teaching and learning at the University of Virginia's College at Wise are transformational experiences" by enabling students to continue to educate themselves (goal 1.1), assume responsibility of citizenship (1.2), and understand the value of education (1.5). In addition, the teaching and learning of these skills contributes to the accomplishment of goals 2.7 (the College offers nationally recognized science and technology programs, which have a strong foundation in the liberal arts) and 3.3 (the College continues to strengthen the quality of K-12 education in Southwest Virginia in partnership with local schools).

The Department has established the following performance indicators and rubric to assess students' quantitative reasoning skills.

Performance Indicators:

- **Conceptual Understanding** - This indicator includes the ability to interpret a problem and determine essential information to develop a method or strategy for solving the problem. Evidence of conceptual understanding would be demonstrated through the ability to make connections between the problem situation, relevant information pertaining to the problem, the mathematical concepts relevant to the problem and logical responses to the problem.
- **Strategy** – This indicator includes the ability to demonstrate appropriate use and application of mathematical concepts. Evidence of proper procedure or method includes modeling the problem, supporting the model with appropriate justification, and modifying the procedure to address factors inherent with the given problem. Evidence of proper application includes the use of mathematical skills, often in combinations, coupled with clearly focused reasoning that leads to a correct solution of the problem.
- **Communication** – This indicator includes the ability to demonstrate understanding of the procedure or method applied to the solution of the problem as well as the ability to evaluate whether a solution is reasonable. Evidence of effective

communication includes the fluency with which the student explains concepts and procedures used in the problem solving process and evaluation of the answer.

Conceptual Understanding
<p>3. The student uses all relevant information to solve the problem. The student translates the problem into appropriate mathematical language The student's answer is consistent with the problem.</p>
<p>2. The student captures the essence of the problem, but is unable to use relevant information to completely solve the problem. The student is able to make some connections between concepts related to the problem. The student's answer is not completely related to the problem.</p>
<p>1. The student translates the problem into inappropriate mathematical language. The student uses incorrect procedures and methods, clearly demonstrating a lack of understanding of the concepts related to the problem.</p>
Problem Solving Strategy
<p>3. The student uses appropriate and insightful procedures and methods. The student applies mathematical principles correctly and precisely, and methods demonstrate insightful thinking. The student solves the problem correctly providing all supporting calculations and necessary verifications.</p>
<p>2. The student applies a method or procedure which is only partially useful. The student's method or procedure is not fully executed and does not include supporting calculations and verifications. The student starts the problem with an appropriate strategy, but applies procedures or methods incorrectly.</p>
<p>1. The student applies an inappropriate method or procedure, resulting in an incorrect solution, or a correct solution is given without any support.</p>
Communication
<p>3. The student uses mathematical language precisely and effectively communicates his/her thinking. The solution process is organized and includes strong support. The student verifies the solution is correct and reasonable and gives a complete response to the question.</p>
<p>2. The student uses terminology inconsistently or misuses appropriate terminology. The solution process includes some support, but explanations are unclear or not complete. The student checks the solution, but does not provide support that the solution is reasonable.</p>
<p>1. The student does not use appropriate mathematical terminology. The solution process does not include explanation or the student's explanations are not understandable and focused. The student fails to verify the solution and provides no support that the solution is reasonable.</p>

- Rubric Scale: 3 – More than competent
 2 – Satisfactory / Competent
 1 – Unsatisfactory / Not competent

All students pursuing an undergraduate degree are required to complete 6 semester hours in mathematics as part of the general education core. The department believes this requirement contributes to the foundational development of formal quantitative reasoning skills, thus ensuring that all students have the opportunity to meet the key quantitative reasoning learning outcomes.

The courses most students complete to fulfill the general education mathematics requirement are two courses from the following: MATH 100: Introduction to Algebra (3 hrs), MATH 101: College Algebra (3 hrs), MATH 102: Finite Mathematics (3 hrs), MATH 111: Pre-calculus I (3 hrs), MATH 112: Pre-calculus II (3 hrs), MATH 118: Elementary Probability and Statistics (4 hrs), and MATH 204: Calculus I (4 hrs). A student may not receive credit for both MATH 100 and MATH 101, nor can a student receive credit for MATH 111 and one of MATH 100 or MATH 101; thus, all students must complete at least one course beyond MATH 100, MATH 101, or MATH 111. Therefore, the department designates MATH 102, 112, 118, and 204 as terminal courses for the general education requirement.

Assessment of student achievement for the indicated quantitative reasoning outcomes will be carried out in the general education terminal mathematics courses as follows:

- Quantitative reasoning questions that are specific to the terminal courses for the mathematics general education requirement (MATH 102, 112, 118, and 204) will be included on the final exam in all sections of these courses. Two questions will be selected randomly from a question bank developed by members of the department for each terminal course.
- Evaluation committees, composed of members of the department, will be selected by the chair of the department for each of the terminal courses. The committees will evaluate student work using the rubric and an average score for the three performance indicators will be determined and student achievement will be ranked as follows:

Average Score N	Rank
$2.5 \leq N \leq 3$	More than competent
$1.5 \leq N < 2.5$	Competent
$N < 1.5$	Unsatisfactory

The Department established initial goals for performance standards (*italicized statements*), and performance results for the 2006 academic year by semester are as follows:

- *90 % of students should earn an average score that ensures a competent rank.*
- *15 % of students should earn an average score that ensures a more than competent rank.*

Spring 2006 - 181 students were tested in MATH 102, MATH 103 (now MATH 112), MATH 208 (now MATH 118) and MATH 204 and the average scores by course are as follows:

Course	Average Score
MATH 102	1.65
MATH 103	1.90
MATH 208	1.97
MATH 204	2.15
Overall Avg.	2.03

The number and percent of students at each rank are as follows:

Average Score	Rank	Number of Students	Percent of Students
$N < 1.5$	Unsatisfactory	36	19.9%
$N \geq 1.5$	Competent/ More than Competent	145	80.1%
$2.5 \leq N \leq 3$	More than Competent	53	29.3%

Fall 2006 – 113 students were tested in MATH 102, MATH 112, and MATH 204 and the average scores by course are as follows:

Course	Average Score
MATH 102	1.97
MATH 112	1.89
MATH 204	2.00
Overall Avg.	1.96

The number and percent of students at each rank are as follows:

Average Score	Rank	Number of Students	Percent of Students
$N < 1.5$	Unsatisfactory	22	19.5%
$N \geq 1.5$	Competent/ More than Competent	91	80.5%
$2.5 \leq N \leq 3$	More than Competent	34	30%

The Department also established a plan of action (*italicized statements*) to improve student achievement should the performance standards not be met. The departmental response for each point of the action plan follows:

- *The Department will review the placement vehicle to ensure that students are beginning the mathematics sequence in an appropriate course.* The Department revised both the mathematics placement test and scoring rubric to 1) more accurately diagnose algebraic weaknesses which affects the Math 100/101/111 placement, and 2) more accurately determine higher level algebraic skills and reasoning skills which affects the Math 112/204 placement. The Department will monitor the placement process closely and adjust the test and scoring rubric as needed, but Fall 2006 placements and final grades indicate the placement process accurately places students in appropriate courses.
- *The Department will evaluate the quantitative reasoning questions to determine if the unsatisfactory performance level was due to an anomaly (e.g. the question was poorly worded or not appropriate for the given terminal course) in the question rather than student learning.* The Department evaluated the quantitative reasoning questions and determined that unsatisfactory performance was not linked to particular questions. There does seem to be a correlation between course grades and quantitative reasoning scores at all ranks.
- *The Department will review course content to determine if there is a correlation between unsatisfactory performance on particular questions (i.e. less than 65 % of students earn an average score that ensures a competent rank) and the emphasis on the tested concepts in the terminal courses. If such a correlation is found, the Department would realign course content to rectify the indicated deficiency in student performance.* The Department found no correlation between unsatisfactory performance on particular course questions and emphasis on tested concepts. However, the Department is making a concerted effort to place greater emphasis on problem solving in all of the general education mathematics courses including the calculus sequence.
- *The Department is currently in the process of developing a terminal course for those students pursuing a degree other than mathematics, computer science, management information systems, software engineering, natural science or accounting.* The Department piloted the course MATH 195: Applications of Mathematics in the Spring 2007 semester and the course will be offered as

MATH 115: Applications of Mathematics each semester beginning in the Fall 2007 semester. MATH 115 includes topics from the foundations of applied mathematics with emphasis on problem solving and quantitative methods. Anecdotal evidence from the course instructors suggests that this course will further ensure that students have the opportunity to meet the key quantitative reasoning learning outcomes via means more relevant to their interests.

- *The Department recently developed the MATH 111: Pre-calculus I and MATH 112: Pre-calculus II sequence for students who do not place in MATH 204: Calculus I, but are pursuing a degree within the departments of mathematical sciences or the natural sciences. The courses in this sequence were designed to ensure that students have the skills to successfully complete the calculus sequence and thus providing students the opportunity to meet key quantitative reasoning outcomes in a relevant context for their majors. Preliminary evaluation of the MATH 111 and MATH 112 sequence indicates that students are effectively improving their higher level algebraic skills and problem solving skills. Instructors report that more time can now be spent on application topics that are relevant for the mathematical and natural sciences majors. Preliminary evaluation also indicates that students completing the MATH 111-112 sequence are better prepared for calculus. In particular, students are more easily grasping concepts dealing with the transcendental functions.*