

2012-13 Assessment of General Education Outcomes

Quantitative Reasoning (Full Report)

Office of Institutional Assessment and Evaluation

July, 2013

"Working together to create a culture of evidence-based decision making..."

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Executive Summary

In Spring Semester 2013, the Office of Institutional Assessment and Evaluation (OIAE) consulted with chairs of the departmental final examination committees for College Algebra I, College Algebra II, and Pre-calculus for the purpose of deciding which questions on the final examinations would be used to measure the general education learning outcome, *quantitative reasoning (QR)*. To aid in the identification of questions that would be used to measure quantitative reasoning, committee chairs were given the general education competencies for quantitative reasoning as defined by the Mathematical Association of America (MAA).

Methodology

Committee chairs were asked to identify at least two questions on their respective final examinations that measured each of the following four competencies which define students' ability to: (1) interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them; (2) represent mathematical information symbolically, visually, numerically, and verbally; (3) use arithmetical, algebraic, geometric and statistical methods to solve problems; and (4) estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results. Thus, seven (7), ten (10), and eleven (11) questions were used to collect information on student performance on the aforementioned competencies for College Algebra I, College Algebra II, and Pre-Calculus, respectively. Each professor received an Excel spreadsheet on which to report their students' question and final examination scores. In addition to students' names, the spreadsheets contained the students' school/college, gender and classification. "Competent" performance was defined as earning a question or final examination score of at least 60%. The response rate among professors was 81.1% (30 out of 37).

Key Findings

Across all courses – College Algebra I, College Algebra II and Pre-calculus -- the competency with the highest percentage of students (valid cases only) to meet or exceed 60% was competency 3, which required students to use arithmetical, algebraic, geometric and statistical methods to solve problems (procedural knowledge). The competency with the lowest percent of students (valid cases only) who met or exceeded 60% was competency 1, which required students to interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them (higher order and critical thinking skills).

The analyses of the final examination scores by student classification reveal that freshmen outperformed their peers on each of the four quantitative reasoning competencies on the College Algebra II and Pre-Calculus final examination, however, student performance on the quantitative reasoning competencies for College Algebra I were mixed. With the exception of competency 2 on the College Algebra II final examination, females outperformed males on every other quantitative reasoning competency on the College Algebra I, College Algebra II, and Pre-Calculus final examination.

The results also show that large percentages of students either withdrew or had no final examination score reported for them in their respective courses. For example, 45% of females, 48% of males, and 44% of freshmen who originally enrolled in College Algebra I either withdrew or had no final exam score. If all *freshmen, sophomores and juniors* re-enrolled in the mathematics courses from which they withdrew or had no final examination score, the cost in AY2013-14 dollars would be \$535,210. This estimate is based on 118 of 445 students (26.5%) re-enrolling in College Algebra I (3 credits), 41 of 437 students (9.4%) re-enrolling in College Algebra II, and 20 of 118 students (16.9%) re-enrolling in Pre-calculus (4 credits) at the undergraduate part-time rate of \$895 per credit hour. The attrition rates by student classification and gender are a major cause for concern.

Conclusions and Recommendations

1. Approximately 48% of the students who took the final examinations in College Algebra I, College Algebra II, and Pre-calculus were able to demonstrate mathematical competency on questions that measured procedural knowledge (e.g., solving mathematical problems); and approximately 46% of students were able to demonstrate competency in areas that measured more higher order or critical thinking skills, such as drawing inferences, determining reasonableness, identifying alternatives or selecting optimal results.

Recommendation 1: The University community should set performance expectations for quantitative reasoning competencies. These expectations should be based, in part, on the measures that are used to assess student learning. Faculty and students should strive to meet these expectations.

2. The high attrition rate in College Algebra I, especially among freshmen (44.2%), females (45.3%), and males (48.3%) is an indication that students lack the necessary prerequisite skills (e.g., mathematical, study or personal) to persist and succeed in the entry-level college credit-bearing mathematics course that leads to a degree.

Recommendation 2: Re-institute integrity into the placement testing system by ensuring that test security is adequate and that placement recommendations that provide students with the greatest probability of success are followed.

3. The rates of attrition in College Algebra I, College Algebra II, and Pre-calculus result in higher institutional costs and possibly more student debt or time-to-degree.

Recommendation 3: Faculty and students must set realistic retention goals for College Algebra I, College Algebra II and Pre-calculus and strive to attain them.

4. Students place themselves at a high probability of failing to meet minimum competency levels in College Algebra I, College Algebra II, and Pre-calculus if they postpone their (re-)enrollment in these courses until their senior year.

Recommendation 3: Academic advisors in the schools and colleges should collaborate with enrollment management personnel (and faculty) to carefully monitor students' performance (grades) in entry-level degree credit-bearing courses so that students' course-taking behaviors lead to successful completion of these courses, and students are able to apply what they have learned in upper division courses.

This list of recommendations is not intended to be exhaustive. Rather, the list is intended to be a starting point from which to develop and implement a strategic plan that results in successful learning outcomes and exceptional educational experiences for all Howard University students.

Gerunda B. Hughes, Director July, 2013



2012-13 Assessment of General Education Outcomes Quantitative Reasoning

The Assessment of Quantitative Reasoning

In Spring Semester 2013, the Office of Institutional Assessment and Evaluation (OIAE) consulted with chairs of the departmental final examination committees for College Algebra I, College Algebra II, and Pre-calculus for the purpose of deciding which questions on the final examinations would be used to measure the general education learning outcome, *quantitative reasoning (QR)*. To aid in the identification of questions that would be used to measure quantitative reasoning, committee chairs were given the general education competencies for quantitative reasoning as defined by the Mathematical Association of America (MAA). Chairs were asked to identify at least two questions on their respective final examination that measured students' ability to:

- Quantitative Reasoning Competency 1 (QRC1): Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them
- Quantitative Reasoning Competency 2 (QRC2): Represent mathematical information symbolically, visually, numerically, and verbally
- Quantitative Reasoning Competency 3 (QRC3): Use arithmetical, algebraic, geometric and statistical methods to solve problems
- Quantitative Reasoning Competency 4 (QRC4): Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results

The assessment of *quantitative reasoning* occurs each spring semester; therefore, the OIAE set three goals for this assessment activity for AY 2012-2013: (1) to improve the measurement – reliability and validity – of quantitative reasoning as defined by the four competencies, (2) to glean information about student performance in mathematics based on student classification and gender so that appropriate interventions can be designed and implemented, and (3) to increase the response rate among professors who report their students' performance data. To improve the measurement of the competencies, OIAE decided to collect data on multiple questions for each competency. This decision to collect more information has the effect of increasing the validity of inferences about the level of students' competency in quantitative reasoning.

Thus, OIAE was able to (1) improve the measurement of quantitative reasoning by collecting more data on student performance without increasing the level of reporting effort required from participating professors; and (2) disaggregate the student performance data by student classification and gender so that the results could be used to improve student learning. In Spring 2013, there were a total of 18 sections of College Algebra I. Of these 18 sections, data from 3 of

the sections were not submitted to the OIAE, which accounted for 14.4% (64 of 445) of the original students enrolled in College Algebra I. There were a total of 14 sections of College Algebra II. Of these 14 sections, data from 4 of the sections were not submitted to the OIAE, which accounted for 21.7% (95 of 437) of the original students enrolled in College Algebra II. There were a total of 5 sections of Pre-Calculus. Of these 5 sections, data from one of the sections was not submitted to the OIAE, which accounted for 28.8% (34 of 118) of the original students enrolled in Pre-Calculus.

The question number and point value, the statement of the question, and the related competency are presented in Tables 1, 8, and 16 for College Algebra I, College Algebra II and Pre-calculus, respectively. "Competent" performance was defined as earning a question or final examination score of at least 60%.

College Algebra I

The final examination for College Algebra I for Spring Semester 2013 consisted of 16 questions and a total possible score of 195 points. Table 1 presents the questions that were selected to measure each of three competencies (QRC2, QRC, and QRC4). Questions 3, 4, and 10 were selected to measure QRC2. Questions 5, 14, and 15 were selected to measure QRC3. Question 7 was selected to measure QRC4. A copy of the College Algebra I final examination is in Appendix A.

RESULTS: Across All Sections, by School/College, Student Classification, and Gender

Table 2 presents the results of student performance on the College Algebra I final examination for all sections by school or college. The results indicate that 239 of 445 or 53.7% of the enrollees had a final exam score and, therefore, were considered "valid cases" for these analyses. Thus, 206 or 46.3% of the students who did not have a final exam score either withdrew from the course, remained in the course but did not take the final exam, or took a different final exam because they were prospective graduates (seniors). Final exam scores for 64 students enrolled in College Algebra I were not submitted to the OAIE, accounting for 31.1% (64 out of 206) of the missing data. Still, the retention rate for College Algebra I was moderate across all schools and colleges, ranging for 35.0% to 60.6%. Across all sections of College Algebra I, the results of data analyses on student performance indicate that for:

- Questions 5, 14, and 15, which measured students' ability to *represent mathematical information symbolically, visually, numerically, and verbally (QRC2),* 117 of 236 valid cases or 49.6% of the students who took the final exam earned a question score of 60% or higher, and 117 of 445 or 26.3% of the original enrollees earned a score of 60% or higher.
- Questions 3, 4, and 10, which measured students' ability to *use arithmetical, algebraic, geometric and statistical methods to solve problems (QRC3)*, 149 of 235 valid cases or 63.4% of the students who took the final exam earned a question score of 60% or higher, and 149 of 445 or 33.5% of the original enrollees earned a score of 60% or higher.

• Question 7, which measured students' ability to *recognize that mathematical and statistical methods have limits (QRC4)*, 130 of 235 valid cases or 55.3% of the students who took the final exam earned a question score of 60% or higher, and 130 of 445 or 29.2% of the original enrollees earned a score of 60% or higher.

| Question # (Points) | Question Description | QR Competency Measured |
|------------------------|--|--|
| 5. (10pts) | Let A = (2,1) and B = (-6, 5). (a) Find the distance between A and B. (b) Find the midpoint of the line segment between A and B. | |
| 14. (15pts) | Let $f(x) = 3^x$. (a) What is $f(4)$? (b) If $f(x) = \frac{1}{9}$, what is x ? (c) Sketch the graph of the function f . | (2) Represent mathematical information symbolically, visually, numerically, and verbally. |
| 15. (15pts) | Sketch the graph of the quadratic function $f(x) = x^2 - 2x - 2$, clearly showing the x- and y- intercepts, as well as the vertex. | |
| 3. (15pts) | Solve the following equations. (a) $x^2 - 2x - 24 = 0$ (b) $\sqrt{x - 2} = x - 4$ | |
| 4. (15pts) | Solve the following inequalities, writing your answer in interval notation. (a) $2x + 3 < 4x - 1$ (b) $ 3x - 1 < 5$ (c) $ 4 - x > 2$ | (3) Use arithmetical, algebraic, geometric and statistical methods to |
| 10. (10pts) | Oliver has to borrow \$15,000 for a year in order to pay his school debts. His bank offers to lend him the money at a simple interest rate of 8% per year.(a) How much money will Oliver owe in interest?(b) How much does Oliver have to pay the bank at the end of the one year? | solve problems |
| 7. (10pts) | Find an equation for the line through $(6, 2)$ and perpendicular to the line passing through $(1,1)$ and $(7,4)$. | (4) Recognize that mathematical and statistical methods have limits |

Table 1. Questions and QR Competencies for College Algebra I Final Examination

For all questions on the final exam, 98 of 239 valid cases or 41% of the students earned a score of 60% or higher, and 98 of 445 or 22.0% of the original enrollees earned a score of 60% or higher.

Results by School/College: College Algebra I

Among students enrolled in College Algebra I, the largest representation of students was from the College of Arts and Sciences (N=269 of 445, 60.4%) and the smallest representation was from the School of Education (N=8 of 445, 1.8%).

The results indicate that the School of Education had the highest percentage of students who took the final examination and earned a total score of 60% or higher (N=3 of 4, 75%). The School of Communications had the lowest percentage of students who took the final examination and earned a total score of 60% or higher (N=18 of 38, 47.4%); however, this may be due to the small number of valid cases. The results for the other schools and colleges were as follows: College of Arts and Sciences (N=92 of 151, 60.9%), School of Business (N=14 of 19, 73.7%), College of Nursing and Allied Health Sciences (N=10 of 20, 50%), and College of Engineering, Architecture & Computer Science (N=4 of 7, 57.1%). At the institutional level, the percent of students who took the final examination and earned a score of 60% or higher was 41%. This does not mean that only 41% of students who took the test earned a passing grade (grade D or better) in College Algebra I. Rather, these results indicate that about 41% of the students were able to demonstrate the minimum level of competency on their College Algebra I final examination.

Table 2 also presents the percentage of *original enrollees* in College Algebra I who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 20% to 41.2%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 22%. This does not mean that only 22% of the original enrollees earned a passing grade (grade D or better) in College Algebra I. Rather, these results indicate that 22% of the original enrollees were able to demonstrate the minimum level of competency on their College Algebra I final examination.

| Table 2. Quantitative Reasoning for Spring Semester 2013 by School and CollegeAlgebra I Final Examination | | | | | | | | |
|---|--------------------|-------------------------|----------------|--------------------------|--|--|--|--|
| Student Classification | Number of Cases | Withdrew or No Score | Valid Cases | Item # & (QR Comp) | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher | |
| | 269 | 121 | 148 | 5, 14, & 15 (2) | 71 | 48.0% | 26.4% | |
| College of Arts & | 269 | 122 | 147 | 3, 4, & 10 (3) | 93 | 63.3% | 34.6% | |
| Sciences | 269 | 122 | 147 | 7 (4) | 81 | 55.1% | 30.1% | |
| | 269 | 118 | 151 | Total Exam | 92 | 60.9% | 34.2% | |
| | 20 | 13 | 7 | 5, 14, & 15 | 5 | 71.4% | 25.0% | |
| College of Engineering, | 20 | 13 | 7 | 3,4, & 10 | 4 | 57.1% | 20.0% | |
| Architecture & Computer Science | 20 | 13 | 7 | 7 | 4 | 57.1% | 20.0% | |
| | 20 | 13 | 7 | Total Exam | 4 | 57.1% | 20.0% | |
| | 8 | 4 | 4 | 5, 14, & 15 | 2 | 50.0% | 25.0% | |
| School of | 8 | 4 | 4 | 3,4, & 10 | 2 | 50.0% | 25.0% | |
| Education | 8 | 4 | 4 | 7 | 1 | 25.0% | 12.5% | |
| | 8 | 4 | 4 | Total Exam | 3 | 75.0% | 37.5% | |
| | 33 | 13 | 20 | 5, 14, & 15 | 12 | 60.0% | 36.4% | |
| College of Nursing and | 33 | 13 | 20 | 3,4, & 10 | 13 | 65.0% | 39.4% | |
| Allied Health Sciences | 33 | 13 | 20 | 7 | 13 | 65.0% | 39.4% | |
| | 33 | 13 | 20 | Total Exam | 10 | 50.0% | 30.3% | |
| | 34 | 15 | 19 | 5, 14, & 15 | 5 | 26.3% | 14.7% | |
| School of | 34 | 15 | 19 | 3,4, & 10 | 12 | 63.2% | 35.3% | |
| Business | 34 | 15 | 19 | 7 | 7 | 36.8% | 20.6% | |
| | 34 | 15 | 19 | Total Exam | 14 | 73.7% | 41.2% | |
| | 81 | 43 | 38 | 5, 14, & 15 | 22 | 57.9% | 27.2% | |
| School of | 81 | 43 | 38 | 3,4, & 10 | 25 | 65.8% | 30.9% | |
| Communications | 81 | 43 | 38 | 7 | 24 | 63.2% | 29.6% | |
| | 81 | 43 | 38 | Total Exam | 18 | 47.4% | 22.2% | |
| | 445 | 209 | 236 | 5, 14, & 15 | 117 | 49.6% | 26.3% | |
| Institutional | 445 | 210 | 235 | 3,4, & 10 | 149 | 63.4% | 33.5% | |
| Results | 445 | 210 | 235 | 7 | 130 | 55.3% | 29.2% | |
| | 445 | 206 | 239 | Total Exam | 98 | 41.0% | 22.0% | |

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Allied Health Sciences, School of Business, and School of Communications. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including prospective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

Results by Student Classification: College Algebra I

Table 3 presents the results of student performance on the College Algebra I final examination for all classifications of students. Of the 445 students enrolled in the course, freshmen had the largest representation (N=249 of 445, 60.0%) and seniors had the smallest representation (N=42 of 445, 9.4%). The results also indicate that sophomores had the highest percentage of students who took the final examination and earned a total score of 60% or higher (N=30 of 63, 47.6%). Juniors had the lowest percentage of students who took the final examination and earned a total score of 60% or higher (N=8 of 23, 34.8%).

| Student Classification | Number of Cases | Withdrew or No Score | Valid Cases | Item # | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|---------------------------|--------------------|-------------------------|----------------|-------------|--|---|---|
| | 249 | 113 | 136 | 5, 14, & 15 | 70 | 51.5% | 28.1% |
| Enschman | 249 | 114 | 135 | 3,4, & 10 | 91 | 67.4% | 36.5% |
| Freshinan | 249 | 114 | 135 | 7 | 76 | 56.3% | 30.5% |
| | 249 | 110 | 139 | Total Exam | 55 | 39.6% | 22.1% |
| | 109 | 46 | 63 | 5, 14, & 15 | 33 | 52.4% | 30.3% |
| Contonion | 109 | 46 | 63 | 3,4, & 10 | 41 | 65.1% | 37.6% |
| Sophomore | 109 | 46 | 63 | 7 | 36 | 57.1% | 33.0% |
| | 109 | 46 | 63 | Total Exam | 30 | 47.6% | 27.5% |
| | 45 | 22 | 23 | 5, 14, & 15 | 9 | 39.1% | 20.0% |
| Turtur | 45 | 22 | 23 | 3,4, & 10 | 13 | 56.5% | 28.9% |
| Junior | 45 | 22 | 23 | 7 | 9 | 39.1% | 20.0% |
| | 45 | 22 | 23 | Total Exam | 8 | 34.8% | 17.8% |
| | 42 | 28 | 14 | 5, 14, & 15 | 5 | 35.7% | 11.9% |
| Samian | 42 | 28 | 14 | 3,4, & 10 | 4 | 28.6% | 9.5% |
| Semor | 42 | 28 | 14 | 7 | 9 | 64.3% | 21.4% |
| | 42 | 28 | 14 | Total Exam | 5 | 35.7% | 11.9% |
| | 445 | 209 | 236 | 5, 14, & 15 | 117 | 49.6% | 26.3% |
| Institutional | 445 | 210 | 235 | 3,4, & 10 | 149 | 63.4% | 33.5% |
| Results | 445 | 210 | 235 | 7 | 130 | 55.3% | 29.2% |
| | 445 | 206 | 239 | Total Exam | 98 | 41.0% | 22.0% |

Table 3. Quantitative Reasoning for Spring Semester 2013 by Student Classification College Algebra I Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, and Nursing and Allied Health Sciences. (2) *Number of Cases* indicates the number of "original enrollees" on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

The results also indicate that retention rates for College Algebra I varied across all classifications and decreased as classification level increased (See "valid cases"): freshmen (N=139 of 249, 55.8%); sophomores (N=63 of 109, 57.8%); juniors (N=23 of 45, 51.1%); and seniors (N=14 of 42 33.3%). Essentially, almost half of all freshmen, sophomores, and juniors who were enrolled in College Algebra did not have a departmental final examination score reported for them. The retention rate for seniors, however, may be somewhat underestimated since seniors who were prospective graduates took a final examination approximately one week before the departmental final examination was administered or was excused from the final altogether.

Figure 1 presents the percentage of *original enrollees* in College Algebra I who earned a score of 60% or higher on the departmental final examination by student classification -- the percentages ranged from 11.9% for seniors to 27.5% for sophomores.



Figure 1

Descriptive Statistics by Student Classification: College Algebra I

Table 4 provides descriptive statistics for the 239 valid cases who took the department final examination in College Algebra I in Spring Semester 2013. Valid cases are those students for whom a question or final examination score is reported. Raw scores on the final examination could range from 0 to 195. Observed raw scores ranged from 0 to 187.5. Table 4 shows the percentage scores and range from 0% to 96.2%, for example, if the raw score is 80 (out of 195), the percentage score is 41% in Table 4. The highest mean score occurred among sophomores,

M=54.6%, and the lowest variability occurred among juniors, SD=20.1%. The lowest mean score occurred among juniors, M=48.7%, and highest variability occurred among seniors, SD=27.8%.

| Classification | Valid N | Minimum | Maximum | Mean | Std. Dev. |
|-----------------------|---------|---------|---------|-------|-----------|
| Freshman | 139 | 0% | 96.2% | 52.5% | 23.3% |
| Sophomore | 63 | 6.2% | 90.8% | 54.6% | 21.3% |
| Junior | 23 | 4.6% | 85.9% | 48.7% | 20.1% |
| Senior | 14 | 0% | 91.3% | 50.2% | 27.8% |
| Institutional Results | 239 | 0% | 96.2% | 52.6% | 22.7% |

Table 4. Descriptive Statistics for Algebra I by Student Classification (Percentages)Spring Semester 2013

Figure 2 presents the mean scores on the College Algebra I final examination by student classification for valid cases only. The graph shows that, overall, the mean scores for all student classifications -- freshmen, sophomores, juniors and seniors – were all below 60% or a D grade.



Figure 2

Inferential Statistics by Student Classification: College Algebra I

F-Test: An Analysis of Variance (ANOVA) was performed on the four mean percentage scores by student classification. The results of the *F*-test in Table 5 show that there is no statistically significant difference in the mean scores at 5% significant level for freshmen, sophomores, juniors and seniors on the departmental final examination for College Algebra I, F(3,235)=.439, p=.725.

| | Sum of Squares | df | Mean Square | F | Sig. |
|----------------|-------------------|-----|----------------|------|------|
| Between Groups | 2593.827 | 3 | 864.609 | .439 | .725 |
| Within Groups | 463045.366 | 235 | 1970.406 | | |
| Total | 465639.194 | 238 | | | |

| Table 5. ANOVA for Final Exam (Percentage) Score | e |
|--|---|
| by Student Classification in College Algebra I | |

A Post Hoc analysis was not performed because the ANOVA was not significant.

Results by Gender: College Algebra I

Of the 445 students enrolled in College Algebra I, 66.5% (N=296 of 445) were female and 33.5% (N=149 of 445) were male, thereby reflecting a ratio of females to males of almost 2:1. Table 6 shows that of the three competencies measured, females and males performed better on "use arithmetical, algebraic, geometric and statistical methods to solve problems" (QRC3). Overall, females performed slightly better than males on the Algebra I final examination, however, this difference was not statistically significant as indicated by the *t*-test below. Most likely because of the high attrition rates among females (N=134 of 296 or 45.3%) and males (N=72 of 149 or 48.3%), Table 6 shows that only 23.3% of females (N=69 of 296) and 19.5% of males (N=29 of 149) who originally enrolled in College Algebra I earned a score of 60% or higher on the final examination.

Table 7 presents the results of an independent *t*-test performed on the mean percentage scores by gender. The results indicate that there is no significant effect by gender, t(237) = 9.39, p=.349. Females and males performed very similarly.

| Gender | No. of Cases | Withdrew or No Score | Valid Cases | Item # & (QR Comp) | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|--------------------------|-----------------|----------------------------|----------------|--------------------------|---|--|---|
| | 296 | 137 | 159 | 5, 14, & 15 | 81 | 50.9% | 27.4% |
| Female | 296 | 138 | 158 | 3,4, & 10 | 101 | 63.9% | 34.1% |
| remate | 296 | 138 | 158 | 7 | 92 | 58.2% | 31.1% |
| | 296 | 134 | 162 | Total Exam | 69 | 42.6% | 23.3% |
| | 149 | 72 | 77 | 5, 14, & 15 | 36 | 46.8% | 24.2% |
| Mala | 149 | 72 | 77 | 3,4, & 10 | 48 | 62.3% | 32.2% |
| Walc | 149 | 72 | 77 | 7 | 38 | 49.4% | 25.5% |
| | 149 | 72 | 77 | Total Exam | 29 | 37.7% | 19.5% |
| | 445 | 209 | 236 | 5, 14, & 15 | 117 | 49.6% | 26.3% |
| Institutional Results | 445 | 210 | 235 | 3,4, & 10 | 149 | 63.4% | 33.5% |
| | 445 | 210 | 235 | 7 | 130 | 55.3% | 29.2% |
| | 445 | 206 | 239 | Total Exam | 98 | 41.0% | 22.0% |

Table 6. Quantitative Reasoning for Spring Semester 2013 by GenderCollege Algebra I Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Nursing and Allied Health Sciences, Business, and Communications. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, students did not take the final (including perspective graduating students), or students did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

| Gender | Valid N | Mean of Total Exam | Std. Dev. | t | df | Sig. (2-tailed) |
|--------|---------|-----------------------|-----------|------|-----|--------------------|
| Female | 162 | 53.5% | 22.3% | 020 | 227 | 240 |
| Male | 77 | 50.6% | 23.5% | .939 | 257 | .349 |

Table 7. Mean Comparison by Gender for College Algebra I, Spring Semester 2013

College Algebra II

The final examination for College Algebra II for Spring Semester 2013 consisted of 15 questions. Questions 1-7 were worth 20 points each and questions 8-15 were worth 15 points each. Students were instructed to answer questions 1-7 and any (4) of questions 8-15. There was a total possible score of 200 points. Table 8 presents the questions that were selected to measure each of four competencies. Questions 5, 6, and 9 were selected to measure QRC1, questions 2 and 4 to measure QRC2, questions 1, 3, and 8 to measure QRC3, and questions 7 and 11 to measure QRC4. Since students were able to select any of the questions from 8-15, "percent of original enrollees scoring 60% or higher" is not computed in Table 9 for quantitative reasoning competencies 1, 3, and 4. A copy of the College Algebra II final examination is in Appendix B.

RESULTS: Across All Sections, by School/College, Student Classification, and Gender

Table 9 presents the results of student performance on the College Algebra II final examination for all sections by school or college. The results indicate that 263 of 437 or 60.2% of the original enrollees had a final examination score and were considered "valid cases" for these analyses. Thus, 174 or 39.8% of the students who did not have a final exam score either withdrew from the course, remained in the course but did not take the final exam, or took a different final exam because they were prospective graduates (seniors). Final exam scores for 95 students enrolled in College Algebra II were not submitted to the OAIE, accounting for 54.6% (95 out of 174) of the missing data. Nevertheless, the retention rate for College Algebra II varied across schools and colleges, ranging from 43.3% among students enrolled in the College for Nursing and Allied Health Sciences to 85.7% among students enrolled in the College Algebra II, the results of data analyses on student performance indicate that for:

- Questions 5, 6, and 9, which measured students' ability to *interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them* (*QRC1*), 71 of 149 valid cases or 47.7% of the students who took the final exam earned a question score of 60% or higher.
- Questions 2 and 4, which measured students' ability to *represent mathematical information symbolically, visually, numerically, and verbally (QRC2),* 125 of 256 valid cases or 48.8% of the students who took the final exam earned a question score of 60% or higher.
- Questions 1, 3, and 8, which measured students' ability to *use arithmetical, algebraic, geometric and statistical methods to solve problem (QRC3)*, 33 of 80 valid cases or 41.2% of the students who took the final exam earned a question score of 60% or higher.
- Questions 7 and 11, which measured students' ability to *recognize that mathematical and statistical methods have limits (QRC4)*, 67 of 128 valid cases or 52.3% of the students who took the final exam earned a question score of 60% or higher.

For all questions on the final exam, 124 of 263 valid cases or 47.1% of the students earned a score of 60% or higher, and 124 of 437 or 28.4% of the original enrollees earned a score of 60% or higher.

| Item # (Points) | Item Description | Competency Measured | | | |
|--------------------|---|--|--|--|--|
| 5. (20 pts) | Find the vertex, focus and directrex of the following parabola. Sketch the graph. $x^2 - 2x = 8y - 1$ | | | | |
| 6. (20 pts) | (a) Determine the common ratio, the fifth term and the <i>nth - term</i> of the geometric sequence with terms 2, 6, 18, 54 (b) Find the sum of the first 15 terms of the sequence from part 5 (a) (c) Expand the following expression (x + 3)⁵ | (1) Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them. | | | |
| 9. (15 pts) | A retirement savings plan pay 4.5% interest compounded continuously. How long will it take for an investment of \$25,000 to double? | | | | |
| 2. (20 pts) | Given the following rational function $f(x) = \frac{2x^2-8}{x^2-1}$ Find (a) The Domain (b) The x – intercepts (c) The y – intercepts (d) The Vertical asymptotes if any (e) The Horizontal asymptotes if any | (2) Represent mathematical information symbolically, visually, numerically, and verbally. | | | |
| 4. (20 pts) | Sketch the region defined by the following set of inequalities and <i>Maximize</i> the objective function $z = 3x + 5y$ $\begin{cases} x \ge 0, y \ge 0 \\ x + 3y \le 6 \\ x + y \le 4 \end{cases}$ | | | | |
| 1. (20 pts) | (a) Solve the following equation for x log₂(x² − 1) = 3 (b) Write the following expression as a sum and/or a difference of logarithms, express all powers as factors. ln[(x²+3)(√x-5)/(2x³)] | (3) Use arithmetical, algebraic, geometric and statistical methods to solve problems | | | |

Table 8. Questions and QR Competencies for College Algebra II Final Examination

| 3 (20 pts) | (a) Solve the following system using Cramer's Rule $\begin{cases} 2x - 4y = -2 \\ 3x + 2y = 3 \end{cases}$ (b) Let the matrices be defined as follows: $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \qquad B = \begin{bmatrix} 2 & -1 \\ 0 & 3 \end{bmatrix}$ $C = \begin{bmatrix} -3 & 1 & 0 \\ 4 & -2 & 1 \end{bmatrix} \qquad D = \begin{bmatrix} -1 & 3 \\ 2 & 4 \\ 0 & -1 \end{bmatrix}$ | (3) Use arithmetical, algebraic, geometric and statistical methods to solve problems |
|-----------------|---|---|
| 8. (15 pts) | Find all rational zeroes of the polynomial $P(x) = x^{4} + 12x^{3} + 31x^{2} - 32$ | |
| 7. (20 pts) | (a) Determine the number of permutations of the letters of the word "Banana"? (b) Evaluate <i>P</i> (6, 3) (c) A bag contains 4 green marbles, 2 red marbles, 5 blue marbles and 1 white marble. A ball is chosen at random, what is the probability that the ball is neither red or blue? | |
| 11. (15 pts) | (a) Find the inverse of the following matrix and then check your answer by multiplying the inverse by the original matrix. (³ 5) (b) Use the inverse of the matrix above to solve the following system of equations. (³ x + 5y = -1) (³ x + 2y = 0 | (4) Recognize that mathematical and statistical methods have limits |

*Table 8 continued from previous page.

Results by School/College: College Algebra II

Of the 437 students enrolled in College Algebra II, the largest representation of students was from the College of Arts and Science (N=240 of 437 or 54.9%) and the smallest representation was from the School of Education (N=6 of 437 or 1.4%).

The results indicate that the School of Communication had the highest percentage of students who took the final examination and earned a total score of 60% or higher (N=18 of 26 or 69.2%). The College of Nursing and Allied Health Sciences had the lowest percentage of students who took the final examination and earned a total score of 60% or higher (N=5 of 13, 38.5%); however, this may due small number of valid cases. The results for the other schools and colleges were as follows: College of Arts and Sciences (N=64 of 140, 45.7%), School of Business (N=30 of 73, 41.1%), College of Engineering, Architecture & Computer Science (N=4 of 6, 66.7%), and School of Education (N=3 of 5, 60%). At the institutional level, the percent of students who took the College Algebra II final examination and earned a score of 60% or higher was 47.1%. This does not mean that only 47.1% of students who took the test earned a passing grade (grade D or better) in College Algebra II. Rather, these results indicate that about 47.1% of the students were able to demonstrate the minimum level of competency on their College Algebra II final examination.

Table 9 also presents the percentage of *original enrollees* in College Algebra II who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 16.7% to 57.1%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 28.4%. This does not mean that only 28.4% of the original enrollees earned a passing grade (grade D or better) in College Algebra II. Rather, these results indicate that 28.4% of the students were able to demonstrate the minimum level of competency on their College Algebra II final examination.

| Student Classification | Number of Cases | Withdrew or No Score | Valid Cases | Item # & (QR Comp) | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|--------------------------------|--------------------|-------------------------|-------------|--------------------------|--|--|--|
| | 240 | 162 | 78 | 5, 6, & 9 (1) | 33 | 42.3% | NA |
| College of Arts & | 240 | 104 | 136 | 2 & 4 (2) | 58 | 42.6% | 24.2% |
| Sciences | 240 | 195 | 45 | 1, 3 & 8 (3) | 19 | 42.2% | NA |
| | 240 | 169 | 71 | 7 & 11 (4) | 34 | 47.9% | NA |
| | 240 | 100 | 140 | Total Exam | 64 | 45.7% | 26.7% |
| | 7 | 3 | 4 | 5, 6, & 9 | 4 | 100.0% | NA |
| College | 7 | 1 | 6 | 2 & 4 | 3 | 50.0% | 42.9% |
| Engineering, Architecture & | 7 | 6 | 1 | 1, 3 & 8 | 0 | 0.0% | NA |
| Computer Science | 7 | 3 | 4 | 7 & 11 | 3 | 75.0% | NA |
| | 7 | 1 | 6 | Total Exam | 4 | 66.7% | 57.1% |
| | 6 | 3 | 3 | 5, 6, & 9 | 2 | 66.7% | NA |
| | 6 | 1 | 5 | 2 & 4 | 4 | 80.0% | 66.7% |
| School of Education | 6 | 2 | 4 | 1, 3 & 8 | 3 | 75.0% | NA |
| | 6 | 4 | 2 | 7 & 11 | 1 | 50.0% | NA |
| | 6 | 1 | 5 | Total Exam | 3 | 60.0% | 50.0% |
| | 30 | 25 | 5 | 5, 6, & 9 | 4 | 80.0% | NA |
| Collago of Nursing | 30 | 18 | 12 | 2 & 4 | 10 | 83.3% | 33.3% |
| and Allied Health | - | - | - | 1, 3 & 8 | - | - | NA |
| Sciences | 30 | 22 | 8 | 7 & 11 | 5 | 62.5% | NA |
| | 30 | 17 | 13 | Total Exam | 5 | 38.5% | 16.7% |
| | 111 | 69 | 42 | 5, 6, & 9 | 21 | 50.0% | NA |
| | 111 | 39 | 72 | 2 & 4 | 35 | 48.6% | 31.5% |
| School of Business | 111 | 88 | 23 | 1, 3 & 8 | 6 | 26.1% | NA |
| | 111 | 77 | 34 | 7 & 11 | 16 | 47.1% | NA |
| | 111 | 38 | 73 | Total Exam | 30 | 41.1% | 27.0% |
| | 43 | 26 | 17 | 5, 6, & 9 | 7 | 41.2% | NA |
| | 43 | 18 | 25 | 2 & 4 | 15 | 60.0% | 34.9% |
| School of Communications | 43 | 36 | 7 | 1, 3 & 8 | 5 | 71.4% | NA |
| Communications | 43 | 34 | 9 | 7 & 11 | 8 | 88.9% | NA |
| | 43 | 17 | 26 | Total Exam | 18 | 69.2% | 41.9% |
| | 437 | 288 | 149 | 5, 6, & 9 | 71 | 47.7% | NA |
| | 437 | 181 | 256 | 2 & 4 | 125 | 48.8% | 28.6% |
| Institutional Results | 437 | 357 | 80 | 1, 3 & 8 | 33 | 41.3% | NA |
| | 437 | 309 | 128 | 7 & 11 | 67 | 52.3% | NA |
| | 437 | 174 | 263 | Total Exam | 124 | 47.1% | 28.4% |

| Table 9 | Quantitative | Reasoning | for Spring | Semester | 2013 by S | chool and | College |
|---------|--------------|-----------|------------|----------|-----------|-----------|---------|
| Lanc 2. | Quantitative | Reasoning | for spring | Semester | 2013 Dy S | chool and | Conege |

Note: (1) Institutional Results include Arts & Sciences, Engineering & Architecture, Education, Allied Health Sciences, School of Business, and School of Communications and exclude one student from Continuing Education. (2) Number of Cases indicates the number of students on the official class roster. (3) Withdrew or No Score includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) Valid Cases indicate the number of cases included in the analysis for which there is a question or exam score (5) Items 8, 9, and 11 were optional, which may have decreased to the number of valid cases.

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Results by Student Classification: College Algebra II

Table 10 presents the results of student performance on the College Algebra II final examination for all classifications of students. Of the 437 students enrolled in the course, freshmen had the largest representation (N=235 of 437 or 53.8%) and juniors had the smallest representation (N=41 of 437 or 9.4%). The results also indicate that freshmen had the highest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=82 of 155 or 52.9%). Seniors had the lowest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=4 of 11 or 36.4%).

| Student Classification | Number of Cases | Withdrew or No Score | Valid Cases | Item # | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|---------------------------|--------------------|-------------------------|----------------|------------|---|---|---|
| | 235 | 150 | 85 | 5, 6, & 9 | 46 | 54.1% | NA |
| | 235 | 82 | 153 | 2 & 4 | 87 | 56.9% | 37.0% |
| Freshman | 235 | 182 | 53 | 1, 3 & 8 | 20 | 37.7% | NA |
| | 235 | 153 | 82 | 7 & 11 | 47 | 57.3% | NA |
| | 235 | 80 | 155 | Total Exam | 82 | 52.9% | 34.9% |
| | 102 | 58 | 44 | 5, 6, & 9 | 17 | 38.6% | NA |
| | 102 | 31 | 71 | 2 & 4 | 23 | 32.4% | 22.5% |
| Sophomore | 102 | 87 | 15 | 1, 3 & 8 | 9 | 60.0% | NA |
| | 102 | 68 | 34 | 7 & 11 | 12 | 35.3% | NA |
| | 102 | 28 | 74 | Total Exam | 28 | 37.8% | 27.5% |
| | 41 | 27 | 14 | 5, 6, & 9 | 5 | 35.7% | NA |
| | 41 | 19 | 22 | 2 & 4 | 10 | 45.5% | 24.4% |
| Junior | 41 | 32 | 9 | 1, 3 & 8 | 4 | 44.4% | NA |
| | 41 | 36 | 5 | 7 & 11 | 3 | 60.0% | NA |
| | 41 | 18 | 23 | Total Exam | 10 | 43.5% | 24.4% |
| | 59 | 53 | 6 | 5, 6, & 9 | 3 | 50.0% | NA |
| | 59 | 49 | 10 | 2 & 4 | 5 | 50.0% | 8.5% |
| Senior | 59 | 56 | 3 | 1, 3 & 8 | 0 | 0.0% | NA |
| | 59 | 52 | 7 | 7 & 11 | 5 | 71.4% | NA |
| | 59 | 48 | 11 | Total Exam | 4 | 36.4% | 6.8% |
| | 437 | 288 | 149 | 5, 6, & 9 | 71 | 47.7% | NA |
| | 437 | 181 | 256 | 2 & 4 | 125 | 48.8% | 28.6% |
| Institutional Results | 437 | 357 | 80 | 1, 3 & 8 | 33 | 41.3% | NA |
| incourto | 437 | 309 | 128 | 7 & 11 | 67 | 52.3% | NA |
| | 437 | 174 | 263 | Total Exam | 124 | 47.1% | 28.4% |

Table 10. Quantitative Reasoning for Spring Semester 2013 by Student ClassificationCollege Algebra II Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, and Nursing and Allied Health Sciences. (2) *Number of Cases* indicates the number of "original enrollees" on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

The results also indicate that retention rates for College Algebra II were moderately high, with the exception of seniors (See "valid cases"). The retention rates were as follows: freshmen (N=155 of 235 or 66.0%); sophomores (N=74 of 102 or 72.5%); juniors (N=23 of 41 or 56.1%); and seniors (N=11 of 59 or 18.6%).

Figure 3 presents the percentage of *original enrollees* in College Algebra II who earned a score of 60% or higher on the departmental final examination by classification -- the percentages ranged from 6.8% for seniors to 34.9% for freshmen.



Figure 3

Descriptive Statistics by Student Classification: College Algebra II

Table 11 provides descriptive statistics for the 263 valid cases who took the department final examination in College Algebra II in Spring Semester 2013. Valid cases are those students for whom a question or final examination score is reported. Raw scores on the final examination could range from 0 to 200. Observed raw scores ranged from 0 to 188. Table 12 shows the percentage scores and range from 0% to 94%, for example, if the raw score is 80 (out of 200), the percentage score is 40% in Table 12. The highest mean score occurred among freshmen, M=59.8%, SD=21.3%; the lowest mean score occurred among sophomores, M=51.4%, SD=18.7%.

| Classification | Valid N | Minimum | Maximum | Mean | Std. Dev. |
|-----------------------|---------|---------|---------|-------|-----------|
| Freshman | 155 | 6% | 94% | 59.8% | 21.3% |
| Sophomore | 74 | 10% | 85.5% | 51.4% | 18.7% |
| Junior | 23 | 20.5% | 82.5% | 53.1% | 20.5% |
| Senior | 11 | 0% | 87.5% | 53.3% | 26.7% |
| Institutional Results | 263 | 0% | 94% | 56.7% | 21.0% |

Table 11. Descriptive Statistics for College Algebra II by Student Classification (Percentages)Spring Semester 2013

Figure 4 presents the mean scores on the College Algebra II final examination by student classification for valid cases only. The graph shows that freshmen were the only class to approach the minimum mean criterion performance of at least 60%. Specifically, the mean score for freshmen on the College Algebra II final examination is 59.8%. All other student classifications, sophomores, juniors and seniors, failed to meet the criterion score of 60% or higher with mean scores of 51.4%, 53.1%, and 53.3%, respectively.



Figure 4

Inferential Statistics by Student Classification: College Algebra II

F-Test and Post Hoc Analyses: An Analysis of Variance (ANOVA) was performed on the four mean scores by student classification. The results of the *F*-test in Table 12 show that there is a statistically significant difference in the mean scores for freshmen, sophomores, juniors and seniors on the departmental final examination for College Algebra II, F(3,259)=3.08, p=0.03.

| | Sum of Squares | df | Mean Square | F | Sig. |
|----------------|----------------|-----|-------------|-------|------|
| Between Groups | 15984.470 | 3 | 5328.157 | 3.080 | .028 |
| Within Groups | 448113.414 | 259 | 1730.168 | | |
| Total | 464097.884 | 262 | | | |

Table 12. ANOVA for Final Exam Percentage Scoresby Student Classification in College Algebra II

A Post Hoc analysis was performed in order to examine pair-wise differences in mean performances by student classification. Table 13 shows that the mean score for freshmen is significantly higher than the mean score for sophomores. There were no other statistically significant differences between any other group means.

| | | Mean | G4 1 | | 95% Confidence | | |
|--------------------|--------------------|----------------|---------------|-------|----------------|---------|--|
| (I) Classification | (J) Classification | Difference | Std. Error | Sig. | Lower | Linner | |
| | | (I-J) | LIIUI | | Bound | Bound | |
| | Sophomore | 16.78845 | 5.53223 | .017 | 2.0537 | 31.5232 | |
| Freshman | Junior | 13.51318 | 9.20079 | .629 | -12.4229 | 39.4492 | |
| | Senior | 13.05073 | 16.46465 | .971 | -39.6469 | 65.7483 | |
| | Freshman | -16.78845 | 5.53223 | .017 | -31.5232 | -2.0537 | |
| Sophomore | Junior | -3.27526 | 9.57700 | 1.000 | -30.0169 | 23.4664 | |
| | Senior | -3.73771 | 16.67780 | 1.000 | -56.5641 | 49.0886 | |
| | Freshman | -13.51318 | 9.20079 | .629 | -39.4492 | 12.4229 | |
| Junior | Sophomore | 3.27526 | 9.57700 | 1.000 | -23.4664 | 30.0169 | |
| | Senior | 46245 | 18.22630 | 1.000 | -55.1823 | 54.2574 | |
| | Freshman | -13.05073 | 16.46465 | .971 | -65.7483 | 39.6469 | |
| Senior | Sophomore | 3.73771 | 16.67780 | 1.000 | -49.0886 | 56.5641 | |
| | Junior | .46245 | 18.22630 | 1.000 | -54.2574 | 55.1823 | |

Table 13. Post Hoc Multiple Comparisons for Final Exam Percentage Scores by Student Classification in College Algebra II

Note: Tamhane's T2 Post Hoc test is used, and equal variances are not assumed.

Results by Gender: College Algebra II

Of the 437 students enrolled in College Algebra II, 68.9% (N=301 of 437) were female and 31.1% (N=136 of 437) were male, thereby reflecting a ratio of females to males of almost 2:1. Table 7 shows that of the four competencies measured, females performed better on "*recognize that mathematical and statistical methods have limits*" (QRC4). Whereas, males performed better on "*recognize that mathematical information symbolically, visually, numerically, and verbally*" (category 2). Overall, females performed slightly better than males on the Algebra II final examination, however, this difference was not statistically significantly as indicated by the *t*-test below. Attrition rates among females (N=127 of 301 or 42.2%) and males (N=47 of 136 or 35.6%) were moderate. Table 14 shows that only 27.9% of females (N=84 of 301) and 29.4% of males (N=40 of 136) who originally enrolled in College Algebra II earned a score of 60% or higher on the final examination.

| Gender | No. of Cases | Withdrew or No Score | Valid Cases | Item # & (QR Comp) | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|--------------------------|-----------------|----------------------------|----------------|--------------------------|---|---|---|
| | 301 | 195 | 106 | 5, 6, & 9 | 51 | 48.1% | 16.9% |
| Female | 301 | 133 | 168 | 2 & 4 | 80 | 47.6% | 26.6% |
| | 301 | 244 | 57 | 1, 3 & 8 | 24 | 42.1% | 8.0% |
| | 301 | 231 | 70 | 7 & 11 | 42 | 60.0% | 14.0% |
| | 301 | 127 | 174 | Total Exam | 84 | 48.3% | 27.9% |
| | 136 | 93 | 43 | 5, 6, & 9 | 20 | 46.5% | 14.7% |
| | 136 | 48 | 88 | 2 & 4 | 45 | 51.1% | 33.1% |
| Male | 136 | 113 | 23 | 1, 3 & 8 | 9 | 39.1% | 6.6% |
| | 136 | 86 | 50 | 7 & 11 | 25 | 50.0% | 18.4% |
| | 136 | 47 | 89 | Total Exam | 40 | 44.9% | 29.4% |
| | 437 | 288 | 149 | 5, 6, & 9 | 71 | 47.7% | NA |
| T | 437 | 181 | 256 | 2 & 4 | 125 | 48.8% | 28.6% |
| Institutional Results | 437 | 357 | 80 | 1, 3 & 8 | 33 | 41.3% | NA |
| | 437 | 309 | 128 | 7 & 11 | 67 | 52.3% | NA |
| | 437 | 174 | 263 | Total Exam | 124 | 47.1% | 28.4% |

Table 14. Quantitative Reasoning for Spring Semester 2013 by GenderCollege Algebra II Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Nursing and Allied Health Sciences, Business, and Communications. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, students did not take the final (including perspective graduating students), or students did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

Table 15 presents the results of an independent *t*-test performed on the mean percentage scores by gender. The results indicate that there is no significant effect by gender, t(261) = 1.352, p=.178. Females and males performed relatively similarly.

| Gender | Valid N | Mean of Total Exam | Std. Dev. | t | df | Sig. (2-tailed) |
|--------|---------|-----------------------|-----------|-------|-----|--------------------|
| Female | 174 | 57.9% | 20.8% | 1 250 | 261 | .178 |
| Male | 89 | 54.2% | 21.3% | 1.552 | 201 | |

 Table 15. Mean Comparison by Gender for College Algebra II, Spring Semester 2013

Pre-Calculus

The final examination for Pre-calculus for Spring Semester 2013 consisted of 17 questions and a total score of 200 points. Table 16 presents the questions that were identified to measure each of four competencies. Questions 10 and 12 were selected to measure QRC1, questions 6, 15, and 17 to measure QRC2, questions 4, 5, 14, and 16 to measure QRC3, and questions 11 and 13 to measure QRC4. A copy of the final examination is in Appendix C.

| Table 16. | Questions and | QR | Competencies | for | Pre-calculus | Final | Examination |
|-----------|----------------------|----|--------------|-----|---------------------|-------|-------------|
|-----------|----------------------|----|--------------|-----|---------------------|-------|-------------|

| Item # (Points) | Item Description | Competency Measured | | | | |
|--------------------|---|--|--|--|--|--|
| 10. (10 pts) | If sin $x = 4/5$ and x is in the second quadrant, find the exact value of cos 2x. | | | | | |
| 12. (15 pts) | 12.The population of a bacterial colony doubles every 90 minutes. The colony initially has 120 individuals.(15 pts)(a) Give an equation for the number n(t) of individuals in the colony after t hours (b) When will there be a million individuals in the colony? | | | | | |
| 6. (10 pts) | Use the laws of logarithms to: (a) Expand $\log\left(\frac{x\sqrt{y+1}}{z^3}\right)$ as much as possible; (b) Combine $2\ln(x) - \frac{1}{3}\ln(y) + 3\ln(z)$ into a single logarithm. | | | | | |
| 15. (15 pts) | For the function $f(x) = 3\sin\left(2\left(x - \frac{\pi}{4}\right)\right)$: (a) Find the amplitude, period and phase shift; (b) Sketch the graph of two complete periods of f. | (2) Represent mathematical information symbolically, visually, numerically, and verbally. | | | | |
| 17. (15 pts) | If $G(x, y) = 16x + 14y$ is the objective function, find the maximum and minimum values of G on the region given by: $3x + 2y \le 12$ $7x + 5y \le 29$ $x \ge 0$ $y \ge 0.$ | | | | | |
| 4. (10 pts) | Evaluate: a) $\log_3(9)$: b) $4^{\log_2(5)}$ | | | | | |
| 5. (10 pts) | Solve the equation $e^{2x} + 2e^x - 3 = 0$. | | | | | |
| 14. (15 pts) | Find all solutions to the following system of equations: 2x + 4y - 2z = 6 $x + 4y + 2z = 7$ $x + 6y + 5z = 11.$ | (3) Use arithmetical, algebraic, geometric and statistical methods to solve problems. | | | | |
| 16. (15 pts) | Angle A of a triangle is 34° , and the two sides adjacent to this angle are $b = 5$ and $c = 6$. Find the length of the side a opposite angle A, to the nearest tenth. | | | | | |
| 11. (10 pts) | Verify the identity: $\frac{1}{1-\sin^2 x} = 1 + \tan^2 x.$ | (4) Recognize that mathematical and statistical | | | | |
| 13. (15 pts) | Find the exact value of $\sin\left(\sin^{-1}\left(\frac{3}{4}\right) - \cos^{-1}\left(\frac{1}{3}\right)\right)$. | methods have limits | | | | |

RESULTS: Across All Sections, by School/College, Student Classification, and Gender

Table 17 presents the results of student performance on the Pre-calculus final examination for all sections by school or college. The results indicate that 59 of 118 or 50% of the original enrollees had a final examination score and were considered "valid cases" for these analyses. Thus, 59 of 118 or 50% of the students who did not have a final exam score either withdrew from the course, remained in the course but did not take the final exam, or took a different final exam because they were prospective graduates (seniors). Final exam scores for 34 students enrolled in Pre-Calculus were not submitted to the OAIE, accounting for 57.6% (34 out of 59) of the missing data. The retention rate for Pre-calculus varied across the schools and colleges represented, ranging from 48.9% (N=43 of 88) among students enrolled in the College of Arts & Sciences to 100% (N=1of 1) among students enrolled in the School of Education. Across all sections of Pre-calculus, the results of data analyses on student performance indicate that for:

- Questions 10 and 12, which measured students' ability to *interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them* (*QRC1*), 13 of 41 valid cases or 31.7% of the students who took the final exam earned a question score of 60% or higher.
- Questions 6, 15 and 17, which measured students' ability to *represent mathematical information symbolically, visually, numerically, and verbally (QRC2),* 20 of 41 valid cases or 48.8% of the students who took the final exam earned a question score of 60% or higher.
- Questions 4, 5, 14, and 16, which measured students' ability to *use arithmetical, algebraic, geometric and statistical methods to solve problems (QRC3)*, 13 of 41 valid cases or 31.7% of the students who took the final exam earned a question score of 60% or higher.
- Questions 11 and 13, which measured students' ability to *recognize that mathematical and statistical methods have limits (QRC4)*, 20 of 41 valid cases or 48.8% of the students who took the final exam earned a question score of 60% or higher.

For all questions on the final examination, 14 of 59 valid cases or 23.7% of the students earned a score of 60% or higher, and 14 of 118 or 11.9% of the original enrollees earned a score of 60% or higher.

Results by School/College: Pre-calculus

Of the 118 students enrolled in Pre-calculus, the largest representation of students was from the College of Arts and Science (N=88 of 118 or 74.6%) and the smallest representation was from the School of Education (N=1 of 118 or 0.8%). No students from the School of Communications were enrolled in Pre-calculus.

The results indicate that the School of Education had the highest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=1 of 1 or 100%). The results

for the College of Arts and Sciences, which had a much larger representation in Pre-calculus, were N=13 of 43 or 30.2%. In addition, none of the students from the College of Engineering, Architecture and Computer Sciences or the College of Nursing and Allied Health Sciences who took the final examination earned a total score of 60% or higher. At the institutional level, the percent of students who took the final examination and earned a score of 60% or higher was 23.7%. This does not mean that only 23.7% of students who took the test earned a passing grade (grade D or better) in Pre-Calculus. Rather, these results indicate that about 23.7% of the students were able to demonstrate the minimum level of competency on their College Algebra I final examination.

Table 17 also presents the percentage of *original enrollees* in Pre-calculus who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 0% to 100%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 11.9%. This does not mean that only 11.9% of the original enrollees earned a passing grade (grade D or better) in Pre-calculus. Rather, these results indicate that 11.9% of the students were able to demonstrate the minimum level of competency on their Pre-calculus final examination.

Results by Student Classification: Pre-calculus

Table 18 presents the results of student performance on the Pre-calculus final examination for all classifications of students. Of the 118 students enrolled in the course, freshmen had the largest representation (N=65 of 118 or 55.1%) and juniors had the smallest representation (N=12 of 118 or 10.2%). The results also indicate that freshmen had the highest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=11 of 30 or 36.7%). Seniors had the lowest percentage of students *who took the final examination* and earned a total score of 60% or higher (N=0 of 3 or 0.0%).

The results also indicate that retention rates for Pre-calculus increased as student classification increased: freshmen (N=30 of 65 or 46.2%), sophomores (N=17 of 27 or 63.0%), juniors (N=9 of 12 or 75.0%), and seniors (N=3 of 14 or 21.4%) (See "valid cases"). The retention rate for seniors, however, may be somewhat underestimated since seniors who were prospective graduates took a final examination approximately one week before the departmental final examination was administered or was excused from the final altogether.

Figure 5 presents the percentage of *original enrollees* in Pre-calculus who earned a score of 60% or higher on the departmental final examination by student classification -- the percentages ranged from 0.0% for seniors to 16.9% for freshmen.

| Student Classificatio n | Number of Cases | Withdrew or No Score | Valid Cases | Item # & (QR Comp) | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|-------------------------------|--------------------|-------------------------|----------------|--------------------------|---|---|---|
| | 88 | 54 | 34 | 10 & 12 (1) | 12 | 35.3% | 13.6% |
| College of | 88 | 54 | 34 | 6, 15, & 17 (2) | 16 | 47.1% | 18.2% |
| Arts & Sciences | 88 | 54 | 34 | 4, 5, 14, & 16 (3) | 11 | 32.4% | 12.5% |
| | 88 | 54 | 34 | 11 & 13 (4) | 18 | 52.9% | 20.5% |
| | 88 | 45 | 43 | Total Exam | 13 | 30.2% | 14.8% |
| | 20 | 16 | 4 | 10 & 12 | 0 | 0.0% | 0.0% |
| College | 20 | 16 | 4 | 6, 15, & 17 | 2 | 50.0% | 10.0% |
| Architecture & Computer | 20 | 16 | 4 | 4, 5, 14, & 16 | 0 | 0.0% | 0.0% |
| Science | 20 | 16 | 4 | 11 & 13 | 2 | 50.0% | 10.0% |
| | 20 | 7 | 13 | Total Exam | 0 | 0.0% | 0.0% |
| | 1 | 0 | 1 | 10 & 12 | 1 | 100.0% | 100.0% |
| | 1 | 0 | 1 | 6, 15, & 17 | 1 | 100.0% | 100.0% |
| School of Education | 1 | 0 | 1 | 4, 5, 14, & 16 | 1 | 100.0% | 100.0% |
| | 1 | 0 | 1 | 11 & 13 | 0 | 0.0% | 0.0% |
| | 1 | 0 | 1 | Total Exam | 1 | 100.0% | 100.0% |
| | 4 | 2 | 2 | 10 & 12 | 0 | 0.0% | 0.0% |
| College of | 4 | 2 | 2 | 6, 15, & 17 | 1 | 50.0% | 25.0% |
| Nursing and Allied Health | 4 | 2 | 2 | 4, 5, 14, & 16 | 1 | 50.0% | 25.0% |
| Sciences | 4 | 2 | 2 | 11 & 13 | 0 | 0.0% | 0.0% |
| | 4 | 2 | 2 | Total Exam | 0 | 0.0% | 0.0% |
| | 118 | 77 | 41 | 10 & 12 | 13 | 31.7% | 11.0% |
| | 118 | 77 | 41 | 6, 15, & 17 | 20 | 48.8% | 16.9% |
| Institutional Results | 118 | 77 | 41 | 4, 5, 14, & 16 | 13 | 31.7% | 11.0% |
| | 118 | 77 | 41 | 11 & 13 | 20 | 48.8% | 16.9% |
| | 118 | 59 | 59 | Total Exam | 14 | 23.7% | 11.9% |

Table 17. Quantitative Reasoning for Spring Semester 2013 by School and CollegePre-calculus Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, and Allied Health Sciences. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including prospective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score. (5) The five (5) students enrolled in the School of Business did not have valid exam scores.

| Student Classification | Number of Cases | Withdrew or No Score | Valid Cases | Item # | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|---------------------------|--------------------|-------------------------|----------------|----------------|--|---|---|
| | 65 | 47 | 18 | 10 & 12 | 10 | 55.6% | 15.4% |
| | 65 | 47 | 18 | 6, 15, & 17 | 12 | 66.7% | 18.5% |
| Freshman | 65 | 47 | 18 | 4, 5, 14, & 16 | 9 | 50.0% | 13.8% |
| | 65 | 47 | 18 | 11 & 13 | 10 | 55.6% | 15.4% |
| | 65 | 35 | 30 | Total Exam | 11 | 36.7% | 16.9% |
| | 27 | 13 | 14 | 10 & 12 | 2 | 14.3% | 7.4% |
| | 27 | 13 | 14 | 6, 15, & 17 | 6 | 42.9% | 22.2% |
| Sophomore | 27 | 13 | 14 | 4, 5, 14, & 16 | 2 | 14.3% | 7.4% |
| | 27 | 13 | 14 | 11 & 13 | 6 | 42.9% | 22.2% |
| | 27 | 10 | 17 | Total Exam | 2 | 11.8% | 7.4% |
| | 12 | 6 | 6 | 10 & 12 | 1 | 16.7% | 8.3% |
| | 12 | 6 | 6 | 6, 15, & 17 | 2 | 33.3% | 16.7% |
| Junior | 12 | 6 | 6 | 4, 5, 14, & 16 | 1 | 16.7% | 8.3% |
| | 12 | 6 | 6 | 11 & 13 | 3 | 50.0% | 25.0% |
| | 12 | 3 | 9 | Total Exam | 1 | 11.1% | 8.3% |
| | 14 | 11 | 3 | 10 & 12 | 0 | 0.0% | 0.0% |
| | 14 | 11 | 3 | 6, 15, & 17 | 0 | 0.0% | 0.0% |
| Senior | 14 | 11 | 3 | 4, 5, 14, & 16 | 1 | 33.3% | 7.1% |
| | 14 | 11 | 3 | 11 & 13 | 1 | 33.3% | 7.1% |
| | 14 | 11 | 3 | Total Exam | 0 | 0.0% | 0.0% |
| | 118 | 77 | 41 | 10 & 12 | 13 | 31.7% | 11.0% |
| | 118 | 77 | 41 | 6, 15, & 17 | 20 | 48.8% | 16.9% |
| Institutional Results | 118 | 77 | 41 | 4, 5, 14, & 16 | 13 | 31.7% | 11.0% |
| | 118 | 77 | 41 | 11 & 13 | 20 | 48.8% | 16.9% |
| | 118 | 59 | 59 | Total Exam | 14 | 23.7% | 11.9% |

Table 18. Quantitative Reasoning for Spring Semester 2013 by Student Classification Pre-calculus Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, Nursing and Allied Health Sciences, and Education. (2) *Number of Cases* indicates the number of "original enrollees" on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.



Figure 5

Descriptive Statistics by Student Classification: Pre-calculus

Table 19 provides descriptive statistics for the 59 valid cases who took the department final examination in Pre-calculus in Spring Semester 2013. Valid cases are those students for whom a final examination score is reported. Raw scores on the final examination could range from 0 to 200. Table 18 shows the percentage scores, which ranges from 3.2% to 88.5%. Table 19 presents the descriptive statistics for student performance by classification in percentage score units. The highest mean score occurred among freshmen, M=43.4%; the lowest mean score occurred among seniors, M=31.7%; and the highest variability occurred among freshmen, SD=25.5%.

 Table 19. Descriptive Statistics for Pre-calculus by Student Classification (Percentages)

 Spring Semester 2013

| Spring benester 2015 | | | | | | | | | | |
|-----------------------|---------|---------|---------|--------|-----------|--|--|--|--|--|
| Classification | Valid N | Minimum | Maximum | Mean | Std. Dev. | | | | | |
| Freshman | 30 | 3.2% | 86.5% | 43.4% | 25.5% | | | | | |
| Sophomore | 17 | 4.5% | 88.5% | 37.0% | 21.4% | | | | | |
| Junior | 9 | 9.0% | 83.5% | 41.4% | 20.9% | | | | | |
| Senior | 3 | 17% | 45.0% | 31.7% | 14.1% | | | | | |
| Institutional Results | 59 | 3.2% | 88.5% | 40.63% | 23.03% | | | | | |

Figure 6 presents the mean scores on the Pre-calculus final examination by student classification for valid cases only. The graph shows that on average, all classification of students (freshmen, sophomores, juniors, and seniors) failed to meet the minimum mean criterion score of 60%. The minimum mean criterion performance of at least 60% was not met by any classification of students.





Inferential Statistics by Student Classification: Pre-calculus

F-Test: An Analysis of Variance (ANOVA) was performed on the four mean scores by student classification. The results of the *F*-test in Table 20 show that there is not a statistically significant difference in the mean scores for freshmen, sophomores, juniors, and seniors on the departmental final examination for Pre-calculus, F(3, 55)=.425, p=0.736.

| | Sum of Squares | df | Mean Square | F | Sig. |
|----------------|-------------------|----|----------------|------|------|
| Between Groups | 2787.889 | 3 | 929.296 | .425 | .736 |
| Within Groups | 120220.815 | 55 | 2185.833 | | |
| Total | 123008.704 | 58 | | | |

A Post Hoc analysis was not performed because the ANOVA was not significant.

Results by Gender: Pre-Calculus

Of the 118 students enrolled in Pre-Calculus, 61.0% (*N*=72 of 118) were female and 39.0% (*N*=46 of 118) were male. Table 21 shows that of the four competencies measured, females and males performed better on "*represent mathematical information symbolically, visually, numerically, and verbally,*" (QRC2) and "*recognize that mathematical and statistical methods have limits,*" (QRC4). Overall, females performed significantly better than males on the Pre-Calculus final examination, as indicated by the independent *t*-test below. Most likely because of the high attrition rates among females (*N*=37 of 72 or 51.4%) and males (*N*=24 of 46 or 52.2%), Table 7 shows that only 15.3% of females (*N*=11 of 72) and 6.5% of males (*N*=3 of 46) who originally enrolled in Pre-Calculus earned a score of 60% or higher on the final examination.

| Gender | No. of Cases | Withdrew or No Score | Valid Cases | Item # & (QR Comp) | No. of Valid Cases Scoring 60% or Higher | Percent of Valid Cases Scoring 60% or Higher | Percent of Original Enrollees Scoring 60% or Higher |
|--------|-----------------|----------------------------|----------------|--------------------------|---|---|---|
| Female | 72 | 44 | 28 | 10 & 12 | 10 | 35.7% | 13.9% |
| | 72 | 44 | 28 | 6, 15, & 17 | 15 | 53.6% | 20.8% |
| | 72 | 44 | 28 | 4, 5, 14, & 16 | 12 | 42.9% | 16.7% |
| | 72 | 44 | 28 | 11 & 13 | 15 | 53.6% | 20.8% |
| | 72 | 37 | 35 | Total Exam | 11 | 31.4% | 15.3% |
| Male | 46 | 33 | 13 | 10 & 12 | 3 | 23.1% | 6.5% |
| | 46 | 33 | 13 | 6, 15, & 17 | 5 | 38.5% | 10.9% |
| | 46 | 33 | 13 | 4, 5, 14, & 16 | 1 | 7.7% | 2.2% |
| | 46 | 33 | 13 | 11 & 13 | 5 | 38.5% | 10.9% |
| | 46 | 22 | 24 | Total Exam | 3 | 12.5% | 6.5% |

Table 21. Quantitative Reasoning for Spring Semester 2013 by Gender Pre-Calculus Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, and Nursing and Allied Health Sciences. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, students did not take the final (including perspective graduating students), or students did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

Table 22 presents the results of an independent *t*-test performed on the mean percentage scores by gender. The results indicate that there is a significant effect by gender, t(57) = 2.750, p=.008. Females performed significantly better than males on the Spring 2013 Pre-Calculus final examination.

| Gender | Valid N | Mean of Total Exam | Std. Dev. | t | df | Sig. (2-tailed) |
|--------|---------|-----------------------|-----------|-------|----|--------------------|
| Female | 35 | 47.1% | 23.3% | 2.750 | 57 | .008 |
| Male | 24 | 31.2% | 19.5% | 2.750 | | |

Table 22. Mean Comparison by Gender for Pre-Calculus, Spring Semester 2013

2012-13 Assessment of Quantitative Reasoning: Full Report

The Economics of Student Drop-Out in Mathematics Courses

During the 2009-10 year, the Office of Institutional Assessment and Evaluation began to estimate the cost of student drop-out in mathematics courses in terms of dollars and cents and in extended time-to-degree. In the 2010-11 report we noted, "There are costs to students and to the institution when students drop out of courses, fail to meet certain competencies or earn failing grades... oftentimes students have to re-enroll in a course and pay for it again...the cost to the institution is in additional salaries for professors and perhaps lower four-year graduation rates."

For Spring Semester 2011, (if these students had to re-enroll in these courses) we estimated that the potential cost in AY2011-12 dollars would be \$654,381 for College Algebra I, \$290,836 College Algebra II, \$92,684 for Pre-calculus, and \$1,037,901 for a total cost to students. For Spring Semester 2012, (if these students had to re-enroll in these courses) we estimated that the potential cost in AY2012-13 dollars would be \$242,097 for College Algebra I, \$131,036 College Algebra II, \$95,880 for Pre-calculus, and \$469,013 for a total cost to students.

The Spring Semester 2013 estimated costs (for students whose grades were reported to OIAE and data were submitted in time and followed report requirements), in terms of tuition dollars for freshmen, sophomores, and juniors who either officially withdrew from a mathematics course or did not have a final examination score reported for them, are presented in Table 23. The table presents the cost for retaking the courses in AY2013-14.

| Course | No. of Students who Withdrew or did not have a final exam score | Number of Credit Hours per Course | Cost per Credit Hour* | Total Cost |
|-----------------------|--|---|-----------------------------|------------|
| College Algebra I | | | | |
| Freshmen | 69 | 3 | \$895 | \$185,265 |
| Sophomores | 30 | 3 | | 80,550 |
| Juniors | 19 | 3 | | 51,015 |
| Sub-Total for CAI | 118 | | | \$316,830 |
| College Algebra II | | | | |
| Freshmen | 19 | 4 | \$895 | \$68,020 |
| Sophomores | 14 | 4 | | 50,120 |
| Juniors | 8 | 4 | | 28,640 |
| Sub-Total for CAII | 41 | | | \$146,780 |
| Pre-calculus | | | | |
| Freshmen | 11 | 4 | \$895 | \$39,380 |
| Sophomores | 7 | 4 | | 25,061 |
| Juniors | 2 | 4 | | 7,160 |
| Sub-Total for Pre-cal | 20 | | | \$71,600 |
| TOTAL COST | | | | \$535,210 |

Table 23. Cost for Retaking College Algebra I, College Algebra II, and Pre-calculus

*Undergraduate part-time rate per credit hour for AY2013-14.

**Data missing due failure of submission was not used to calculate the economics statistics.

Summary

For Spring 2013, the general education competency, quantitative reasoning, was assessed by examining student performance on the departmental final examinations in College Algebra I, College Algebra II, and Pre-Calculus. Competent performance was defined by an item or final examination score of 60% or higher. Professors were asked to report student performance on selected items on the final which measure one of the following quantitative reasoning competencies as defined by the Mathematical Association of America.

- (QRC1): Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them
- (QRC2): Represent mathematical information symbolically, visually, numerically, and verbally
- (QRC3): Use arithmetical, algebraic, geometric and statistical methods to solve problems
- (QRC4): Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results

For College Algebra I, 49.6% of students who took the final examination earned a score of 60% or higher on competency 2, whereas 26.3% of the original enrollees earned a score of 60% or higher on competency 2; 63.4% versus 33.5% on competency 3; and 55.3% versus 29.2% on competency 4. Among the different schools and colleges, the college of engineering, architecture, and computer science (CEACS), School of communications (SOC), and the college of nursing and Allied health sciences (CNAHS) had the highest percentage of student who took the final examination and earned a score of 60% or higher on competency 2, 3, and 4, respectively. The college of nursing and Allied health sciences (CNAHS) had the highest percentage of original enrollees who earned a score of 60% or higher on competency 2, 3, and 4. In regards to student classification, sophomores, freshmen, and seniors, had the highest percentage of students who took the final examination and earned a score of 60% or higher on competency 2, 3, and 4, respectively. Sophomores had the highest percentage of original enrollees who earned a score of 60% or higher on competency 2, 3, and 4. The gender based results revealed that females had the highest percentage of both students who took the final examine and of original enrollees who earned a score of 60% or higher on competency 2, 3, and 4.

For College Algebra II, 47.7% of students who took the final examination earned a score of 60% or higher on competency 1, 48.8% on competency 2; 41.2% on competency 3; and 52.3% on competency 4. "Percent of original enrollees scoring 60% or higher" was not computed for quantitative reasoning competencies 1, 3, and 4, however, 28.6% of the original enrollees earned a score of 60% or higher on competency 2. Among the different schools and colleges, the college of engineering, architecture, and computer science (CEACS), college of nursing and Allied health sciences (CNAHS), School of Education (SOE), and the School of communications (SOC), had the highest percentage of student who took the final examination and earned a score of 60% or higher on competency 1, 2, 3, and 4, respectively. The school of education (SOE) had the highest percentage of original enrollees who earned a score of 60% or higher on competency 2. In regards to student classification, freshmen had the highest percentage of students who took the final examination and earned a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 60% or higher on competency 3 and 4, respectively. Freshmen had the highest percentage a score of 6

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percentage of original enrollees who earned a score of 60% or higher on competency 2. The gender based results revealed that females had the highest percentage of students who took the final examine and earned a score of 60% or higher on competencies 1, 3, and 4, whereas males had the highest percentage of both students who took the final examine and of original enrollees who earned a score of 60% or higher on competency 2.

For Pre-Calculus, 31.7% of students who took the final examination earned a score of 60% or higher on competency 1, whereas 11% of the original enrollees earned a score of 60% or higher on competency 1; 48.8% versus 16.9% on competency 2, 37.1% versus 11% on competency 3; and 48.8% versus 16.9% on competency 4. Among the different schools and colleges, the school of education (SOE) had the highest percentage of both students who took the final examination and of original enrollees who earned a score of 60% or higher on competency 1, 2, and 3. The college of arts and sciences (COAS) had the highest percentage of both students who took the final examination and of original enrollees who earned a score of 60% or higher on competency 4. In regards to student classification, freshmen had the highest percentage of students who took the final examination and earned a score of 60% or higher on competencies 1, 2, 3, and 4. Freshmen had the highest percentage of original enrollees who earned a score of 60% or higher on competencies 1 and 3, whereas, sophomores and juniors had the highest percentage of original enrollees who earned a score of 60% or higher on competencies 2 and 4, respectively. The gender based results revealed that females had the highest percentage of both students who took the final examination and of original enrollees who earned a score of 60% or higher on competencies 1, 2, 3, and 4.

Freshmen outperformed their peers on each of the four quantitative reasoning competencies on the College Algebra II and Pre-Calculus final examination, however, student performance on the quantitative reasoning competencies for College Algebra I were mixed. With the exception of competency 2 on the College Algebra II final examination, females out performed males on every other quantitative reasoning competency on the College Algebra I, College Algebra II, and Pre-Calculus final examination.

The improvement of students' competencies in *quantitative reasoning*, as defined by performance in College Algebra I, College Algebra II and Pre-calculus, must begin with strategies to reduce the attrition rates in these courses. Students who officially withdrew from the courses, stop attending without officially withdrawing, or failed the courses (earn a grade of F) will have to re-take the courses in order to fulfill degree requirements and graduate. The estimated costs to the university in real dollars and cents for students to re-take these courses are cumulative and prohibitive. The costs are cumulative because each year the university must provide instructional resources for new entrants as well as for those returning students who must retake the courses. The costs are prohibitive because (1) they are high and could lead to increased student debt and time-to-degree, and (2) each year the university invests generously in professional developmental/remediation programs that are designed to prepare underprepared students for college level mathematics and reduce the rates of recidivism in the general education mathematics courses. Hence, while the awarding degrees is important, institutions are increasingly placing an equally important premium on student learning outcomes; that is, what students know and are able to do when they graduate. In fact, institutional effectiveness is being defined, in part, by the extent to which institutions are able to provide credible evidence that students are achieving the learning goals that institutions have set for themselves.

Disaggregating student performance data by school/college, student classification and gender allows university personnel to develop specific strategies for targeted student groups. Doing so demonstrates that a 'one size fits all' may not be an effective approach for improving student learning outcomes or achieving institutional goals. The data clearly show that too many students (males in particular) are failing to persist and succeed in their mathematics courses.

Analyzing student performance data by competency also reveals areas of strength or weakness in the university's instructional programs. The analyses of student performance data for College Algebra I, College Algebra II and Pre-calculus suggest that overall, students performed better on items requiring them to use arithmetical, algebraic, geometric and statistical methods to solve problems (procedural knowledge). Students were less successful on problems that required them to interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them (higher order and critical thinking skills.

Faculty, academic advisors, peer counselors, student affairs personnel, university administrators, and most importantly, students themselves must work collaboratively to do what is necessary to improve students' competencies in *quantitative reasoning* (See Conclusions and Recommendations in the "Executive Summary).

Appendix A. College Algebra I



Percent of Students That Scored 60% or Higher on College Algebra I Final Examination by School/College, Spring 2013 Education 75.0% (3/4) School of Business 73.7% (14/19) Arts & Sciences 60.9% (92/151) Engineering & Architecture 57.1% (4/7) 50.0% (10/20) Allied Health Sciences School of Communications 47.4% (18/38) Institution 41.0% (98/239) 0% 20% 40% 60% 80% Pass Rate (60% or higher)









Figure A1 presents a "Box-and-Whiskers Plot" of the total score on the final examination for College Algebra I by school/college. The horizontal line in each plot represents the median or middle raw score distribution. The medians for HS and SC have the highest median scores, whereas, ED and SB have the lowest median scores.



Figure A1. Exam Score by School/College: College Algebra I

Figure A2 presents a "Box-and-Whiskers Plot" of the total score on the final examination for College Algebra I by student classification. The medians for freshmen, sophomores, and seniors are almost identical (about 100 points); whereas the median for juniors is somewhat lower.



Figure A2. Exam Score by Student Classification: College Algebra I

Figure A3 presents a "Box-and-Whiskers Plot" of the total score on the final examination for College Algebra I by gender. The medians for females and males are almost identical, however, the median score for males is slightly lower.



Figure A3. Exam Score by Gender: College Algebra I

HOWARD UNIVERSITY Department of Mathematics College Algebra 1 - Math 006 Final Examination Tuesday April 30, 2013

Instructions: This examination consists of 16 exercises worth a total of 200pts. Answer all questions. Show your work neatly. **Calculators are not** allowed.

1. [10 points] Find all real solutions. If there are none, say so.

(a)
$$2x + 1 = x - 3$$

(b) $\frac{x}{x-1} = \frac{x+2}{x-3}$

2. [15 points] How much pure alcohol should be added to 1 liter of a 30% alcohol solution to get a 50% solution?

3. [15 points] Solve the following equations.

(a) $x^2 - 2x - 24 = 0$ (b) $\sqrt{x - 2} = x - 4$

4. [15 points] Solve the following inequalities, writing your answer in interval notation.

(a) 2x + 3 < 4x - 1(b) |3x - 1| < 5(c) |4 - x| > 2

5. [10 points] Let A = (2, 1) and B = (-6, 5).

(a) Find the distance between A and B.

(b) Find the midpoint of the line segment between A and B.

6. [15 points]

(a) Write an equation for the circle with center (3, -1) and radius √5
(b) Find the center and radius of the circle with equation x² + y² - 6x + 4y - 3 = 0.

7. [10 points] Find an equation for the line through (6, 2) and perpendicular to the line passing through (1, 1) and (7, 4).

Howard University

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8. [15 points] Write the equation expressing the facts that t is jointly proportional to r and s and inversely proportional to u, and that if r = 3, s = 2, and u = 12, then t = 15.

9. [10 points] Find the domain of the function $f(x) = \frac{\sqrt{4-x^2}}{x}$.

10.[10 points] Oliver has to borrow \$15,000 for a year in order to pay his school debts. His bank offers to lend him the money at a simple interest rate of 8% per year.

(a) How much money will Oliver owe in interest?

(b) How much does Oliver have to pay the bank at the end of the one year?

11. [10 points] Jasmine deposits \$2,000 in a savings account at the bank. The bank offers 5% interest compounded quarterly. How much will Jasmine have in the savings account after 1 year? Leave your answer as a fraction raised to a power. Do not calculate.

12. [10 points] Find the average rate of change of the function $f(x) = x^4 - 4x$ between x = -1 and x = 3.

13. [10 points] How many complete revolutions a circular disk with radius 3 feet would have made when it has rolled 94.2 feet? (Take $\pi = 3.14$)

14.[15 points] Let f(x) = 3^x.
a) What is f(4)?
b) If f(x) = ¹/₉, What is x?
c) Sketch the graph of the function f.

15.[15 points] Sketch the graph of the quadratic function $f(x) = x^2 - 2x - 2$, clearly showing the x- and y- intercepts, as well as the vertex.

16.[10 points] a) If $4^{-x} = 7$, what is 4^{2x} equal to? b) If $2^x = 3$, what is 4^{-x} equal to?

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2012-13 Assessment of Quantitative Reasoning: Full Report





Figure B1 presents a "Box-and-Whiskers Plot" of the total score on the final examination for College Algebra II by school/college. The median for the School of Education is the highest, whereas, the School of Business has the lowest median scores.



Figure B1. Exam Score by School/College: College Algebra II

Figure B2 presents a "Box-and-Whiskers Plot" of the total score on the final examination for College Algebra II by student classification. The median for sophomores and juniors are almost identical (about 100 points), whereas the median for freshmen and seniors where somewhat higher.



Figure B2. Exam Score by Student Classification: College Algebra II

Figure B3 presents a "Box-and-Whiskers Plot" of the total score on the final examination for College Algebra II by Gender. The median for males and females are almost identical, however, the median for females was slightly higher.



Figure B3. Exam Score by Gender: College Algebra II

HOWARD UNIVERSITY - DEPARTMENT OF MATHEMATICS

ALGEBRA 2 (MATH 010) FINAL EXAMINATION - SPRING 2013 SHOW ALL WORK. NO WORK/NO CREDIT

PART 1 - Answer all seven questions in this section (20 points each)

1. a) Solve the following equation for x

$$\log_2(x^2 - 1) = 3$$

b) Write the following expression as a sum and/or a difference of logarithms, express all powers as factors.

$$\ln\left[\frac{(x^2+3)(\sqrt{x-5})}{2x^3}\right]$$

- 2. Given the following rational function $f(x) = \frac{2x^2-8}{x^2-1}$ Find
 - a) The Domain
 - b) The x intercepts
 - c) The y intercepts
 - d) The Vertical asymptotes if any
 - e) The Horizontal asymptotes if any
- 3. a) Solve the following system using Cramer's Rule

$$\begin{cases} 2x - 4y = -2\\ 3x + 2y = 3 \end{cases}$$

b) Let the matrices be defined as follows: $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ $B = \begin{bmatrix} 2 & -1 \\ 0 & 3 \end{bmatrix}$

$$C = \begin{bmatrix} -3 & 1 & 0 \\ 4 & -2 & 1 \end{bmatrix} \qquad D = \begin{bmatrix} -1 & 3 \\ 2 & 4 \\ 0 & -1 \end{bmatrix}$$

Find the entries of the matrix $F = 2B^2 - CD$

4. Sketch the region defined by the following set of inequalities and Maximize the

objective function z = 3x + 5y

$$\begin{cases} x \ge 0, \ y \ge 0\\ x + 3y \le 6\\ x + y \le 4 \end{cases}$$

5. Find the vertex, focus and directrix of the following parabola. Sketch the graph.

$$x^2 - 2x = 8y - 1$$

 a) Determine the common ratio, the fifth term and the nth - term of the geometric sequence with terms 2, 6, 18, 54 ...

b) Find the sum of the first 15 terms of the sequence from part 5(a)

c) Expand the following expression $(x + 3)^5$

7. a) Determine the number of permutations of the letters of the word "Banana"?

b) Evaluate P(6,3)

c) A bag contains 4 green marbles, 2 red marbles, 5 blue marbles and 1 white marble. A ball is chosen at random, what is the probability that the ball is **neither** red nor blue?

PART 2 - Answer any four (4) of the following questions (15 points each)

8. Find all rational zeroes of the polynomial

$$P(x) = x^4 + 12x^3 + 31x^2 - 32$$

9. A retirement savings plan pays 4.5% interest compounded continuously. How long will it take for an investment of \$25,000 to double? 10. Solve the following logarithmic equation

$$\log_2(3x^2) + \log_2 12 = 4$$

11. a) Find the inverse of the following matrix and then check your answer by multiplying the inverse by the original matrix.

$$\begin{pmatrix} 3 & 5 \\ 1 & 2 \end{pmatrix}$$

b) Use the inverse of the matrix above to solve the following system of equations.

$$\begin{cases} 3x + 5y = -1\\ x + 2y = 0 \end{cases}$$

12. Complete the square to find the center, foci, vertices and asymptotes of the hyperbola

$$x^2 - 4y^2 - 2x + 16y = 20$$

13. Determine if the infinite geometric series is convergent or divergent. If it is convergent, find it's sum.

$$.1 + .01 + .001 + .0001 + \cdots$$

- 14. Let a_n be the sequence whose first few terms are -12, -8, -4, 0, ...
 a) Determine whether the sequence is arithmetic or geometric and find the common ratio or common difference.
 - b) Find the 100th term
 - c) Evaluate $\sum_{k=4}^{100} a_k$
- 15. a) There are 8 male students and 5 female students in a science class. In how many ways can a committee consisting of 3 males and 3 females be chosen from the students in the class?
 - b) If a group of two students in the class are chosen at random, what is the
 - probability that both students are female?

Appendix C. Pre-calculus



Percent of Students That Scored 60% or Higher on Precalculus Final Examination by School/College, Spring 2013











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Figure C1 presents a "Box-and-Whiskers Plot" of the total score on the final examination for Pre-Calculus by School/College. The AC has the highest median score, whereas EA has the lowest median score.



Figure C1. Exam Score by School/College Pre-Calculus

Figure C2 presents a "Box-and-Whiskers Plot" of the total score on the final examination for Pre-Calculus by student classification. Juniors have the highest median score, whereas seniors have the lowest median score.



Figure C2. Exam Score by student classification: Pre-Calculus

Figure C3 presents a "Box-and-Whiskers Plot" of the total score on the final examination for Pre-Calculus by gender. The female median score was higher than the male median score.



Figure C3. Exam Score by Gender: Pre-Calculus

Do all work, including scratch, in your examination books. Do **not** use calculators on problems calling for **exact values**; calculator answers for those will not be counted. Problems 1 through 11 are worth up to 10 points each, and problems 12 through 17 up to 15 points each.

1. Let $f(x) = \frac{x+1}{x-2}$. Find the inverse function of f.

2. Find all vertical asymptotes, if any, and all horizontal or oblique (slant) asymptotes, if any, of the graph of $f(x) = \frac{x^3 + x^2 + 1}{x^2 - x}$.

3. Give the domains of: a) $f(x) = \frac{2x}{x^2 + 2x - 8}$; b) $g(x) = \ln(2 - x)$.

- 4. Evaluate: a) $\log_3(9)$; b) $4^{\log_2(5)}$.
- 5. Solve the equation $e^{2x} + 2e^{x} 3 = 0$.
- 6. Use the laws of logarithms to:

a) Expand
$$\log\left(\frac{x\sqrt{y+1}}{z^3}\right)$$
 as much as possible;

b) Combine $2\ln(x) - \frac{1}{3}\ln(y) + 3\ln(z)$ into a single logarithm.

7. A sector of a circle of radius 3 has central angle 40°. Find the exact values of: a) the perimeter of the sector; and b) the area of the sector.

Find the exact values of:

$$8.\,\sin\!\left(\frac{11\pi}{12}\right);\qquad \qquad 9.\,\cos\!\left(\frac{13\pi}{8}\right).$$

10. If $\sin x = \frac{4}{5}$ and x is in the second quadrant, find the exact value of $\cos 2x$.

11. Verify the identity:
$$\frac{1}{1-\sin^2 x} = 1 + \tan^2 x$$
.

12. The population of a bacterial colony doubles every 90 minutes. The colony initially has 120 individuals.

a) Give an equation for the number n(t) of individuals in the colony after t hours.

b) When will there be a million individuals in the colony?

13. Find the exact value of $\sin(\sin^{-1}(\frac{3}{4}) - \cos^{-1}(\frac{1}{3}))$.

14. Find all solutions to the following system of equations:

2x + 4y - 2z = 6x + 4y + 2z = 7x + 6y + 5z = 11.

15. For the function $f(x) = 3\sin\left(2(x-\frac{\pi}{4})\right)$:

a) Find the amplitude, period and phase shift;

b) Sketch the graph of two complete periods of f.

16. Angle A of a triangle is 34° , and the two sides adjacent to this angle are b = 5 and c = 6. Find the length of the side a opposite angle A, to the nearest tenth.

17. If G(x,y) = 16x + 14y is the objective function, find the maximum and minimum values of G on the region given by:

 $3x + 2y \le 12$ $7x + 5y \le 29$ $x \ge 0$ $y \ge 0.$