



2013-14 Assessment of General Education Outcomes

Quantitative Reasoning **(Full Report)**

Office of Institutional Assessment and Evaluation

July, 2014

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

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Executive Summary

In the Spring Semester of 2014, the Office of Institutional Assessment and Evaluation (OIAE) consulted with chairs of the departmental final examination committees for College Algebra I, College Algebra II, Pre-calculus, Calculus I, and Applied 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 match each question on their respective exams with one 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. Problems were selected based on two criteria: (a) the number of problems available to measure a particular competency; and (b) whether or not the item was similar to or identical to problems measured in previous years. Thus, seven (7), eight (8), seven (7), eight (8), and six (6) questions were used to collect information on student performance on the aforementioned competencies for College Algebra I, College Algebra II, Pre-Calculus, Calculus I, and Applied Calculus, respectively. *The final decision on matching items with their respective competencies was based solely on the recommendation from the examination chairs.* 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 95.2% (40 out of 42).

Key Findings

Across all courses – College Algebra I, College Algebra II, Pre-calculus, Calculus and Applied 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 QRC1, QRC2, and QRC3 on the College Algebra I final examination. Student performance on the quantitative reasoning competencies for College Algebra II, Pre-Calculus, and Calculus I were mixed. In regards to gender, females outperformed males on each quantitative reasoning competency on the College Algebra I, College Algebra II, and Calculus I final examination. Males outperformed females on each quantitative reasoning competency on the 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, 32.2% of females,

39.5% of males, and 30.9% 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 AY2014-15 dollars would be \$863,380. This estimate is based on 95 of 535 students (17.8%) re-enrolling in College Algebra I (3 credits), 67 of 424 students (15.8%) re-enrolling in College Algebra II, 28 of 159 students (17.6%) re-enrolling in Pre-calculus (4 credits), 28 of 131 students (21.4%) re-enrolling in Calculus I, and 26 of 178 students (14.6%) re-enrolling in Applied Calculus at the undergraduate part-time rate of \$980 per credit hour. The attrition rates by student classification and gender are a major cause for concern.

Conclusions and Recommendations

- 1. Approximately 47% 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 41% 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 (30.9%), females (32.2%), and males (39.5%) 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, Pre-calculus, Calculus I, and Applied 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, Pre-calculus, Calculus I, and Applied 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, 2014



Office of Institutional Assessment and Evaluation

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2013-14 Assessment of General Education Outcomes *Quantitative Reasoning*

The Assessment of Quantitative Reasoning

In the Spring Semester of 2014, the Office of Institutional Assessment and Evaluation (OIAE) consulted with chairs of the departmental final examination committees for College Algebra I, College Algebra II, Pre-calculus, Calculus I, and Applied 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 four goals for this assessment activity for AY 2013-2014: (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, (3) to increase the response rate among professors who report their students’ performance data, and (4) to assesses student quantitative reasoning competency in higher level mathematics courses. To improve the measurement of the competencies, OIAE continued the tradition of collecting 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.

In most instances, 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. The College Algebra II, Applied Calculus, and Calculus I final examinations gave students to option to solve problems on a particular part/section of the exam. For example, the Applied Calculus final examination consisted of 15 problems, however, students were instructed to “answer any 10 problems”. As a result, some quantitative reasoning competencies were either (1) only measured by one problem (if that particular problem was located in a section of the examination where student responses were required) or (2) not measured at all (if the problems measuring a particular competency were located in a section where student responses were optional). In spring 2014, there were a total of 18 sections of College Algebra I. Of these 18 sections, data from 2 of the sections were not submitted to the OIAE, which accounted for 12.1% (65 of 535) of the original students enrolled in College Algebra I. There were a total of 14 sections of College Algebra II, 5 sections of Pre-Calculus, 5 sections of Calculus I, and 5 sections of Applied Calculus. Data from all sections of College Algebra II, Pre-Calculus, Calculus I, and Applied Calculus were submitted to the OIAE.

The question number, the point value, the statement of the question, and the related competency are presented in Tables 1, 8, 16, 21, and 27 for College Algebra I, College Algebra II, Pre-calculus, Calculus I, and Applied Calculus, respectively. “Competent” performance was defined as earning a question or final examination score of at least 60%.

Key Terms and Definitions

- A *valid case* is any student who sat for the departmental final exam and have a question and/or exam score that was reported to the OIAE
- An *original enrollee* is any student who was enrolled in a mathematics course at the start of the spring 2014 semester

College Algebra I

The final examination for College Algebra I for Spring Semester 2014 consisted of 13 questions and a total possible score of 200 points. Table 1 presents the questions that were selected to measure each of three competencies (QRC1, QRC2, and QRC3). Questions 2 and 5 were selected to measure QRC1. Questions 1 and 4 were selected to measure QRC2. Questions 3, 7, and 8 were selected to measure QRC3. 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 65.6% (351 of 535) of the enrollees had a final exam score and, therefore, were considered “valid cases” for these analyses. Thus, 22.2% (119 of 535) 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 65 students enrolled in College Algebra I were not submitted to the OAIE, accounting for 30.2% (65 of 215) of the missing data. Still, the retention rate for College Algebra I was above 50% across all schools and colleges, ranging for 60% to 81.3%. Across all sections of College Algebra I, the results of data analyses on student performance indicate that for:

- ***(QRC1): interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them***, 33.1% (106 of 320) of the valid cases earned a competency score of 60% or higher, and 19.8% (106 of 535) of the original enrollees earned a competency score of 60% or higher.
- ***(QRC2): represent mathematical information symbolically, visually, numerically, and verbally***, 44.4% (154 of 347) of the valid cases earned a competency score of 60% or higher, and 28.8% (154 of 535) of the original enrollees earned a competency score of 60% or higher.
- ***(QRC3): use arithmetical, algebraic, geometric and statistical methods to solve problems***, 64.8% (225 of 347) of the valid cases earned a competency score of 60% or higher, and 42.1% (225 of 535) of the original enrollees earned a competency score of 60% or higher.

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

Question # (Points)	Question Description	QR Competency Measured
2. (10pts)	Find the domain of $f(x) = \sqrt{x^2 - 4}$.	(1) Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
5. (20pts)	(a) Factor a polynomial $x^3 - 9x^2 + x - 9$ and find its zeroes. (b) Find the x and y-intercepts of the graph of the equation $y = x^3 - 9x^2 + x - 9$	
1. (20pts)	The function $f(x)$ is a piecewise defined function given by $f(x) = \begin{cases} 2x & \text{if } x < 0 \\ x + 2 & \text{if } 0 \leq x \leq 2 \\ x^2 & \text{if } x > 2 \end{cases}$ (a) Find $f(-1)$, $f(0)$, $f(1)$, $f(2)$ and $f(10)$. (b) Draw the graph of f .	(2) Represent mathematical information symbolically, visually, numerically, and verbally.
4. (20pts)	Given that $f(x) = 2x^2 + 3x + 1$ find the following: (a) The vertex, axis of symmetry and the intercepts of the parabola that is the graph of the function. (b) The graph of the function.	
3. (20pts)	Given that $f(x) = 2x + 1$, $g(x) = (x - 1)/2$ find the following: (a) $f(0)$, $f(1/2)$. (b) $(f \circ f)(x)$ and $(f \circ g)(x)$.	(3) Use arithmetical, algebraic, geometric and statistical methods to solve problems
7. (10pts)	Solve $4^{1-z} = 1/8^z$ for x.	
8. (10pts)	Solve the equation $3x + 2 = 6x - 7$.	

For the final exam score, 43% (151 of 351) of the valid cases earned a final exam score of 60% or higher, and 28.2% (151 of 535) of the original enrollees earned a final exam 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=323 of 535, 60.4%) and the smallest representation was from the School of Education (N=10 of 535, 1.9%).

The results indicate that the School of Education had the highest percentage of valid cases who earned a total score of 60% or higher (N=3 of 6, 50%). The School of Communications had the lowest percentage of students of valid cases who earned a total score of 60% or higher (N=20 of 55, 36.4%). The results for the other schools and colleges were as follows: College of Arts and Sciences (N=94 of 211, 44.5%), School of Business (N=16 of 36, 44.4%), College of Nursing and Allied Health Sciences (N=13 of 30, 43.3%), and College of Engineering, Architecture & Computer Science (N=5 of 13, 38.5%). At the institutional level, the percent of valid cases who earned a score of 60% or higher was 43%. This does not mean that only 43% of students who took the test earned a passing grade (grade D or better) in College Algebra I. Rather, these results indicate that about 43% 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 22.2% to 31.3%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 28.2%. This does not mean that only 28.2% of the original enrollees earned a passing grade (grade D or better) in College Algebra I. Rather, these results indicate that 28.2% of the original enrollees were able to demonstrate the minimum level of competency on their College Algebra I final examination.

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 535 students enrolled in the course, freshmen had the largest representation (N=330 of 535, 61.7%), while seniors had the smallest representation (N=45 of 535, 8.4%). The results also indicate that juniors had the highest percentage of valid cases who earned a total score of 60% or higher (N=23 of 44, 52.3%). Seniors had the lowest percentage of valid cases who earned a total score of 60% or higher (N=3 of 15, 20.0%).

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=228 of 330, 69.1%); sophomores (N=64 of 95, 67.4%); juniors (N=44 of 65, 66.7%); and seniors (N=15 of 45 33.3%). Essentially, about a third all freshmen, sophomores, and juniors who were enrolled in College Algebra I 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.

**Table 2. Quantitative Reasoning for Spring Semester 2014 by School and College
Algebra 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
College of Arts & Sciences	323	129	194	2 & 5 (QRC1)	61	31.4%	18.9%
	323	113	210	1 & 4 (QRC2)	91	43.3%	28.2%
	323	113	210	3, 7, & 8 (QRC3)	136	64.8%	42.1%
	323	112	211	Total Exam	94	44.5%	29.1%
College of Engineering, Architecture & Computer Science	16	3	13	2 & 5 (QRC1)	4	30.8%	25.0%
	16	3	13	1 & 4 (QRC2)	7	53.8%	43.8%
	16	3	13	3, 7, & 8 (QRC3)	10	76.9%	62.5%
	16	3	13	Total Exam	5	38.5%	31.3%
School of Education	10	4	6	2 & 5 (QRC1)	2	33.3%	20.0%
	10	4	6	1 & 4 (QRC2)	5	83.3%	50.0%
	10	4	6	3, 7, & 8 (QRC3)	5	83.3%	50.0%
	10	4	6	Total Exam	3	50.0%	30.0%
College of Nursing and Allied Health Sciences	44	17	27	2 & 5 (QRC1)	11	40.7%	25.0%
	44	16	28	1 & 4 (QRC2)	14	50.0%	31.8%
	44	16	28	3, 7, & 8 (QRC3)	20	71.4%	45.5%
	44	14	30	Total Exam	13	43.3%	29.5%
School of Business	52	21	31	2 & 5 (QRC1)	12	38.7%	23.1%
	52	16	36	1 & 4 (QRC2)	14	38.9%	26.9%
	52	16	36	3, 7, & 8 (QRC3)	26	72.2%	50.0%
	52	16	36	Total Exam	16	44.4%	30.8%
School of Communications	90	41	49	2 & 5 (QRC1)	16	32.7%	17.8%
	90	36	54	1 & 4 (QRC2)	23	42.6%	25.6%
	90	36	54	3, 7, & 8 (QRC3)	28	51.9%	31.1%
	90	35	55	Total Exam	20	36.4%	22.2%
Institutional Results	535	215	320	2 & 5 (QRC1)	106	33.1%	19.8%
	535	188	347	1 & 4 (QRC2)	154	44.4%	28.8%
	535	188	347	3, 7, & 8 (QRC3)	225	64.8%	42.1%
	535	184	351	Total Exam	151	43.0%	28.2%
<p><i>Note:</i> (1) <i>Institutional Results</i> include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Allied Health Sciences, School of Business, and School of Communications. (2) <i>Number of Cases</i> indicates the number of students on the official class roster. (3) <i>Withdrew or No Score</i> 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) <i>Valid Cases</i> indicate the number of cases included in the analysis for which there is a question or exam score.</p>							

**Table 3. Quantitative Reasoning for Spring Semester 2014 by Student Classification
College Algebra I Final Examination**

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
Freshman	330	111	219	2 & 5 (QRC1)	75	34.2%	22.7%
	330	104	226	1 & 4 (QRC2)	104	46.0%	31.5%
	330	104	226	3, 7, & 8 (QRC3)	153	67.7%	46.4%
	330	102	228	Total Exam	100	43.9%	30.3%
Sophomore	95	37	58	2 & 5 (QRC1)	17	29.3%	17.9%
	95	31	64	1 & 4 (QRC2)	27	42.2%	28.4%
	95	32	63	3, 7, & 8 (QRC3)	38	60.3%	40.0%
	95	31	64	Total Exam	25	39.1%	26.3%
Junior	65	34	31	2 & 5 (QRC1)	12	38.7%	18.5%
	65	22	43	1 & 4 (QRC2)	19	44.2%	29.2%
	65	22	43	3, 7, & 8 (QRC3)	29	67.4%	44.6%
	65	21	44	Total Exam	23	52.3%	35.4%
Senior	45	33	12	2 & 5 (QRC1)	2	16.7%	4.4%
	45	31	14	1 & 4 (QRC2)	4	28.6%	8.9%
	45	30	15	3, 7, & 8 (QRC3)	5	33.3%	11.1%
	45	30	15	Total Exam	3	20.0%	6.7%
Institutional Results	535	215	320	2 & 5 (QRC1)	106	33.1%	19.8%
	535	188	347	1 & 4 (QRC2)	154	44.4%	28.8%
	535	188	347	3, 7, & 8 (QRC3)	225	64.8%	42.1%
	535	184	351	Total Exam	151	43.0%	28.2%
<p><i>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.</i></p>							

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 6.7% for seniors to 35.4% for juniors.

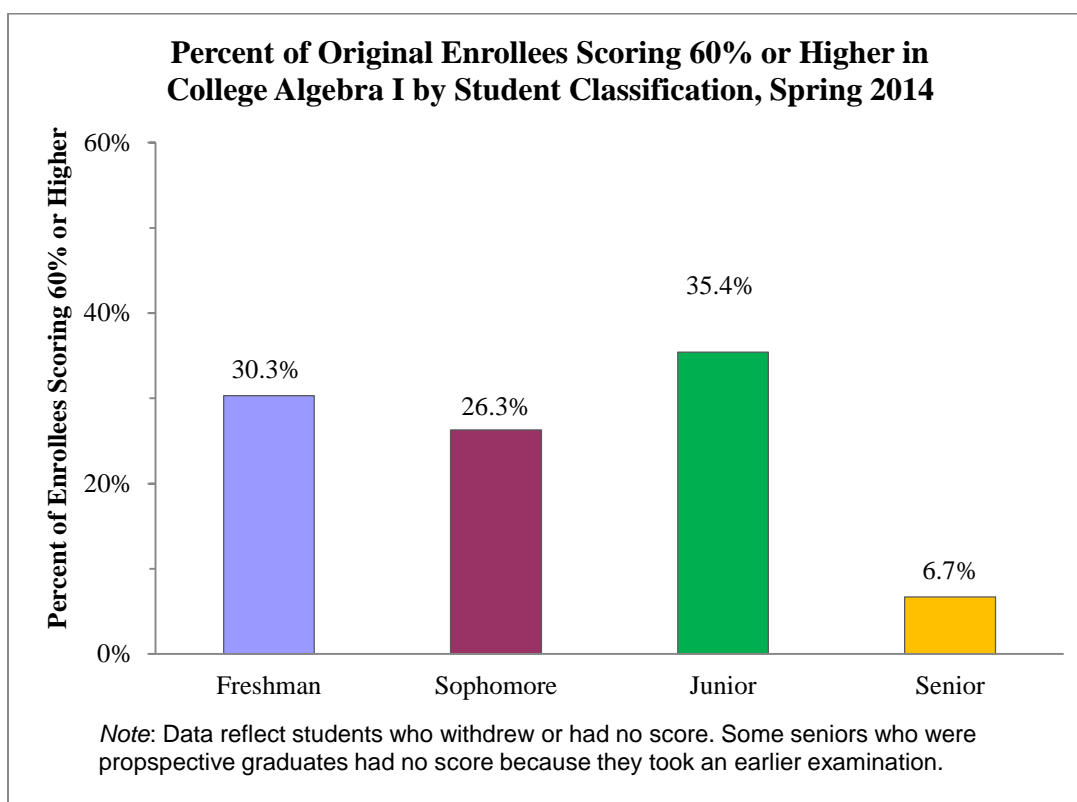


Figure 1

Descriptive Statistics by Student Classification: College Algebra I

Table 4 provides descriptive statistics for the 351 valid cases who took the department final examination in College Algebra I in Spring Semester 2014. Valid cases are those students for whom a question or final examination score is reported. Observed scores on the final examination ranged from 0 to 185. The highest mean score and the lowest variability occurred among juniors ($M=110.59$, $SD=37.38$). The lowest mean score and highest variability occurred among seniors ($M=64.53$, $SD=56.57$).

**Table 4. Descriptive Statistics for Algebra I by Student Classification
Spring Semester 2014**

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	228	0	185	107.23	40.98
Sophomore	64	0	178	92.95	51.63
Junior	44	0	163	110.59	37.38
Senior	15	0	148	64.53	56.57
Institutional Results	351	0	185	103.23	44.37

Figure 2 presents the mean score percentages on the College Algebra I final examination by student classification for valid cases only. Overall, the mean score percentage for all student classifications -- freshmen, sophomores, juniors and seniors – were all below the minimum mean criterion performance 60% or a D grade (120 of 200).

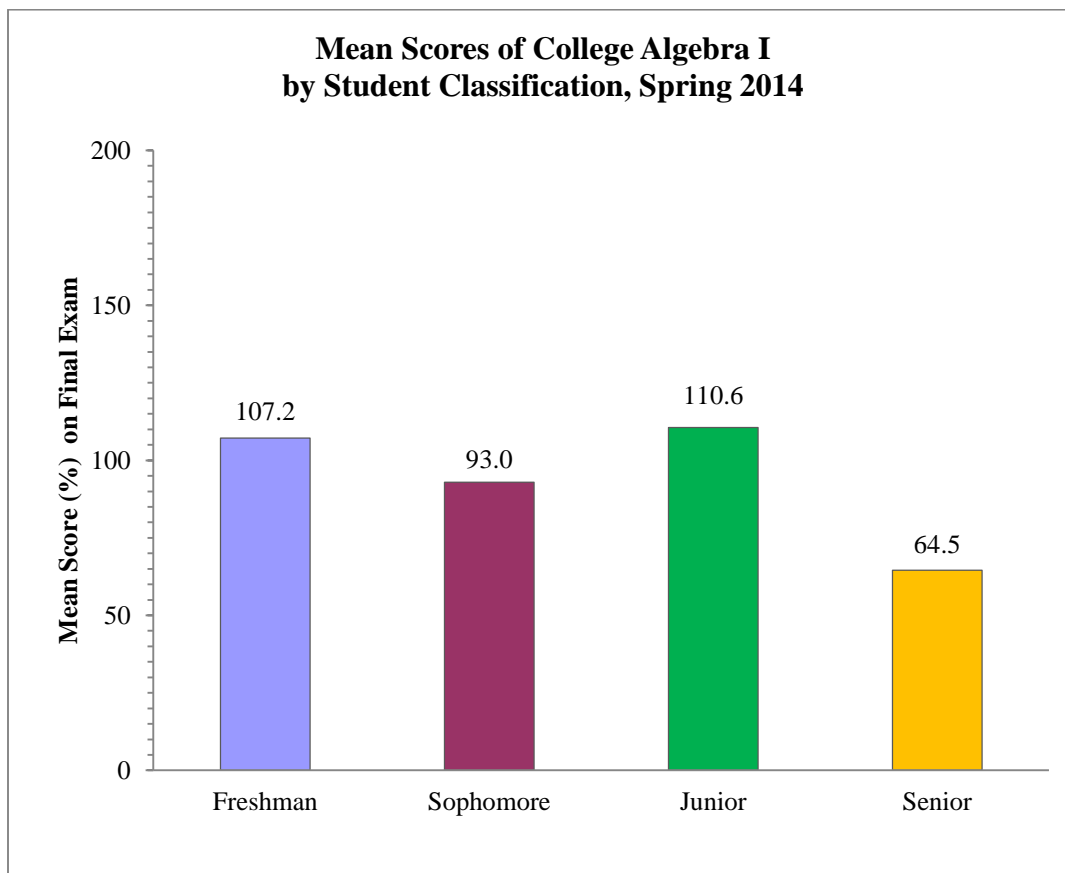


Figure 2

Inferential Statistics by Student Classification: College Algebra I

F-Test: An Analysis of Variance (ANOVA) was conducted to assess mean differences in total exam score by student classification. As indicated in Table 5, there is a statistically significant difference in the mean exam scores by classification on the departmental final examination for College Algebra I, $F(3,347)=6.236, p<.001$.

**Table 5. ANOVA for Final Exam Score
by Student Classification in College Algebra I**

	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	Sig.
Between Groups	35257.310	3	11752.437	6.236	<.001
Within Groups	653937.909	347	1884.547		
Total	689195.219	350			

A post hoc analysis was performed to examine pair-wise differences in mean performances by student classification. Table 6 shows that the mean score for juniors is significantly higher than the mean score for seniors. Thus, compared to seniors, juniors had significantly higher exam scores on the College Algebra I. There were no other statistically significant differences in total exam score between any other group means. There was, however, a significant difference in QRC1 scores based on classification $F(3,316)=3.73, p<.05$. Both freshman and juniors had significantly higher scores on QRC1 than their senior counterparts. Lastly, there was a significant difference in QRC3 scores based on classification $F(3,343)=8.03, p<.001$. Freshmen had significantly higher scores on QRC3 than sophomores.

Table 6. Post Hoc Multiple Comparisons for Final Exam Score by Student Classification in College Algebra I

(I) Classification	(J) Classification	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Junior	Freshman	3.3585	6.2546	.995	-13.617	20.334
	Sophomore	17.6378	8.5675	.227	-5.334	40.609
	Senior	46.0576	15.6553	.050	-.066	92.181

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

Results by Gender: College Algebra I

Of the 535 students enrolled in College Algebra I, 69.7% (N=373 of 535) were female and 30.3% (N=162 of 535) were male, thereby reflecting a ratio of females to males of more than 2:1. Table 7 shows that of the three competencies measured, females and males performed better on (QRC3). Males performed slightly better than females on QRC3, however, the difference was not statistically significant. Overall, females performed slightly better than males on the Algebra I final examination, however, this difference was not statistically significant. Attrition rates were moderate among females (N=120 of 373 or 32.2%) and males (N=64 of 162 or 39.5%). Table 7 shows that only 30% of females (N=112 of 373) and 24.1% of males (N=39 of 162) who originally enrolled in College Algebra I earned a score of 60% or higher on the final examination.

An independent *t*-test was conducted to assess gender differences in total final exam scores and in each of the quantitative reasoning competencies. The *t*-test for the total exam score, QRC2, and QRC3 did not yield any significant results. However, the *t*-test for QRC 1 was statistically significant, $t(318) = 2.60, p=.01$. Females scored significantly higher on QRC1 than their male counterparts.

**Table 7. Quantitative Reasoning for Spring Semester 2014 by Gender
College Algebra I 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	373	141	232	2 & 5 (QRC1)	83	35.8%	22.3%
	373	124	249	1 & 4 (QRC2)	118	47.4%	31.6%
	373	124	249	3, 7, & 8 (QRC3)	159	63.9%	42.6%
	373	120	253	Total Exam	112	44.3%	30.0%
Male	162	74	88	2 & 5 (QRC1)	23	26.1%	14.2%
	162	64	98	1 & 4 QRC2)	36	36.7%	22.2%
	162	64	98	3, 7, & 8 (QRC3)	66	67.3%	40.7%
	162	64	98	Total Exam	39	39.8%	24.1%
Institutional Results	535	215	320	2 & 5 (QRC1)	106	33.1%	19.8%
	535	188	347	1 & 4 (QRC2)	154	44.4%	28.8%
	535	188	347	3, 7, & 8 (QRC3)	225	64.8%	42.1%
	535	184	351	Total Exam	151	43.0%	28.2%
<i>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.</i>							

College Algebra II

The final examination for College Algebra II for Spring Semester 2014 consisted of 16 questions. Questions 1 & 2 were worth 10 points each, questions 3 & 5-7 were worth 20 points each, questions 4 & 10-16 were worth 15 points each, and questions 8 & 9 were worth 5 points each. Students were instructed to answer questions 1-10 and any (4) of questions 11-16. There was a total possible score of 200 points. Table 8 presents the questions that were selected to measure each of four competencies. Questions 1 and 7 were selected to measure QRC1, questions 6 and 10 to measure QRC2, questions 2 and 3 to measure QRC3, and questions 4 and 11 to measure QRC4. 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 75% (318 of 424) of the original enrollees had a final examination score and were considered “valid cases” for these analyses. Thus, 25% (106 of 424) 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). The retention rate for College Algebra II varied across schools and colleges, ranging from 25% among students enrolled in the College of College Engineering, Architecture & Computer Science to 100% among students enrolled in the School of Education. Across all sections of College Algebra II, the results of data analyses on student performance indicate that for:

- ***(QRC1): to interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them***, 43.8% (137 of 313) of the valid cases earned a competency score of 60% or higher, and 32.3% (137 of 424) of the original enrollees earned a score of 60% or higher.
- ***(QRC2): to represent mathematical information symbolically, visually, numerically, and verbally***, 34.2% (102 of 298) of the valid cases earned a competency score of 60% or higher, and 24.1% (102 of 424) of the original enrollees earned a score of 60% or higher.
- ***(QRC3): to use arithmetical, algebraic, geometric and statistical methods to solve problem***, 34.8% (109 of 313) of the valid cases earned a competency score of 60% or higher, and 25.7% (109 of 424) of the original enrollees earned a score of 60% or higher.
- ***(QRC4): to recognize that mathematical and statistical methods have limits***, 29.1% (83 of 285) of the valid cases earned a competency score of 60% or higher, and 19.6% (83 of 424) of the original enrollees earned a score of 60% or higher.

For all questions on the final exam, 32.7% (104 of 318) of the valid cases earned a score of 60% or higher, and 24.5% (124 of 424) of the original enrollees earned a score of 60% or higher.

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

Item # (Points)	Item Description	Competency Measured
1. (10pts)	Solve the following equations for part I. $\log_5 x + \log_5(x + 1) = \log_5 20$	(1) Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
7. (20pts)	Find the center, foci, and vertices of the following ellipse and sketch its graph. $(x + 5)^2 + 4(x - 4)^2 = 16$	
6. (20pts)	Graph the feasible region defined by the following constraints, and maximize the objective function $P(x, y) = 2x + y$ over this region. $x \geq 0, y \geq 0, x + y \leq 3, x + y \geq 1, 2x + y \leq 4$	(2) Represent mathematical information symbolically, visually, numerically, and verbally.
10. (15pts)	Use the indicated matrices to compute; (a) $3A + B$, (b) AC , and (c) B^2 $A = \begin{bmatrix} 0 & 3 & -5 \\ 1 & 2 & 6 \end{bmatrix}, \quad B = \begin{bmatrix} 4 & 1 & 10 \\ -2 & 3 & -2 \end{bmatrix}, \quad C = \begin{bmatrix} 4 & 1 \\ 6 & 2 \\ -2 & 3 \end{bmatrix}$	
2. (10pts)	Write the following expression as a sum and/or difference of logarithms, express all powers as factors. $\ln \left[\sqrt{\frac{x^2 + 4}{(x^2 + 1)(x^3 - 7)^2}} \right]$	(3) Use arithmetical, algebraic, geometric and statistical methods to solve problems
3. (20pts)	For the rational function $R(x) = \frac{x^3 + 1}{x^2 + 2x}$ Find (a) The Domain (interval or set notation) (b) The x- and y- intercept (if any) (c) The Vertical asymptotes (if any) (d) The Horizontal or slant asymptotes (if any)	
4. (15pts)	Solve the following system using Cramer's Rule , if applicable. If Cramer's Rule is not applicable, say so. $\begin{cases} 4x = y - 0 \\ 2x + 7y = 1 \end{cases}$	(4) Recognize that mathematical and statistical methods have limits
11. (15pts)	Find all rational zeros of the polynomial, and write the polynomial in factored form. $H(x) = x^3 + 2x^2 - 5x - 6$	

Results by School/College: College Algebra II

Of the 424 students enrolled in College Algebra II, the largest representation of students was from the College of Arts and Science (N=252 of 424 or 59.4%) and the smallest representation was from the School of Education (N=1 of 424 or 0.2%).

The results indicate that the College of Engineering, Architecture & Computer Science and the School of Education had the highest percentage of valid cases who earned a total score of 60% or higher (N=1 of 1 or 100% for both). For the College of Arts and Sciences which had a much larger representation, 33.3% (64 of 192) of the valid cases earned a total score of 60% or higher. The School of Business had the lowest percentage of valid cases who earned a total score of 60% or higher (N=20 of 83, 24.1%). The results for the other schools and colleges were as follows: College of Nursing and Allied Health Sciences (N=11 of 21, 52.4%), and School of Communications (N=7 of 20, 35%). At the institutional level, 32.7% percent of the valid cases earned a score of 60% or higher on the College Algebra II final examination. This does not mean that only 32.7% of students who took the test earned a passing grade (grade D or better) in College Algebra II. Rather, these results indicate that about 32.7% 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 19.4% to 100%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 24.5%. This does not mean that only 24.5% of the original enrollees earned a passing grade (grade D or better) in College Algebra II. Rather, these results indicate that 24.5% of the students were able to demonstrate the minimum level of competency on their College Algebra II final examination.

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 424 students enrolled in the course, freshmen had the largest representation (N=257 of 424 or 60.6%) and juniors had the smallest representation (N=39 of 424 or 9.2%). The results also indicate that freshmen had the highest percentage of valid cases who earned a total score of 60% or higher (N=81 of 219 or 37%). Seniors had the lowest percentage of valid cases who earned a total score of 60% or higher (N=2 of 15 or 13.3%).

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=219 of 257 or 85.2%); sophomores (N=58 of 74 or 78.4%); juniors (N=26 of 39 or 66.7%); and seniors (N=25 of 54 or 46.3%).

Table 9. Quantitative Reasoning for Spring Semester 2014 by School and College

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
College of Arts & Sciences	252	62	190	1 & 7 (QRC1)	87	45.8%	34.5%
	252	70	182	6 & 10 (QRC2)	66	36.3%	26.2%
	252	63	189	2 & 3 (QRC3)	64	33.9%	25.4%
	252	77	175	4 & 5 (QRC4)	51	29.1%	20.2%
	252	60	192	Total Exam	64	33.3%	25.4%
College Engineering, Architecture & Computer Science	4	3	1	1 & 7 (QRC1)	0	0.0%	0.0%
	4	3	1	6 & 10 (QRC2)	0	0.0%	0.0%
	4	3	1	2 & 3 (QRC3)	1	100.0%	25.0%
	4	3	1	4 & 5 (QRC4)	0	0.0%	0.0%
	4	3	1	Total Exam	1	100.0%	25.0%
School of Education	1	0	1	1 & 7 (QRC1)	0	0.0%	0.0%
	1	0	1	6 & 10 (QRC2)	1	100.0%	100.0%
	1	0	1	2 & 3 (QRC3)	0	0.0%	0.0%
	1	0	1	4 & 5 (QRC4)	1	100.0%	100.0%
	1	0	1	Total Exam	1	100.0%	100.0%
College of Nursing and Allied Health Sciences	32	12	20	1 & 7 (QRC1)	9	45.0%	28.1%
	32	12	20	6 & 10 (QRC2)	11	55.0%	34.4%
	32	12	20	2 & 3 (QRC3)	9	45.0%	28.1%
	32	13	19	4 & 5 (QRC4)	6	31.6%	18.8%
	32	11	21	Total Exam	11	52.4%	34.4%
School of Business	103	20	83	1 & 7 (QRC1)	35	42.2%	34.0%
	103	28	75	6 & 10 (QRC2)	18	24.0%	17.5%
	103	21	82	2 & 3 (QRC3)	23	28.0%	22.3%
	103	32	71	4 & 5 (QRC4)	18	25.4%	17.5%
	103	20	83	Total Exam	20	24.1%	19.4%
School of Communications	32	14	18	1 & 7 (QRC1)	6	33.3%	18.8%
	32	13	19	6 & 10 (QRC2)	6	31.6%	18.8%
	32	12	20	2 & 3 (QRC3)	12	60.0%	37.5%
	32	14	18	4 & 5 (QRC4)	7	38.9%	21.9%
	32	12	20	Total Exam	7	35.0%	21.9%
Institutional Results	424	111	313	1 & 7 (QRC1)	137	43.8%	32.3%
	424	126	298	6 & 10 (QRC2)	102	34.2%	24.1%
	424	111	313	2 & 3 (QRC3)	109	34.8%	25.7%
	424	139	285	4 & 5 (QRC4)	83	29.1%	19.6%
	424	106	318	Total Exam	104	32.7%	24.5%

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.

**Table 10. Quantitative Reasoning for Spring Semester 2014 by Student Classification
College Algebra II Final Examination**

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
Freshman	257	39	218	1 & 7 (QRC1)	102	46.8%	39.7%
	257	52	205	6 & 10 (QRC2)	70	34.1%	27.2%
	257	40	217	2 & 3 (QRC3)	80	36.9%	31.1%
	257	61	196	4 & 5 (QRC4)	57	29.1%	22.2%
	257	38	219	Total Exam	81	37.0%	31.5%
Sophomore	74	20	54	1 & 7 (QRC1)	23	42.6%	31.1%
	74	21	53	6 & 10 (QRC2)	19	35.8%	25.7%
	74	17	57	2 & 3 (QRC3)	22	38.6%	29.7%
	74	21	53	4 & 5 (QRC4)	20	37.7%	27.0%
	74	16	58	Total Exam	17	29.3%	23.0%
Junior	39	13	26	1 & 7 (QRC1)	7	26.9%	17.9%
	39	14	25	6 & 10 (QRC2)	9	36.0%	23.1%
	39	15	24	2 & 3 (QRC3)	7	29.2%	17.9%
	39	17	22	4 & 5 (QRC4)	4	18.2%	10.3%
	39	13	26	Total Exam	4	15.4%	10.3%
Senior	54	39	15	1 & 7 (QRC1)	5	33.3%	9.3%
	54	39	15	6 & 10 (QRC2)	4	26.7%	7.4%
	54	39	15	2 & 3 (QRC3)	0	0.0%	0.0%
	54	40	14	4 & 5 (QRC4)	2	14.3%	3.7%
	54	39	15	Total Exam	2	13.3%	3.7%
Institutional Results	424	111	313	1 & 7 (QRC1)	137	43.8%	32.3%
	424	126	298	6 & 10 (QRC2)	102	34.2%	24.1%
	424	111	313	2 & 3 (QRC3)	109	34.8%	25.7%
	424	139	285	4 & 5 (QRC4)	83	29.1%	19.6%
	424	106	318	Total Exam	104	32.7%	24.5%

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.

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 3.7% for seniors to 31.5% for freshmen.

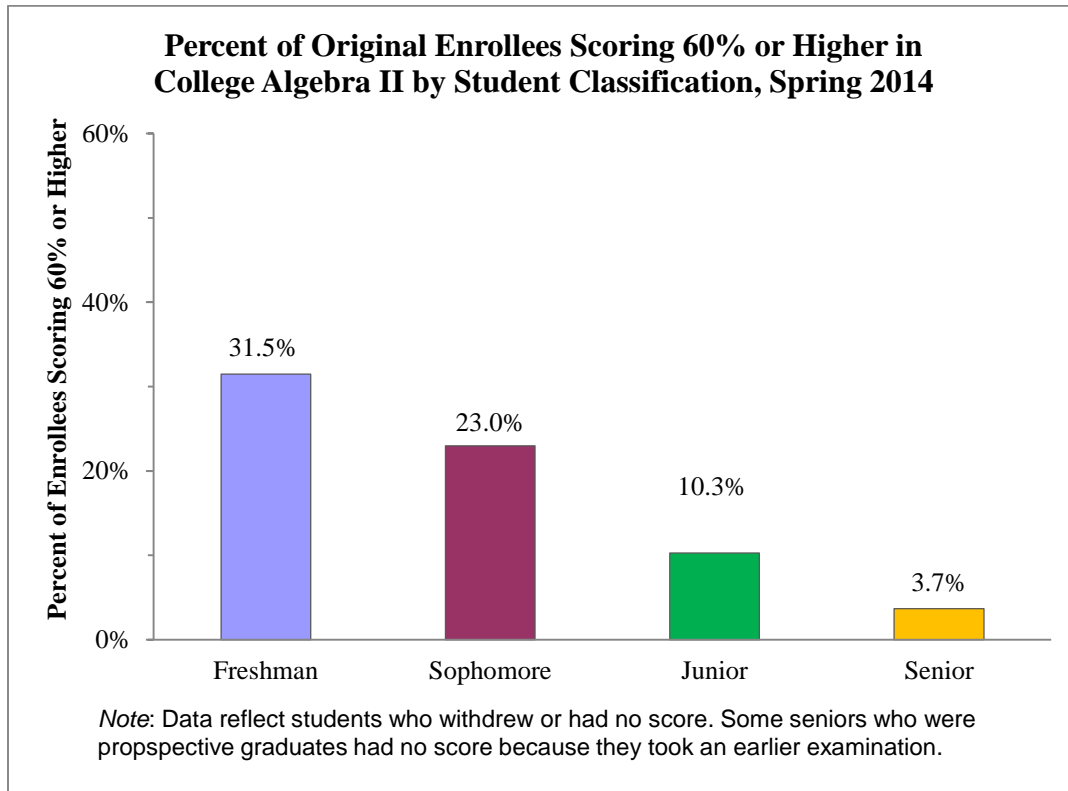


Figure 3

Descriptive Statistics by Student Classification: College Algebra II

Table 11 provides descriptive statistics for the 273 valid cases who took the department final examination in College Algebra II in Spring Semester 2014. Valid cases are those students for whom a question or final examination score is reported. Observed scores on the final examination ranged from 0 to 200. The highest mean score occurred among freshmen ($M=103.54$; $SD=44.93$). The lowest mean score occurred among seniors ($M=70.45$, $SD=48.40$).

Table 11. Descriptive Statistics for College Algebra II by Student Classification Spring Semester 2014

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	189	0	200	103.54	44.93
Sophomore	48	0	200	92.00	50.14
Junior	22	0	180	81.55	42.50
Senior	14	0	143	70.45	48.40
Institutional Results	273	0	200	98.08	46.61

Figure 4 presents the mean score percentages on the College Algebra II final examination by student classification for valid cases only. The graph shows that neither student classification met the minimum mean criterion performance of at least 60% (120 of 200).

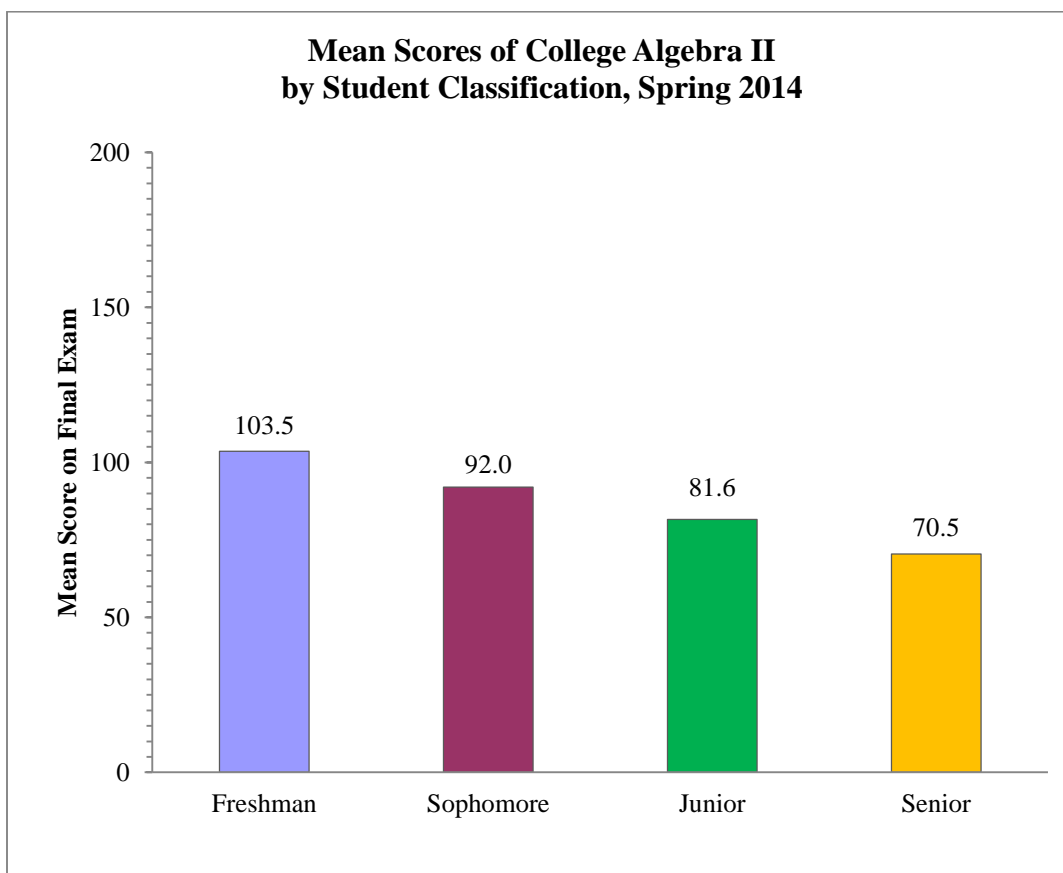


Figure 4

Inferential Statistics by Student Classification: College Algebra II

F-Test and Post Hoc Analyses: An Analysis of Variance (ANOVA) was conducted to compare final exam 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 by student classification on the departmental final examination for College Algebra II, $F(3,314)=4.31$, $p<.01$.

**Table 12. ANOVA for Final Exam Scores
by Student Classification in College Algebra II**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	27219.897	3	9073.299	4.307	.005
Within Groups	661432.143	314	2106.472		
Total	688652.040	317			

A post hoc analysis was performed 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 seniors. There were no other statistically significant differences between any other group means.

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

(I) Classification	(J) Classification	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Freshman	Sophomore	11.5386	6.7777	.324	-5.9670	29.0443
	Junior	21.9843	9.5203	.098	-2.6052	46.5738
	Senior	33.0869	12.2495	.036	1.4484	64.7254

Note: Tukey's honest significant difference (Tukey HSD) Post Hoc test is used, and equal variances are assumed.

Results by Gender: College Algebra II

Of the 424 students enrolled in College Algebra II, 66.5% (N=282 of 424) were female and 33.5% (N=142 of 424) were male, thereby reflecting a ratio of females to males of almost 2:1. Table 14 shows that of the four competencies measured, both females and males performed better on (QRC1). Attrition rates among females (N=61 of 282 or 21.6%) and males (N=45 of 142 or 31.7%) were moderate. Only 28.7% of females (N=81 of 282) and 16.2% of males (N=23 of 142) who originally enrolled in College Algebra II earned a score of 60% or higher on the final examination.

An independent samples *t*-test was conducted to compare final exam scores across gender. The results of the analyses are presented in Tables 15.1 – 15.4. Females performed significantly better than their male counterparts on QRC2, QRC3, and QRC4. Additionally, females performed significantly better than males on the Algebra II final examination, overall. The *t*-test for QRC1 was not significant.

**Table 14. Quantitative Reasoning for Spring Semester 2014 by Gender
College Algebra II 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	282	68	214	1 & 7 (QRC1)	97	45.3%	34.4%
	282	79	203	6 & 10 (QRC2)	77	37.9%	27.3%
	282	67	215	2 & 3 (QRC3)	82	38.1%	29.1%
	282	87	195	4 & 5 (QRC4)	60	30.8%	21.3%
	282	61	221	Total Exam	81	36.7%	28.7%
Male	142	43	99	1 & 7 (QRC1)	40	40.4%	28.2%
	142	47	95	6 & 10 (QRC2)	25	26.3%	17.6%
	142	44	98	2 & 3 (QRC3)	27	27.6%	19.0%
	142	52	90	4 & 5 (QRC4)	23	25.6%	16.2%
	142	45	97	Total Exam	23	23.7%	16.2%
Institutional Results	424	111	313	1 & 7 (QRC1)	137	43.8%	32.3%
	424	126	298	6 & 10 (QRC2)	102	34.2%	24.1%
	424	111	313	2 & 3 (QRC3)	109	34.8%	25.7%
	424	139	285	4 & 5 (QRC4)	83	29.1%	19.6%
	424	106	318	Total Exam	104	32.7%	24.5%

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 15.1 Mean Comparison of QRC2 by Gender for College Algebra II, Spring Semester 2014

Gender	Valid N	Mean of QRC2	Std. Dev.	<i>t</i>	<i>df</i>	Sig. (2-tailed)
Female	208	17.59	10.60	2.032	302	.043
Male	96	14.91	10.90			

Table 15.2 Mean Comparison of QRC3 by Gender for College Algebra II, Spring Semester 2014

Gender	Valid N	Mean of QRC3	Std. Dev.	<i>t</i>	<i>df</i>	Sig. (2-tailed)
Female	215	13.90	8.81	2.466	311	.014
Male	98	11.25	8.85			

Table 15.3 Mean Comparison of QRC4 by Gender for College Algebra II, Spring Semester 2014

Gender	Valid N	Mean of QRC4	Std. Dev.	<i>t</i>	<i>df</i>	Sig. (2-tailed)
Female	195	17.11	11.53	2.201	283	.029
Male	90	13.80	12.31			

Table 15.4 Mean Comparison of Total Exam Score by Gender for College Algebra II, Spring Semester 2014

Gender	Valid N	Mean of Total Exam	Std. Dev.	<i>t</i>	<i>df</i>	Sig. (2-tailed)
Female	221	102.40	47.40	2.516	316	.012
Male	97	88.23	43.41			

Pre-Calculus

The final examination for Pre-calculus for Spring Semester 2014 consisted of 12 questions and a total score of 200 points. Table 16 presents the questions that were identified to measure each of three competencies. Questions 11 and 12 were selected to measure QRC1, questions 1 and 2 to measure QRC2, and questions 3, 5, and 8 to measure QRC3. 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
11. (20 pts)	Suppose that \$12,000 is invested in a savings account paying 5% interest per year. (a) Write the formula for that amount in the account after t years if the interest is compounded monthly. (b) Find the amount in the account after 3 years if the interest is compounded daily. (c) How long will it take for the amount in the account to grow to 20,000 if the interest is compounded continuously?	(1) Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
12. (20 pts)	Graph the feasible region described by the following constraints: $\begin{cases} x \geq 1, \\ y \geq 0, \\ x + y \leq 6, \\ 2x - 3y \geq -3 \end{cases}$	
1. (20 pts)	For the rational function: $G(x) = \frac{3x^3 + 6x^2}{x^2 + x - 2}$ (a) Find the domain. (b) Find the x intercept(s) and the y intercept(s) of f if any. Find all the vertical and horizontal or slant (oblique) asymptote(s) of the graph of f if any.	(2) Represent mathematical information symbolically, visually, numerically, and verbally.
2. (15 pts)	Let $F(x) = x^2 + 1$ (a) What is the range of F , if the domain is $[0,1]$? (b) What is the range F , if the domain is $[-1,1]$? (c) Sketch the graph F for both domains. (d) Does F have an inverse function if the domain is $[-1,1]$? Why or why not? If it does find its inverse sketch, its graph and find the range of the inverse? (e) Does F have an inverse function if the domain is $[0,1]$? Why or why not? If it does find its inverse sketch, its graph and find the range of the inverse?	
3 (20 pts)	(a) Solve the equation: $\log_2 x + \log_2(x - 2) = \log_3 27$ (b) Use laws of logarithms to expand $\log\left(\frac{x^5\sqrt{x-1}}{2x-3}\right)$	(3) Use arithmetical, algebraic, geometric and statistical methods to solve problems.
5. (15 pts)	Find all solutions of following system of linear equations: $\begin{cases} x + y + z &= 1 \\ x + 2y + 3z &= 4 \\ -4x + 5y + 6z &= -7 \end{cases}$	
8. (10 pts)	Find all solutions of the trigonometric equation $4 \cos^2 \theta - 4 \cos \theta + 1 = 0$ for θ	

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 124 of 159 or 78% of the original enrollees had a final examination score and were considered “valid cases” for these analyses. Thus, 35 of 159 or 25.2% 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). The retention rate for Pre-calculus varied across the schools and colleges represented, ranging from 50.0% (N=1 of 2) among students enrolled in the School of Business to 100% (N=1 of 1) among students enrolled in the School of Communications. Across all sections of Pre-calculus, the results of data analyses on student performance indicate that for:

- ***(QRC1): interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them***, 45.9% (56 of 122) of the valid cases earned a competency score of 60% or higher.
- ***(QRC2): represent mathematical information symbolically, visually, numerically, and verbally***, 66.7% (82 of 123) of the valid cases earned a competency score of 60% or higher.
- ***(QRC3): use arithmetical, algebraic, geometric and statistical methods to solve problems***, 61.0% (75 of 123) of the valid cases earned a competency score of 60% or higher.

For all questions on the final examination, 51.6% (64 of 124) of the valid cases earned a final exam score of 60% or higher, and 40.3% (64 of 159) of the original enrollees earned a final exam score of 60% or higher.

Results by School/College: Pre-calculus

Of the 159 students enrolled in Pre-calculus, the largest representation of students was from the College of Arts and Science (N=125 of 159 or 78.6%) and the smallest representation was from the School of Communications (N=1 of 159 or 0.6%).

The results indicate that the School of Communications had the highest percentage of valid cases who earned a total score of 60% or higher (N=1 of 1 or 100%). The College of Nursing and Allied Health Sciences followed with the second highest percentage of valid cases to earn a total score of 60% or higher, 75% (N= 6 of 8). The School of Business had the lowest percentage of valid cases to earn a total score of 60% or higher (N=0 of 1 or 0%). No students from the School of Education were enrolled in Pre-calculus.

At the institutional level, the percent of valid cases to earn a score of 60% or higher was 51.6%. This does not mean that only 51.6% of students who took the test earned a passing grade (grade D or better) in Pre-Calculus. Rather, these results indicate that about 51.6% of the students were able to demonstrate the minimum level of competency on their Pre-Calculus 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 40.3%. This does not mean that only 40.3% of the original enrollees earned a passing grade (grade D or better) in Pre-calculus. Rather, these results indicate that 40.3% 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 159 students enrolled in the course, freshmen had the largest representation (N=110 of 159 or 69.2%), while juniors had the smallest representation (N=12 of 159 or 7.5%). The results also indicate that freshmen had the highest percentage of valid cases who earned a total score of 60% or higher (N=49 of 92 or 53.3%). Juniors had the lowest percentage of valid cases who earned a total score of 60% or higher (N=4 of 9 or 44.4%).

The results also indicate that retention rates for Pre-calculus decreased as student classification increased with the exception of juniors: freshmen (N=92 of 110 or 83.6%), sophomores (N=15 of 22 or 68.2%), juniors (N=9 of 12 or 75.0%), and seniors (N=8 of 15 or 53.3%) (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 26.7% for seniors to 44.5% for freshmen.

**Table 17. Quantitative Reasoning for Spring Semester 2014 by School and College
Pre-calculus Final Examination**

Student School/College	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
College of Arts & Sciences	125	28	97	11 & 12 (QRC1)	42	43.3%	33.6%
	125	28	97	1 & 2 (QRC 2)	63	64.9%	50.4%
	125	28	97	3, 5, & 8 (QRC3)	57	58.8%	45.6%
	125	28	97	Total Exam	47	48.5%	37.6%
College Engineering, Architecture & Computer Science	21	4	17	11 & 12 (QRC1)	9	52.9%	42.9%
	21	4	17	1 & 2 (QRC 2)	13	76.5%	61.9%
	21	4	17	3, 5, & 8 (QRC3)	11	64.7%	52.4%
	21	4	17	Total Exam	10	58.8%	47.6%
College of Nursing and Allied Health Sciences	10	3	7	11 & 12 (QRC1)	5	71.4%	50.0%
	10	3	7	1 & 2 (QRC 2)	5	71.4%	50.0%
	10	3	7	3, 5, & 8 (QRC3)	6	85.7%	60.0%
	10	2	8	Total Exam	6	75.0%	60.0%
School of Business	2	1	1	11 & 12 (QRC1)	0	0.0%	0.0%
	2	1	1	1 & 2 (QRC 2)	0	0.0%	0.0%
	2	1	1	3, 5, & 8 (QRC3)	0	0.0%	0.0%
	2	1	1	Total Exam	0	0.0%	0.0%
School of Communications	1	1	0	11 & 12 (QRC1)	0	-	0.0%
	1	0	1	1 & 2 (QRC 2)	1	100.0%	100.0%
	1	0	1	3, 5, & 8 (QRC3)	1	100.0%	100.0%
	1	0	1	Total Exam	1	100.0%	100.0%
Institutional Results	159	37	122	11 & 12 (QRC1)	56	45.9%	35.2%
	159	36	123	1 & 2 (QRC 2)	82	66.7%	51.6%
	159	36	123	3, 5, & 8 (QRC3)	75	61.0%	47.2%
	159	35	124	Total Exam	64	51.6%	40.3%

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Communication, Business, 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.

**Table 18. Quantitative Reasoning for Spring Semester 2014 by Student Classification
Pre-calculus 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
Freshman	110	18	92	11 & 12 (QRC1)	44	47.8%	40.0%
	110	18	92	1 & 2 (QRC 2)	62	67.4%	56.4%
	110	18	92	3, 5, & 8 (QRC3)	56	60.9%	50.9%
	110	18	92	Total Exam	49	53.3%	44.5%
Sophomore	22	7	15	11 & 12 (QRC1)	5	33.3%	22.7%
	22	7	15	1 & 2 (QRC 2)	8	53.3%	36.4%
	22	7	15	3, 5, & 8 (QRC3)	9	60.0%	40.9%
	22	7	15	Total Exam	7	46.7%	31.8%
Junior	12	4	8	11 & 12 (QRC1)	4	50.0%	33.3%
	12	3	9	1 & 2 (QRC 2)	7	77.8%	58.3%
	12	3	9	3, 5, & 8 (QRC3)	6	66.7%	50.0%
	12	3	9	Total Exam	4	44.4%	33.3%
Senior	15	8	7	11 & 12 (QRC1)	3	42.9%	20.0%
	15	8	7	1 & 2 (QRC 2)	5	71.4%	33.3%
	15	8	7	3, 5, & 8 (QRC3)	4	57.1%	26.7%
	15	7	8	Total Exam	4	50.0%	26.7%
Institutional Results	159	37	122	11 & 12 (QRC1)	56	45.9%	35.2%
	159	36	123	1 & 2 (QRC 2)	82	66.7%	51.6%
	159	36	123	3, 5, & 8 (QRC3)	75	61.0%	47.2%
	159	35	124	Total Exam	64	51.6%	40.3%

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.

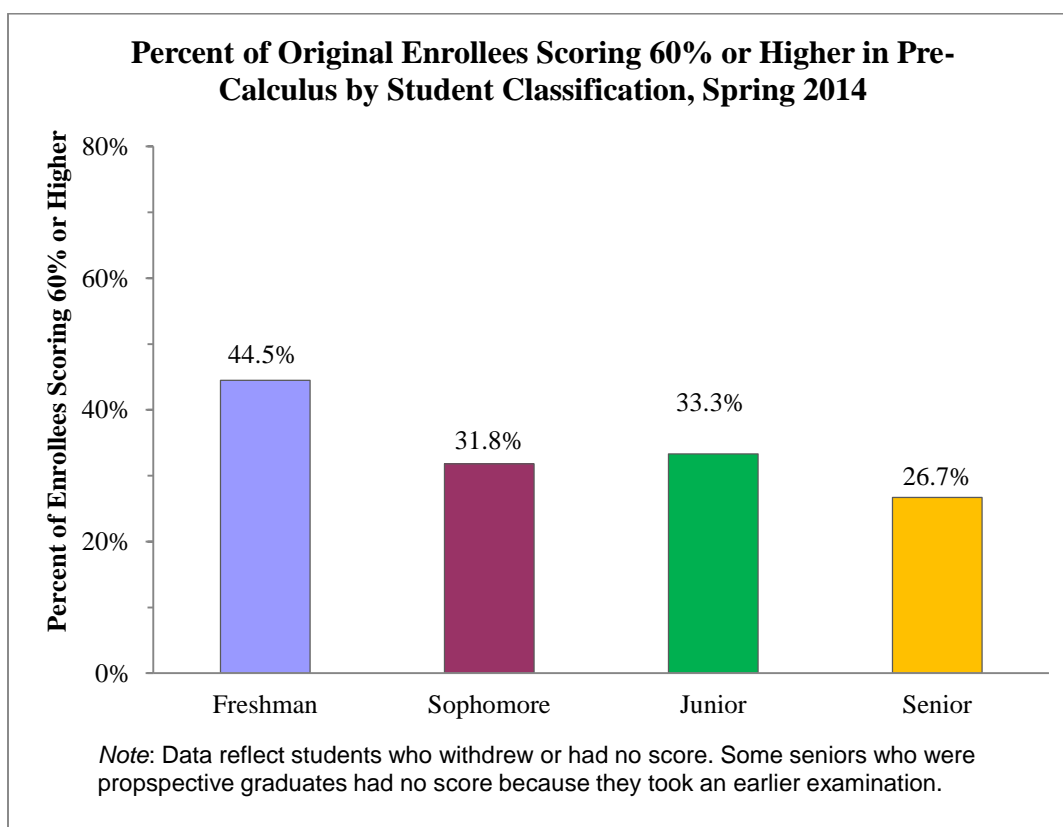


Figure 5

Descriptive Statistics by Student Classification: Pre-calculus

Table 19 provides descriptive statistics for the 124 valid cases who took the department final examination in Pre-calculus in Spring Semester 2014. Valid cases are those students for whom a final examination score is reported. Observed scores on the final examination ranged from 0 to 183. The highest mean score and lowest variability occurred among juniors, $M=124.88$; $SD=33.46$. The lowest mean score occurred among sophomores, $M=109.87$, while the highest variability occurred among seniors, $SD=64.64$.

**Table 19. Descriptive Statistics for Pre-calculus by Student Classification
Spring Semester 2014**

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	92	1	183	115.58	51.29
Sophomore	15	1	180	109.87	53.71
Junior	8	83	168	124.88	33.46
Senior	7	28	178	113.14	64.64
Institutional Results	124	0	183	114.77	51.72

Figure 6 presents the mean scores on the Pre-calculus final examination by student classification for valid cases only. The graph shows that juniors were the only classification of students to meet the minimum mean criterion score of 60% (120 out of 200). Freshmen, sophomores, and seniors did not meet the minimum mean criterion performance of at least 60%.

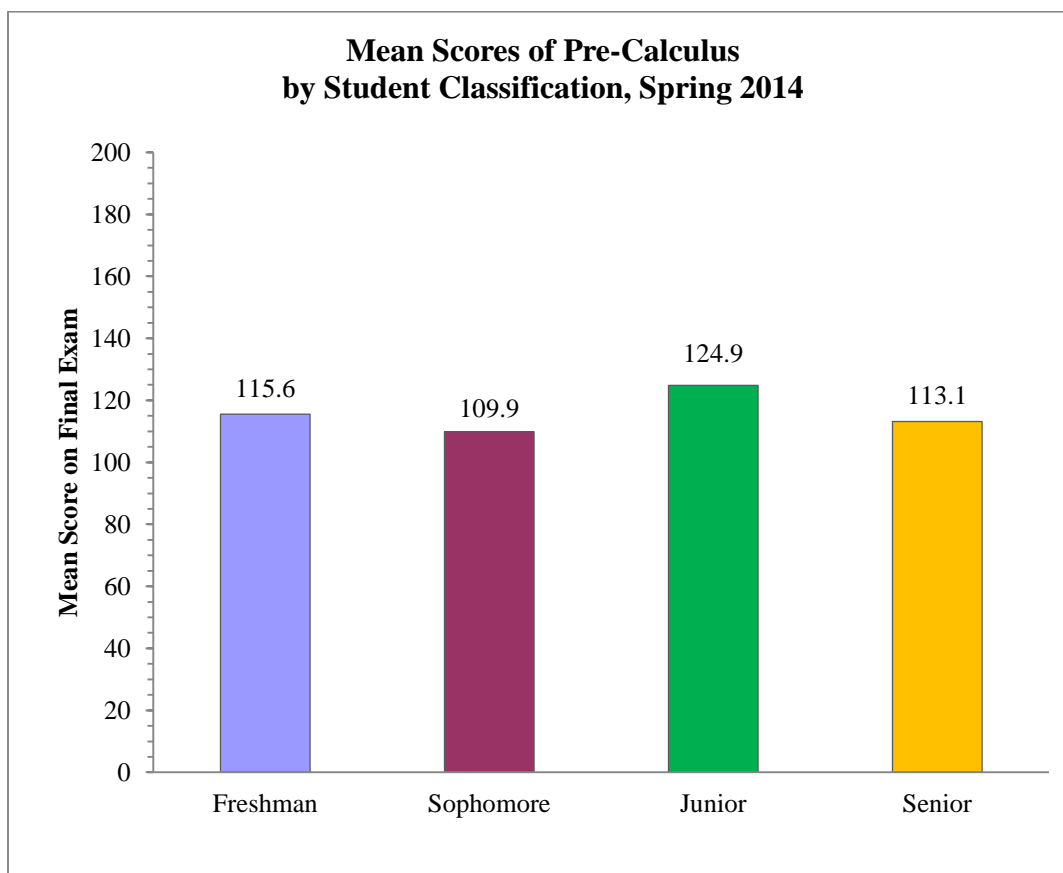


Figure 6

Inferential Statistics by Student Classification: Pre-calculus

F-Test: An Analysis of Variance (ANOVA) was conducted to compare final exam scores across student classification. The results of the *F*-test were not significant $F(3, 120)=.511$, $p=0.676$. There is no statistically significant difference in the mean final exam scores by classification on the departmental final examination for Pre-calculus.

Results by Gender: Pre-Calculus

Of the 159 students enrolled in Pre-Calculus, 70.4% ($N=112$ of 159) were female and 29.6% ($N=47$ of 159) were male. Table 20 shows that of the three competencies measured, males performed their best on (QRC2) and (QRC3), whereas females performed their best on QRC2 only.

A series of independent samples *t*-tests were conducted to compare male and females scores on the three quantitative reasoning competencies, and the total final exam score. The *t*-tests did not reveal any significant findings. There were no gender differences on QRC1, QRC2, QRC3, or total exam score.

**Table 20. Quantitative Reasoning for Spring Semester 2014 by Gender
Pre-Calculus 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	112	27	85	11 & 12 (QRC1)	39	45.9%	34.8%
	112	27	86	1 & 2 (QRC 2)	57	66.3%	50.9%
	112	27	86	3, 5, & 8 (QRC3)	50	58.1%	44.6%
	112	27	87	Total Exam	46	52.9%	41.1%
Male	47	10	37	11 & 12 (QRC1)	17	45.9%	36.2%
	47	10	37	1 & 2 (QRC 2)	25	67.6%	53.2%
	47	10	37	3, 5, & 8 (QRC3)	25	67.6%	53.2%
	47	10	37	Total Exam	18	48.6%	38.3%
Institutional Results	159	37	122	11 & 12 (QRC1)	56	45.9%	35.2%
	159	36	123	1 & 2 (QRC 2)	82	66.7%	51.6%
	159	36	123	3, 5, & 8 (QRC3)	75	61.0%	47.2%
	159	35	124	Total Exam	64	51.6%	40.3%

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.

Calculus I

The final examination for Calculus I for Spring Semester 2014 consisted of 13 questions and a total score of 200 points. Table 21 presents the questions that were identified to measure two competencies. Questions 3, 9 and 12 to measure QRC2, questions 1,2,4,5 and 6 to measure QRC3. Students were instructed to solve all problems in part 1 (Questions 1-6) and to solve any (4) of the problems in Part 2 (questions 7-13). Questions 9 and 12 were excluded from the analysis because they were optional. A copy of the Calculus I final examination is in Appendix D.

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

Table 22 presents the results of student performance on the calculus final examination for all sections by school or college. The results indicate that 74.8% (98 of 131) of the original enrollees had a final examination score and were considered “valid cases” for these analyses. Thus, 33 of 131 or 25.2% 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). The retention rate for Calculus I varied across the schools and colleges represented, ranging from 66.7% (N=2 of 3) among students enrolled in the School of Communications to 100% (N=2 of 2) among students enrolled in the School of Education and the College of Allied Health Sciences. Across all sections of Calculus I, the results of data analyses on student performance indicate that for:

- ***(QRC2): represent mathematical information symbolically, visually, numerically, and verbally***, 21.8% (19 of 87) of the valid cases earned a competency score of 60% or higher, and 14.5% (19 of 131) of the original enrollees earned a competency score of 60% or higher.
- ***(QRC3): use arithmetical, algebraic, geometric and statistical methods to solve problems***, 26.7% (23 of 86) of the valid cases earned a competency score of 60% or higher, and 17.6% (23 of 131) of the original enrollees earned a competency score of 60% or higher.

For all questions on the final examination, 58.6% (82 of 140) of the valid cases earned a final exam score of 60% or higher, and 46.1% (82 of 178) of the original enrollees earned a final exam score of 60% or higher.

Table 21. Questions and QR Competencies for Calculus I Final Examination

Item # (Points)	Item Description	Competency Measured
3. (20 pts)	A small balloon is released at a point 150 feet away from an observer, who is on level ground. If the balloon goes straight up at a rate of 6 feet per second, how fast is the distance from the observer to the balloon increasing when the balloon is 50 feet high?	(2) Represent mathematical information symbolically, visually, numerically, and verbally.
9. (20 pts)	A closed rectangular container with a square base is to have a volume of 2250 cubic inches. The material for the top and bottom of the container will cost \$2 per square inch, and the sides will cost \$3 per square inch. Find the dimensions of the container of least cost.	
12. (20 pts)	Let $g(x) = x + \sin x, 0 \leq x \leq \pi$ (a) Find the area under the graph of g and over the interval $[0, \pi]$. (b) Find the average value of $g(x)$ on the interval $0 \leq x \leq \pi$.	
1. (20 pts)	Find each limit that exists (a finite limit or $+\infty$ or $-\infty$). Otherwise, give reason(s) why the limit does not exist. (a) $\lim_{x \rightarrow 0} \left(\frac{x^2 - 4x + 4}{x^3 - 5x^2 + 14x} \right)$ (b) $\lim_{x \rightarrow \pi^-} \csc x$ (c) $\lim_{h \rightarrow 0} \left(\frac{(x-h)^2 - x^2}{h} \right)$ (d) $\lim_{x \rightarrow \infty} \left(\frac{3x^2 - 4x + 10}{2x^2 - 1} \right)$	(3) Use arithmetical, algebraic, geometric and statistical methods to solve problems.
2. (20 pts)	Find the derivative $y' = dy/dx$ for the following explicitly or implicitly defined functions $y = y(x)$ (c) $y = x \tan^{-1} x - \ln \sqrt{x^2 + 1}$ (d) $y = \cos(\cos(e^x))$ (e) $xy = x - e^y$ (f) $y = x^{x^2}$	
4. (20 pts)	Let $\square(x) = 6x^{4/3} - 3x^{1/3}, -1 \leq x \leq 1$. (a) Find the two critical points of f in the interval $[-1, 1]$. (b) Find the absolute minimum and maximum values of f on the interval $[-1, 1]$.	
5. (20 pts)	Sketch a graph of the function $f(x) = x^4 - 4x^3 + 27 = (x - 3)^2(\square^2 + 2x + 3)$ using the following steps: (a) Identify where the local extrema and inflection points of f occur. (b) Determine the intervals on which f is increasing and the intervals on which f is decreasing. (c) Determine the open interval where f is concave up and where f is concave down. (d) Plot the x -intercept(s), y -intercept, local maxima, local minima, and inflection points of f . Then sketch the curve.	
6. (20 pts)	Evaluate the following integrals. (a) $\int \sin^2 x \cos x \, dx$ (b) $\int \frac{1-2t^3}{t^3} \, dt$ (c) $\int_0^1 \frac{1}{1+x^2} \, dx$ (d) $\int_{-1}^2 (x^2 - x - 2) \, dx$	

Results by School/College: Calculus I

Of the 131 students enrolled in Calculus I, the largest representation of students was from the College of Arts and Science (N=66 of 131 or 50.4%) and the smallest representations came from the School of Education and the College of Allied Health Sciences (N=2 of 131 or 1.5%).

The results indicate that the School of Business had the highest percentage of valid cases who earned a final exam score of 60% or higher (N=2 of 2 or 100%). The results for the College of Arts and Sciences, which had a much larger representation in Calculus I, was 33.3% (15 of 45). The School of Education had the lowest percentage of valid students who earned a total score of 60% or higher (N=0 of 2 or 0%). No students from the School of Communications were enrolled in Calculus I during Spring 2014. At the institutional level, the percent of valid students who earned a score of 60% or higher was 26.5%. This does not mean that only 26.5% of students who took the test earned a passing grade (grade D or better) in Calculus. Rather, these results indicate that about 26.5% of the students were able to demonstrate the minimum level of competency on their Calculus final examination.

Table 22 also presents the percentage of *original enrollees* in Calculus I 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 19.8%. This does not mean that only 19.8% of the original enrollees earned a passing grade (grade D or better) in Calculus. Rather, these results indicate that 19.8% of the students were able to demonstrate the minimum level of competency on their Calculus I final examination.

Results by Student Classification: Calculus I

Table 23 presents the results of student performance on the Calculus I final examination for all classifications of students. Of the 131 students enrolled in the course, freshmen had the largest representation (N=79 of 131 or 60.3%) and seniors had the smallest representation (N=8 of 131 or 6.1%). The results also indicate that sophomores had the highest percentage of valid cases who earned a final exam score of 60% or higher (N=10 of 23 or 43.5%). Freshmen had the lowest percentage of valid cases who earned a final exam score of 60% or higher (N=14 of 69 or 20.3%).

The results also indicate that retention rates for Calculus I decreased as student classification increased with the exception of seniors: freshmen (N=69 of 79 or 87.3%), sophomores (N=23 of 35 or 65.7%), juniors (N=3 of 9 or 33.3%), and seniors (N=3 of 8 or 37.5%) (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 7 presents the percentage of *original enrollees* in Calculus I who earned a score of 60% or higher on the departmental final examination by student classification -- the percentages ranged from 11.1% for juniors to 28.6% for sophomores.

**Table 22. Quantitative Reasoning for Spring Semester 2014 by School and College
Calculus Final Examination**

Student School/College	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
College of Arts & Sciences	66	24	42	3 (QRC2)	10	23.8%	15.2%
	66	24	42	1, 2, 4, 5, & 6 (QRC3)	12	28.6%	18.2%
	66	21	45	Total Exam	15	33.3%	22.7%
College Engineering, Architecture & Computer Science	58	19	39	3 (QRC2)	7	17.9%	12.1%
	58	19	39	1, 2, 4, 5, & 6 (QRC3)	9	23.1%	15.5%
	58	11	47	Total Exam	8	17.0%	13.8%
School of Education	2	0	2	3 (QRC2)	0	0.0%	0.0%
	2	0	2	1, 2, 4, 5, & 6 (QRC3)	0	0.0%	0.0%
	2	0	2	Total Exam	0	0.0%	0.0%
College of Nursing and Allied Health Sciences	2	0	2	3 (QRC2)	2	100.0%	100.0%
	2	1	1	1, 2, 4, 5, & 6 (QRC3)	0	0.0%	0.0%
	2	0	2	Total Exam	1	50.0%	50.0%
School of Business	3	1	2	3 (QRC2)	0	0.0%	0.0%
	3	1	2	1, 2, 4, 5, & 6 (QRC3)	2	100.0%	66.7%
	3	1	2	Total Exam	2	100.0%	66.7%
Institutional Results	131	44	87	3 (QRC2)	19	21.8%	14.5%
	131	45	86	1, 2, 4, 5, & 6 (QRC3)	23	26.7%	17.6%
	131	33	98	Total Exam	26	26.5%	19.8%

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Business, 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.

**Table 23. Quantitative Reasoning for Spring Semester 2014 by Student Classification
Calculus 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
Freshman	79	17	62	3 (QRC2)	11	17.7%	13.9%
	79	18	61	1, 2, 4, 5, & 6 (QRC3)	16	26.2%	20.3%
	79	10	69	Total Exam	14	20.3%	17.7%
Sophomore	35	16	19	3 (QRC2)	6	31.6%	17.1%
	35	14	21	1, 2, 4, 5, & 6 (QRC3)	6	28.6%	17.1%
	35	12	23	Total Exam	10	43.5%	28.6%
Junior	9	6	3	3 (QRC2)	1	33.3%	11.1%
	9	7	2	1, 2, 4, 5, & 6 (QRC3)	0	0.0%	0.0%
	9	6	3	Total Exam	1	33.3%	11.1%
Senior	8	5	3	3 (QRC2)	1	33.3%	12.5%
	8	6	2	1, 2, 4, 5, & 6 (QRC3)	1	50.0%	12.5%
	8	5	3	Total Exam	1	33.3%	12.5%
Institutional Results	131	44	87	3 (QRC2)	19	21.8%	14.5%
	131	45	86	1, 2, 4, 5, & 6 (QRC3)	23	26.7%	17.6%
	131	33	98	Total Exam	26	26.5%	19.8%

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.

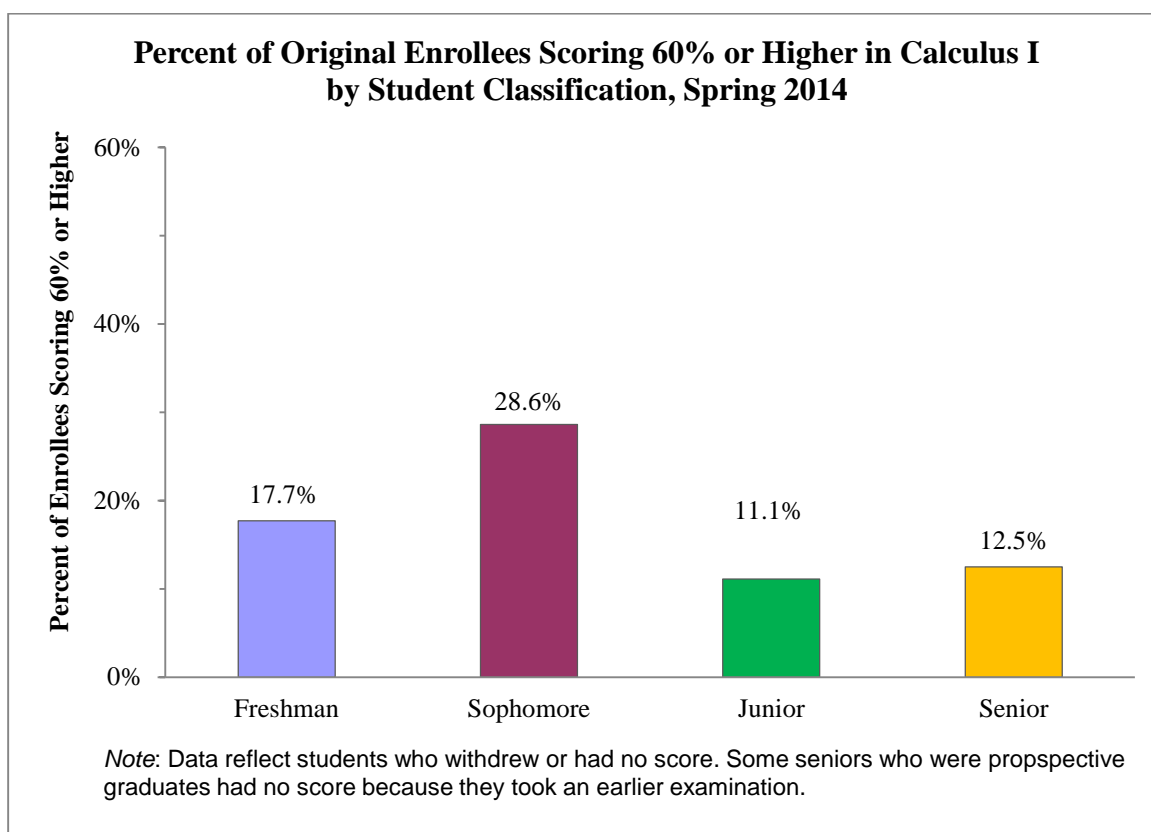


Figure 7

Descriptive Statistics by Student Classification: Calculus I

Table 24 provides descriptive statistics for the 98 valid cases who took the department final examination in Calculus I in Spring Semester 2014. Valid cases are those students for whom a final examination score is reported. Observed scores on the final examination ranged from 0 to 173. The highest mean score and lowest variability occurred among seniors, $M=104.67$; $SD=23.00$. The lowest mean score and highest variability occurred among juniors, $M=66.33$; $SD=73.07$.

**Table 24. Descriptive Statistics for Calculus I Final Exam Score
by Student Classification Spring Semester 2014**

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	69	0	165	71.23	43.50
Sophomore	23	7	173	88.26	52.20
Junior	3	15	150	66.33	73.07
Senior	3	82	128	104.67	23.00
Institutional Results	98	0	173	76.10	46.32

Figure 8 presents the mean scores on the Calculus I final examination by student classification for valid cases only. The graph shows that the minimum mean criterion performance of at least 60% (120 of 200) was not met by any classification of students.

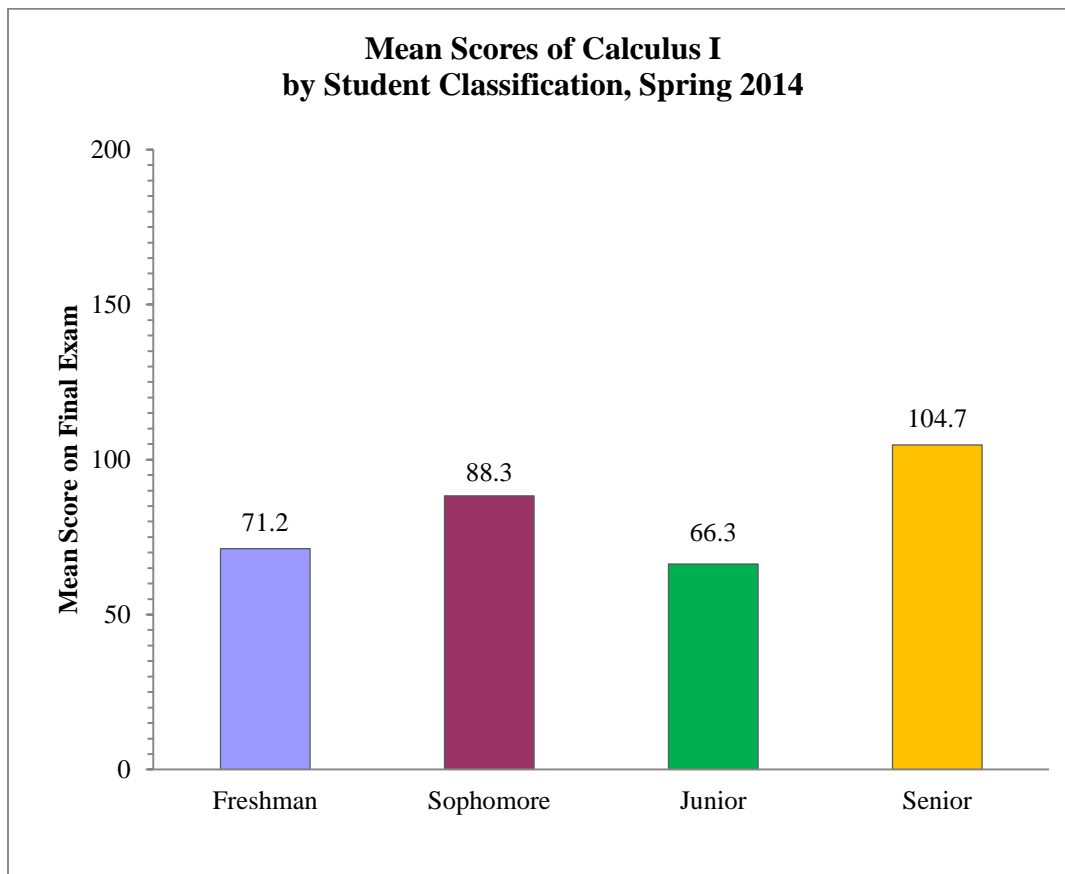


Figure 8

Inferential Statistics by Student Classification: Calculus I

F-Test: An Analysis of Variance (ANOVA) was conducted to examine differences in final exam scores based on student classification. The results of the *F*-test were not significant $F(3, 94) = 1.215, p=.309$. There were no differences in Calculus I final exam scores based on student classification. A post hoc analysis was not performed because the ANOVA was not significant.

Results by Gender: Calculus I

Of the 131 students enrolled in Calculus I, 60.3% ($N=79$ of 131) were female and 45.0% ($N=59$ of 131) were male. Table 25 shows that of the two competencies measured, females performed better on (QRC3), whereas males performed the same on both (QRC2) and (QRC3). 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 Calculus earned a score of 60% or higher on the final examination.

**Table 25. Quantitative Reasoning for Spring Semester 2014 by Gender
Calculus I 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	24	48	3 (QRC2)	11	22.9%	15.3%
	72	25	47	1, 2, 4, 5, & 6 (QRC3)	15	31.9%	20.8%
	72	20	52	Total Exam	17	32.7%	23.6%
Male	59	20	39	3 (QRC2)	8	20.5%	13.6%
	59	20	39	1, 2, 4, 5, & 6 (QRC3)	8	20.5%	13.6%
	59	13	46	Total Exam	9	19.6%	15.3%
Institutional Results	131	44	87	3 (QRC2)	19	21.8%	14.5%
	131	45	86	1, 2, 4, 5, & 6 (QRC3)	23	26.7%	17.6%
	131	33	98	Total Exam	26	26.5%	19.8%

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.

An independent samples *t*-test was conducted to compare Calculus I final exam scores across gender. As Table 26 indicates, there was a significant difference in Calculus I final exam scores by gender, $t(96) = 1.99$, $p = .049$. Females performed significantly better than males on the Spring 2014 Calculus I final examination.

Table 26. Mean Comparison by Gender for Calculus I Final Examination, Spring Semester 2014

Gender	Valid N	Mean of Total Exam	Std. Dev.	<i>t</i>	<i>df</i>	Sig. (2-tailed)
Female	52	84.73	6.11	1.990	96	0.049
Male	46	66.35	6.99			

Applied Calculus

The final examination for Applied Calculus for Spring Semester 2014 consisted of 15 questions and a possible total score of 200 points. Each problem was worth 20 points.

Students were instructed to answer any (10) problems. Table 27 presents the questions that were identified to measure three competencies (QRC1, QRC2, and QRC3). Questions 5 and 6 measured QRC1, questions 4 and 12 measured QRC2, and questions 1, 2, 3, and 7 measured QRC3. Individual QRC analysis were not conducted due to variability of items answered by each student. Only results based on the total exam score are reported. A copy of the Applied Calculus final examination is in Appendix E.

Table 27. Questions and QR Competencies for Applied Calculus Final Examination

Item # (Points)	Item Description	Competency Measured
5. (20 pts)	Determine the intervals on which the function $g(x) = x^2e^x$ is concave up.	(1) Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
6. (20 pts)	A total cost function, in thousands of dollars, is given by $C(q) = q^3 - 6q^2 + 15q$, where q is in thousands and $0 \leq q \leq 5$. (a) Graph $C(q)$. (b) Graph the average cost function $a(q) = \frac{C(q)}{q}$ (c) Determine the exact value of q at which average cost is minimized.	
4. (20 pts)	The perimeter of a rectangular field has a perimeter of 320 feet. Express the area of the field as a function of the length of one of its sides (call it L). Find the L that maximizes the area? What is the corresponding area?	(2) Represent mathematical information symbolically, visually, numerically, and verbally.
12. (20 pts)	Evaluate $\int_{-1}^2 (6x^2 + 2x - 10) dx$.	
1 (20 pts)	(a) Find an equation of the line through (1, -2) with slope 3. (b) Find an equation of the line through the points (3, 1) and (2, 1). (c) Find the slope-intercept form of the line through the points (-2, 1) and (4, 5).	(3) Use arithmetical, algebraic, geometric and statistical methods to solve problems.
2. (20 pts)	Find the derivative of the following functions: (a) $f(x) = e^{2x^2-5x-3}$ (b) $f(x) = \ln(5x^2 - 6x - 2)$.	
3. 20 pts	Consider the curve whose equation is given by $2y^3x^3 - 6x^2 + 3x + 8 = 4y.$ (a) Use implicit differentiation to find $y'(0)$. (b) Find the equation of the tangent line to the graph passing through the point (0, 2).	
7. (20 pts)	(a) Write the equation of the line that is parallel to the line $x - y = 5$ and goes through the point (-2, 1). (b) Write the equation of a line that contains the point (1, 5) and is perpendicular to the line $y = 2x - 6$.	

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

Table 28 presents the results of student performance on the Applied Calculus final examination for all sections by school or college. The results indicate that 78.7% (140 of 178) of the original enrollees had a final examination score and were considered “valid cases” for these analyses. Thus, 21.4% (38 of 178) 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). The retention rate for Applied Calculus varied across the schools and colleges represented, ranging from 61.11% (N=22 of 36) among students enrolled in the College of Arts and Sciences to 100% (N=2 of 2) among students enrolled in the College Engineering, Architecture & Computer Science, the College of Allied Health Sciences, and the School of Communications. Across all sections of Applied Calculus, the results of data analyses on student performance indicate that for all questions on the final examination, 57.7% (79 of 137) of the valid cases earned a final exam score of 60% or higher, and 44.4% (79 of 178) of the original enrollees earned a final exam score of 60% or higher.

Results by School/College: Applied Calculus

Of the 178 students enrolled in Applied Calculus, the largest representation of students was from the School of Business (N=133 of 178 or 74.72%) and the smallest representations were from the College Engineering, Architecture & Computer Science, the College of Allied Health Sciences, and the School of Communications. (N=2 of 178 or 1.1%).

The results indicate that the School of Communications had the highest percentage of valid cases who earned a total score of 60% or higher (N=2 of 2 or 100%). The results for the School of Business, which had a much larger representation in Applied Calculus, were 59.6% (65 of 109). The College of Arts and Sciences had the lowest percentage of valid cases who earned a total score of 60% or higher (N=10 of 22 or 45.5%). No students from the School of Education were enrolled in Applied Calculus during Spring 2014. At the institutional level, the percent of valid cases who earned a score of 60% or higher was 58.6%. This does not mean that only 58.6% of students who took the test earned a passing grade (grade D or better) in Applied Calculus. Rather, these results indicate that about 58.6% of the students were able to demonstrate the minimum level of competency on their Applied Calculus final examination.

Table 28 also presents the percentage of *original enrollees* in Applied Calculus who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 27.8% to 100%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 46.1%. This does not mean that only 46.1% of the original enrollees earned a passing grade (grade D or better) in Applied Calculus. Rather, these results indicate that 46.1% of the students were able to demonstrate the minimum level of competency on their Applied Calculus final examination.

**Table 28. Quantitative Reasoning for Spring Semester 2014 by School and College
Applied Calculus Final Examination**

Student School/College	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
College of Arts & Sciences	36	14	22	Total Exam	10	45.5%	27.8%
College Engineering, Architecture & Computer Science	2	0	2	Total Exam	1	50.0%	50.0%
College of Nursing and Allied Health Sciences	2	0	2	Total Exam	1	50.0%	50.0%
School of Business	133	24	109	Total Exam	65	59.6%	48.9%
School of Communications	2	0	2	Total Exam	2	100.0%	100.0%
Institutional Results	178	38	140	Total Exam	82	58.6%	46.1%

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Communication, Business, 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.

Results by Student Classification: Applied Calculus

Table 29 presents the results of student performance on the Applied Calculus final examination for all classifications of students. Of the 178 students enrolled in the course, freshmen had the largest representation (N=82 of 178 or 46.1%) and seniors had the smallest representation (N=16 of 178 or 9%). The results also indicate that freshmen had the highest percentage of valid cases who earned a total score of 60% or higher (N=47 of 69 or 68.1%). Seniors had the lowest percentage of valid cases who earned a total score of 60% or higher (N=1 of 4 or 25%).

The results also indicate that retention rates for Applied Calculus decreased as student classification increased with the exception of seniors: freshmen (N=69 of 82 or 84.1%), sophomores (N=43 of 51 or 84.3%), juniors (N=21 of 26 or 80.8%), and seniors (N=4 of 16 or 25%) (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 9 presents the percentage of *original enrollees* in Applied Calculus who earned a score of 60% or higher on the departmental final examination by student classification -- the percentages ranged from 6.3% for seniors to 57.3% for freshmen.

**Table 29. Quantitative Reasoning for Spring Semester 2014 by Student Classification
Applied Calculus 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
Freshman	82	13	69	Total Exam	47	68.1%	57.3%
Sophomore	51	8	43	Total Exam	19	44.2%	37.3%
Junior	26	5	21	Total Exam	12	57.1%	46.2%
Senior	16	12	4	Total Exam	1	25.0%	6.3%
Institutional Results	178	38	140	Total Exam	82	58.6%	46.1%

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, Nursing and Allied Health Sciences, Business, and Communications. (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 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.

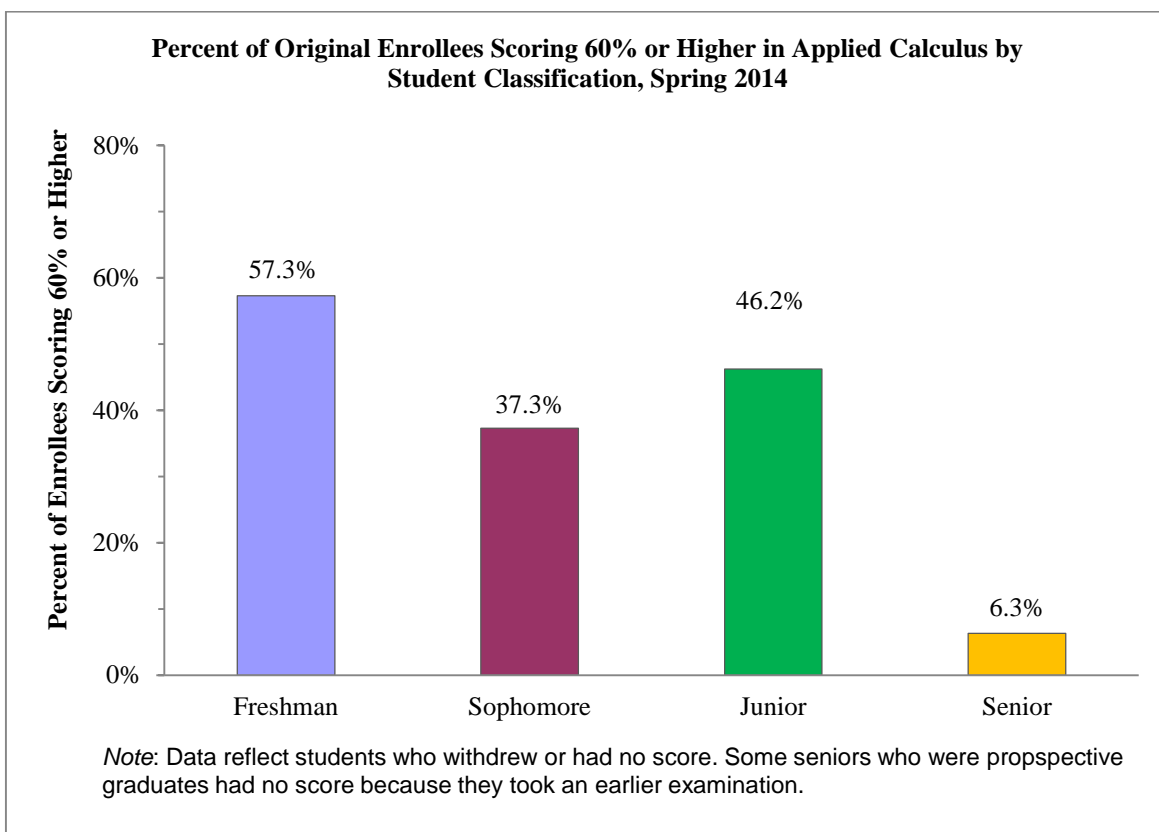


Figure 9

Descriptive Statistics by Student Classification: Applied Calculus

Table 30 provides descriptive statistics for the 140 valid cases who took the department final examination in Applied Calculus in Spring Semester 2014. Valid cases are those students for whom a final examination score is reported. Observed scores on the final examination ranged from 18 to 200. The highest mean score occurred among freshmen, $M=134.32$; the lowest mean score and highest variability occurred among seniors, $M=86.50$; $SD=71.23$. The lowest variability occurred among sophomores, $SD=32.03$.

Table 30. Descriptive Statistics for Applied Calculus Final Exam Score by Student Classification Spring Semester 2014

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	69	62	200	134.32	32.67
Sophomore	43	18	170	110.42	32.03
Junior	21	31	178	116.00	40.00
Senior	4	46	193	86.50	71.23
Institutional Results	140	18	200	123.64	37.14

Figure 10 presents the mean scores on the Applied Calculus final examination by student classification for valid cases only. The graph shows that the minimum mean criterion performance of at least 60% (112 exam points) was met by freshmen students, only. All other student classification did not meet the minimum mean criterion performance of at least (60%).

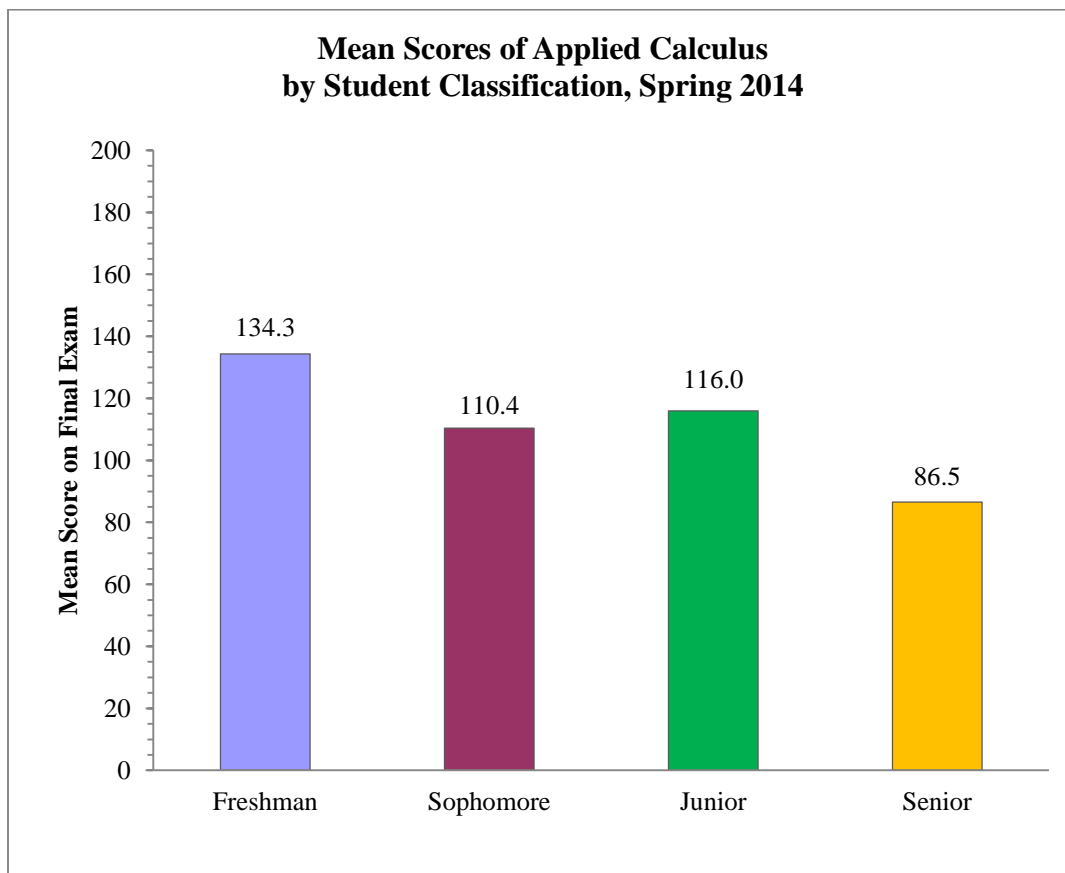


Figure 10

Inferential Statistics by Student Classification: Applied Calculus

F-Test: An Analysis of Variance (ANOVA) was conducted to examine differences in final exam scores based on student classification. The results of the *F*-test in Table 31 show that there is a statistically significant difference in the mean exam scores by classification on the departmental final examination for Applied Calculus, $F(3,133)=5.984$, $p<.01$.

**Table 31. ANOVA for Final Exam Score
by Student Classification in Applied Calculus**

	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	Sig.
Between Groups	21984.046	3	7328.015	5.984	.001
Within Groups	162874.451	133	1224.620		
Total	184858.496	136			

A post hoc analysis was performed in order to examine pair-wise differences in mean performances by student classification. Table 32 shows that the mean score for freshmen was significantly higher than both the mean score for sophomores and seniors. Thus, compared to sophomores and seniors, freshmen had significantly higher exam scores on the Applied Calculus final. There were no other statistically significant differences between any other group means.

Table 32. Post Hoc Multiple Comparisons for Final Exam Score by Student Classification in Applied Calculus

(I) Classification	(J) Classification	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Freshmen	Sophomore	23.9002	6.7991	.003	6.210	41.590
	Junior	18.3188	8.7214	.158	-4.373	41.010
	Senior	47.8188	17.9973	.043	.993	94.644

Results by Gender: Applied Calculus

Of the 178 students enrolled in Applied Calculus, 55.6% ($N=99$ of 178) were female and 44.4% ($N=82$ of 178) were male. Table 33 shows that females and males performed similarly on the Applied Calculus final examination. Among the valid cases, 58.5% of females ($N=48$ of 82) and 58.6% of males ($N=34$ of 58) earned a score of 60% or higher on the Applied Calculus final examination whereas 48.5% of females ($N=48$ of 99) and 43.3% of males ($N=34$ of 79) who originally enrolled in Applied Calculus earned a score of 60% or higher.

Table 33. Quantitative Reasoning for Spring Semester 2014 by Gender Applied Calculus 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	99	17	82	Total Exam	48	58.5%	48.5%
Male	79	21	58	Total Exam	34	58.6%	43.3%
Institutional Results	178	38	140	Total Exam	82	58.6%	46.1%

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Communications, Business, 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.

An independent samples *t*-test was conducted to compare Applied Calculus Final Exam scores by gender. The *t*-test did not reveal any significant findings. There were no gender differences in Applied Calculus final exam scores.

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 2012, (if these students had to re-enroll in these courses) we estimated that the potential cost in AY2012-2013 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. For Spring semester 2013, (if these students had to re-enroll in these courses) we estimated that the potential cost in AY2013-2014 dollars would be \$316,830 for College Algebra I, \$146,780 College Algebra II, \$71,600 for Pre-calculus, and \$535,210 for a total cost to students.

The Spring Semester 2014 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 34. The table presents the cost for retaking the courses in AY2014-15.

Summary

For Spring 2014, the general education competency, quantitative reasoning, was assessed by examining student performance on the departmental final examinations in College Algebra I, College Algebra II, Pre-Calculus, Calculus I, and Applied Calculus. Competent performance was defined by a QRC score 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

Table 34. Cost for Retaking College Algebra I, College Algebra II, and Pre-calculus

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	62	3	\$980	\$182,280
Sophomores	18	3		\$52,920
Juniors	15	3		\$44,100
<i>Sub-Total for College Algebra I</i>	95			\$279,300
College Algebra II				
Freshmen	38	4	\$980	\$148,960
Sophomores	16	4		\$62,720
Juniors	13	4		\$50,960
<i>Sub-Total for College Algebra II</i>	67			\$262,640
Pre-Calculus				
Freshmen	18	4	\$980	\$70,560
Sophomores	7	4		\$27,440
Juniors	3	4		\$11,760
<i>Sub-Total for Pre-Calculus</i>	28			\$109,760
Calculus I				
Freshmen	10	4	\$980	\$39,200
Sophomores	12	4		\$47,040
Juniors	6	4		\$23,520
<i>Sub-Total for Calculus I</i>	28			\$109,760
Applied Calculus				
Freshmen	13	4	\$980	\$50,960
Sophomores	8	4		\$31,360
Juniors	5	4		\$19,600
<i>Sub-Total for Applied Calculus</i>	26			\$101,920
TOTAL COST				\$863,380

*Undergraduate part-time rate per credit hour for AY2014-15.

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

For College Algebra I, 33.1% of the valid cases earned a score of 60% or higher on QRC 1, whereas 19.8% of the original enrollees earned a score of 60% or higher on QRC 1; 44.4% versus 28.8% on QRC2; and 64.8% versus 42.1% on QRC3. Among the different schools and colleges, the college of nursing and Allied health sciences (CNAHS) had the highest percentage of valid cases who earned a score of 60% or higher on QRC1. The School of Education (SOE) had the highest percentage of valid cases who earned a score of 60% or higher on QRC2 and QRC3. The College of engineering, architecture, and computer science (CEACS) had the highest percentage of original enrollees who earned a score of 60% or higher on competency 1 and 3, whereas the SOE had the highest percentage of original enrollees who earned a score of 60% or higher on competency 2. In regards to student classification, juniors had the highest percentage

of valid cases who earned a score of 60% or higher on QRC1, whereas freshmen had the highest percentage of valid cases who earned a score of 60% or higher on QRC2 and QRC3. Freshmen also had the highest percentage of original enrollees who earned a score of 60% or higher on competency 1, 2, and 3. The gender based results revealed that females had the highest percentage of valid cases who earned a score of 60% or higher on competency 1 and 2, while males had the highest percentage of valid cases who earned a score of 60% or higher on competency 3. Females did have the highest percentage of original enrollees who earned a score of 60% or higher on competency 1, 2, and 3.

For College Algebra II, 43.8% of the valid cases earned a score of 60% or higher on QRC 1, whereas 32.3% of the original enrollees earned a score of 60% or higher on QRC 1; 34.2% versus 24.1% on QRC2; 34.8% versus 25.7% on QRC3; and 29.1% versus 19.6% on QRC4. Among the different schools and colleges, the College of Arts and Sciences (COAS) had the highest percentage of valid cases and original enrollees who earned a score of 60% or higher on QRC1. The School of Education (SOE) had the highest percentage of valid cases and original enrollees who earned a score of 60% or higher on QRC2 and QRC4. College of Engineering, Architecture, and Computer Science (CEACS) had the highest percentage of valid cases who earned a score of 60% or higher on QRC3, however, the School of Communications (SOC) had the highest percentage of original enrollees who earned a score of 60% or higher on QRC3. In regards to student classification, freshmen had the highest percentage of valid cases who earned a competency score of 60% or higher on QRC1, and the highest percentage of original enrollees who earned a competency score of 60% or higher on QRC1, QRC2, and QRC3. Sophomores had the highest percentage of valid cases who earned a competency score of 60% or higher on QRC3 and QRC4, and the highest percentage of original enrollees who earned a competency score of 60% or higher on QRC4. Juniors had the highest percentage of valid cases who earned a competency score of 60% or higher on QRC2. The gender based results revealed that females had the highest percentage of valid cases and original enrollees who earned a competency score of 60% or higher on QRC1, QRC2, QRC3, and QRC4

For Pre-Calculus, 45.9% of students who took the final examination earned a score of 60% or higher on QRC1, whereas 35.2% of the original enrollees earned a score of 60% or higher on QRC1; 66.7 versus 51.6% on QRC2; and 61% versus 47.2% on QRC3. Among the different schools and colleges, the college of nursing and Allied health sciences (CNAHS) had the highest percentage of valid cases and original enrollees who earned a score of 60% or higher on QRC1. The School of Communications had the highest percentage of valid cases and original enrollees who earned a score of 60% or higher on QRC2 and QRC3. In regards to student classification, juniors had the highest percentage of valid cases who earned a score of 60% or higher on QRC1, QRC2, and QRC3. Juniors also had the highest percentage of original enrollees who earned a score of 60% or higher on QRC2. Freshmen had the highest percentage of original enrollees who earned a score of 60% or higher on QRC1 and QRC3. The gender based results revealed that females and males had an equal number of valid cases who earned a score of 60% or higher on QRC1. Males had a higher percentage of valid cases who earned a score of 60% or higher on QRC2 and QRC3. Males also had a higher percentage of original enrollees who earned a score of 60% or higher on QRC1, QRC2, and QRC3.

For Calculus I, 21.8% of students who took the final examination earned a competency score of 60% or higher on QRC2, whereas 14.5% of the original enrollees earned a score of 60% or higher on QRC2. Additionally, 26.7% of students who took the final examination earned a

competency score of 60% or higher on QRC3, whereas 17.6% of the original enrollees earned a score of 60% or higher on QRC3. Among the different schools and colleges, the college of nursing and Allied health sciences (CNAHS) had the highest percentage of valid cases and original enrollees who earned a score of 60% or higher on QRC2. The School of Business (SOB) had the highest percentage of valid cases and original enrollees who earned a score of 60% or higher on QRC3. In regards to student classification, juniors and seniors had an equal percentage of valid cases who earned a score of 60% or higher on QRC2, however, seniors had the highest percentage of valid cases who earned a score of 60% or higher on QRC3. Sophomores had the largest percentage of original enrollees who earned a score of 60% or higher on QRC2, whereas, freshmen had the largest percentage of original enrollees who earned a score of 60% or higher on QRC3. The gender based results revealed that females had the largest percentage of valid cases and original enrollees who earned a competency score of 60% or higher on QRC2 and QRC3.

For Applied Calculus, analysis of student performance data on individual quantitative reasoning competencies was not possible. Only analyses based on students' total score on the Applied Calculus final examination were conducted. The institutional results indicate that 58.6% of the valid cases and 46.1% of the original enrollees earned a score of 60% or higher on the final exam. Among the different school and colleges, the School of Communications (SOC) had the largest percentage of valid cases and original enrollees who earned a score of 60% or higher on the final exam. In regards to student classification, freshmen had the largest percentage of valid cases and original enrollees who earned a score of 60% or higher on the final exam. The gender based results revealed that males had the largest percentage of valid cases who earned a score of 60% or higher on the final exam, whereas females had the largest percentage of original enrollees who earned a score of 60% or higher on the final exam.

Despite their low enrollment, students in the School of Education performed better on QRC2, whereas students in the School of Communications performed better on QRC3. Freshmen outperformed their peers on QRC1, QRC2, and QRC3 on the College Algebra I final examination. Student performance by classification on the quantitative reasoning competencies for College Algebra II, Pre-Calculus, and Calculus I were mixed. Females outperformed males on each quantitative reasoning competency on the College Algebra I, College Algebra II, and Calculus I final examination. Males outperformed females on each quantitative reasoning competency on the Pre-Calculus final examination.

The improvement of students' competencies in *quantitative reasoning*, as defined by performance in College Algebra I, College Algebra II, Pre-calculus, Calculus I, and Applied 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;

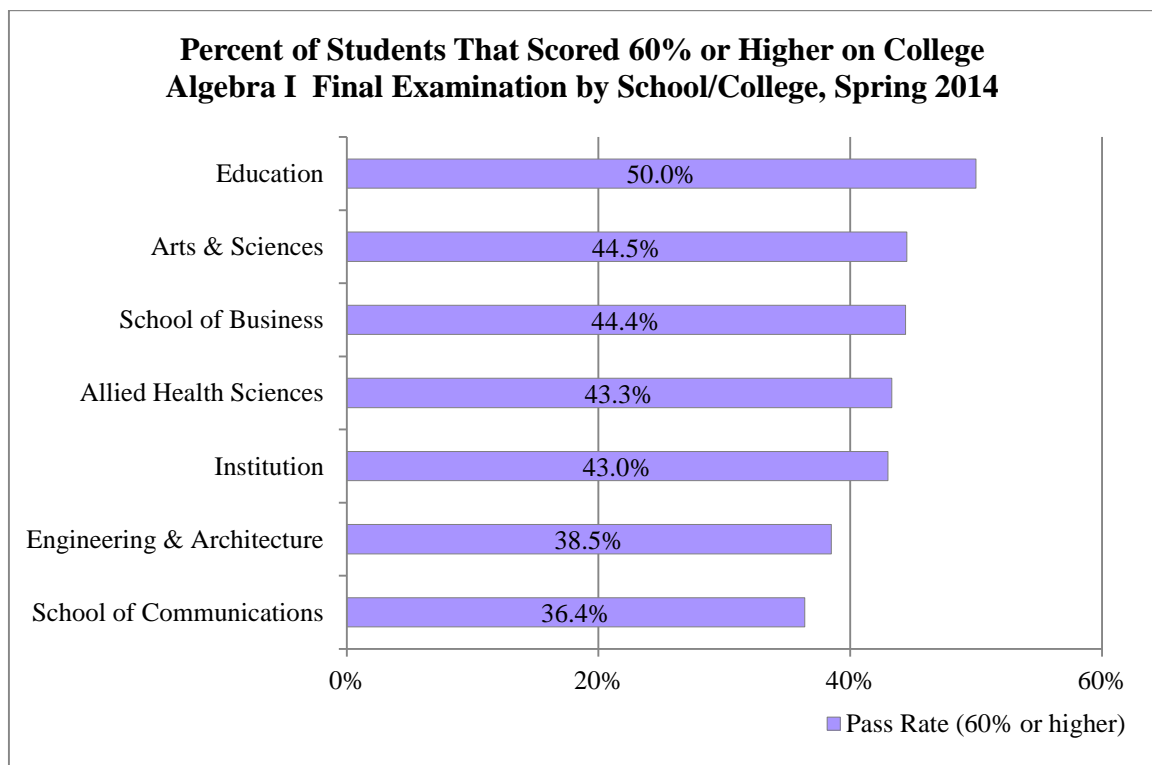
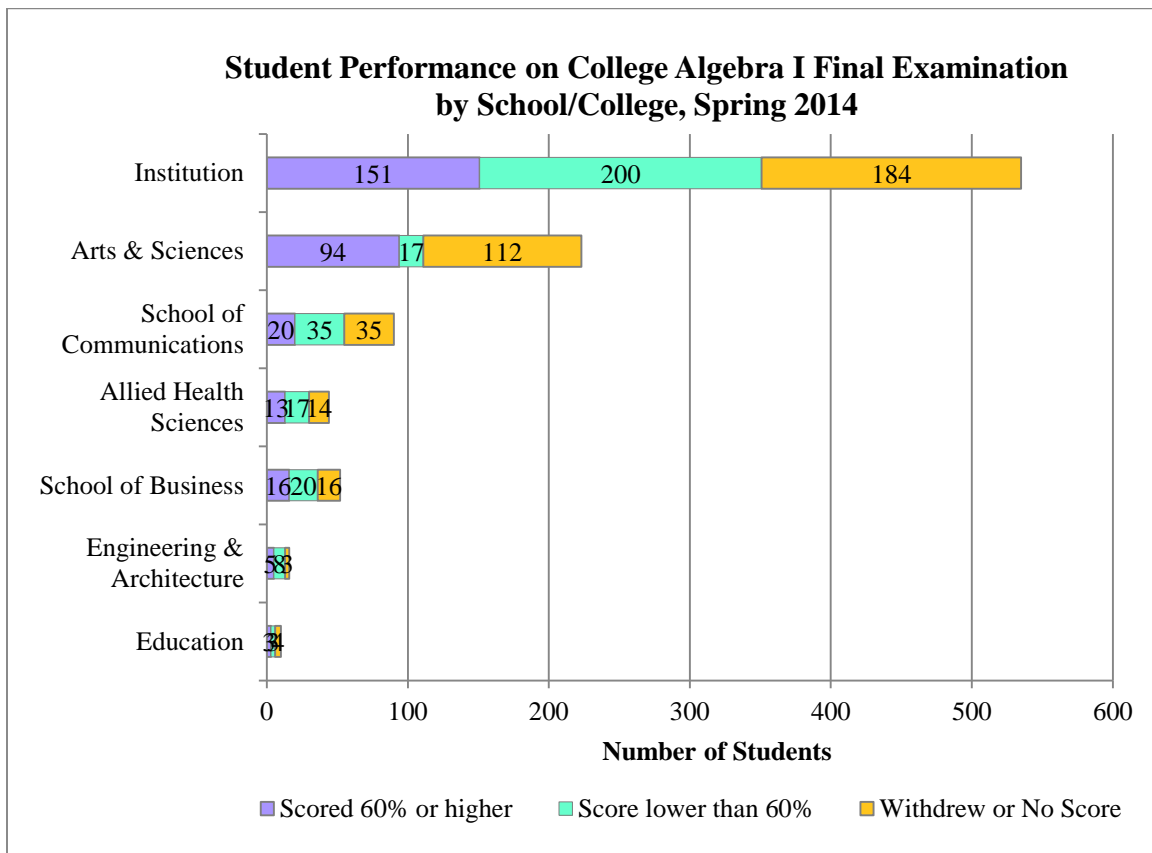
that is, what students know and are able to do when they graduate. In fact, institutional effectiveness is being defined, in part, by the extent to which institutions are able to provide credible evidence that students are achieving the learning goals that institutions have set for themselves.

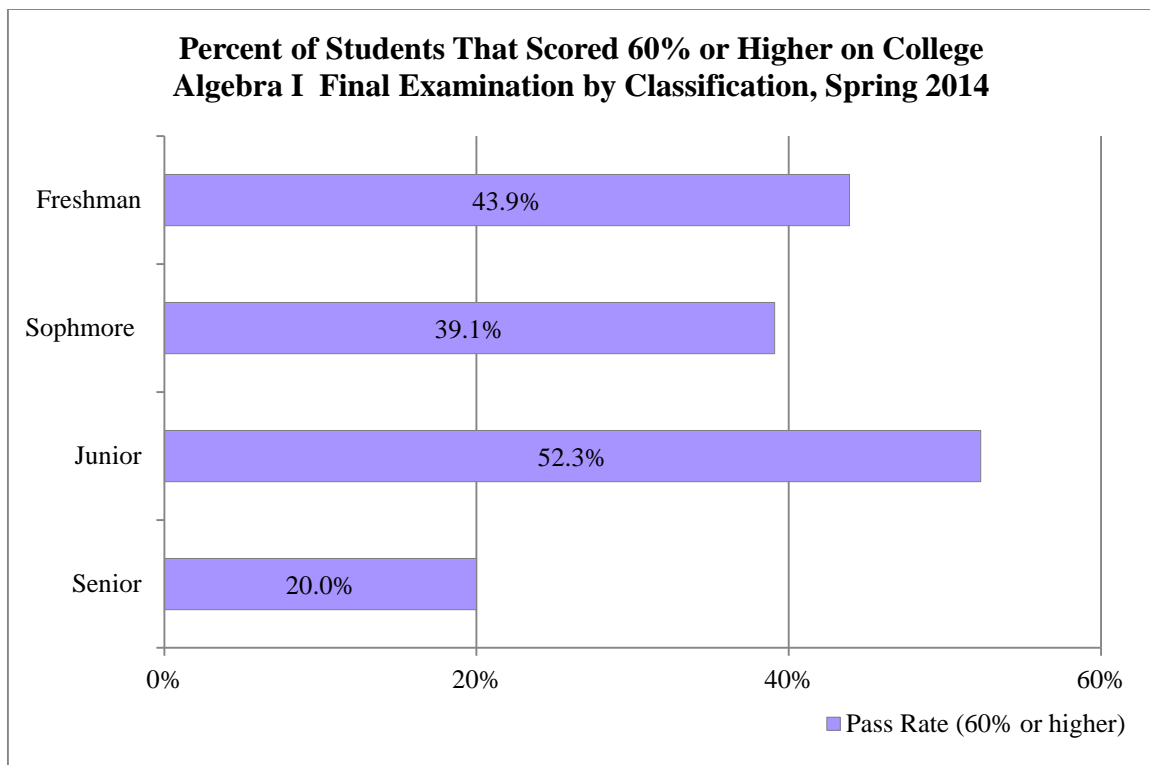
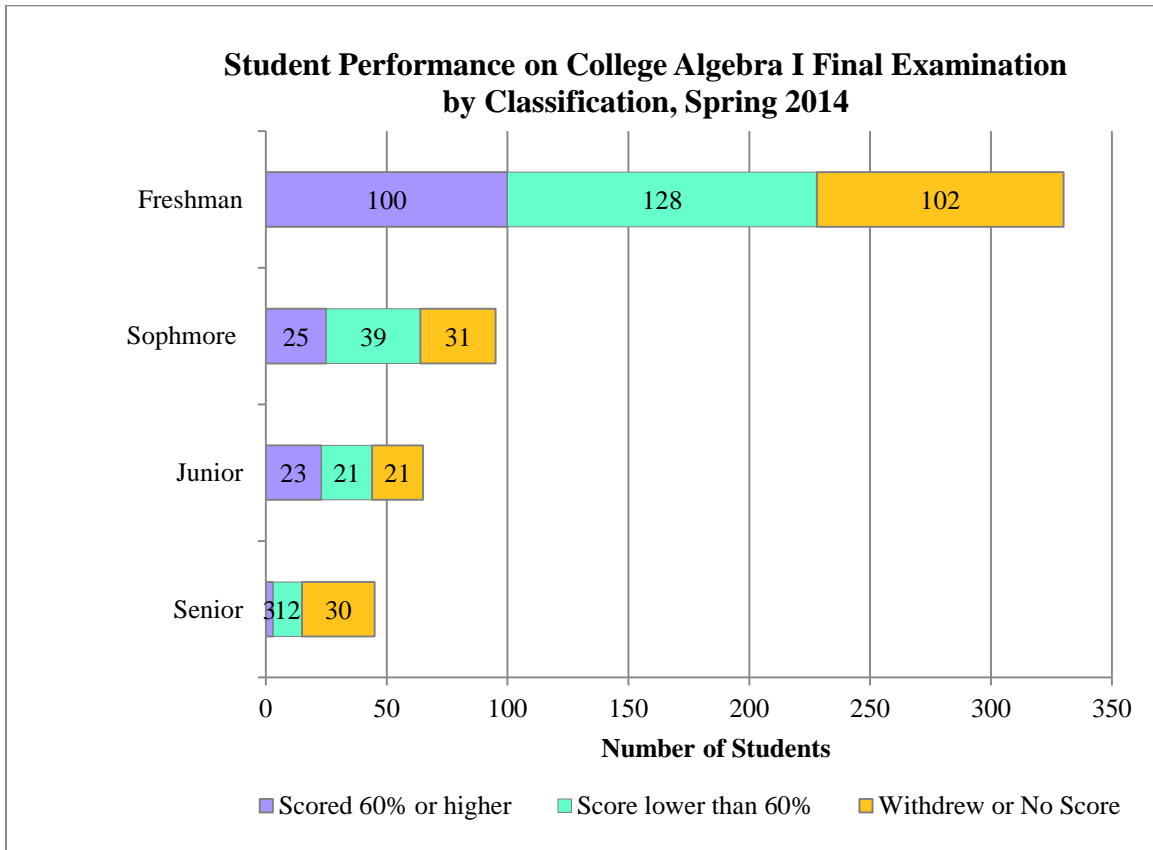
Disaggregating student performance data by school/college, student classification and gender allows university personnel to develop specific strategies for targeted student groups. Doing so demonstrates that a ‘one size fits all’ may not be an effective approach for improving student learning outcomes 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, Pre-calculus, Calculus, and Applied 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).

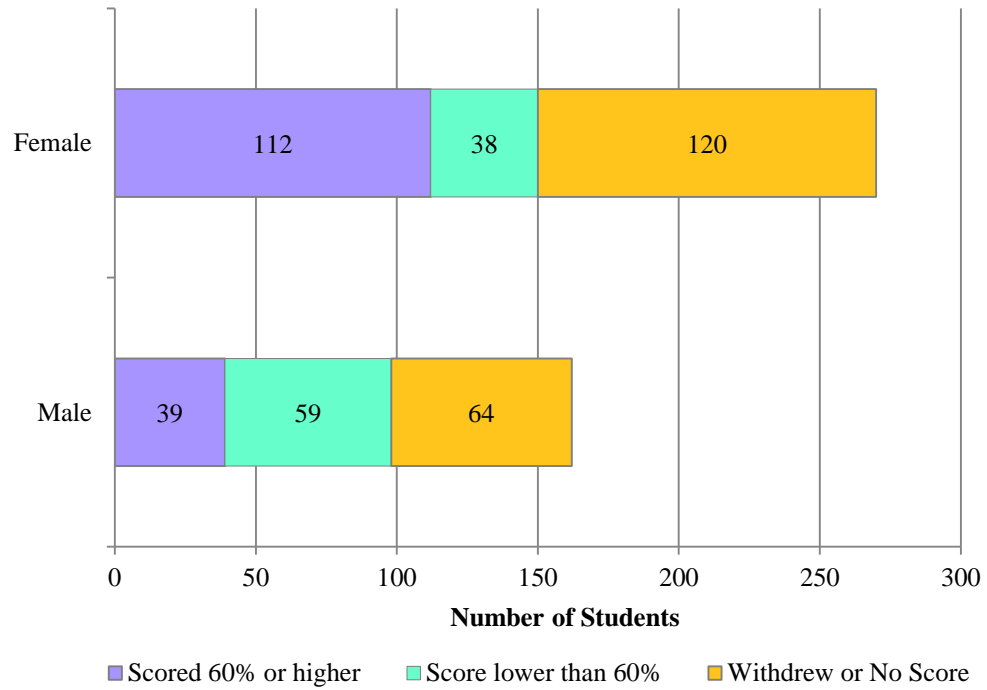
Faculty, academic advisors, peer counselors, student affairs personnel, university administrators, and most importantly, students themselves must work collaboratively to do what is necessary to improve students’ competencies in *quantitative reasoning* (See Conclusions and Recommendations in the “Executive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

Appendix A. College Algebra I





**Student Performance on College Algebra I Final Examination
by Gender, Spring 2014**



**Percent of Students That Scored 60% or Higher on College
Algebra I Final Examination by Gender, Spring 2014**

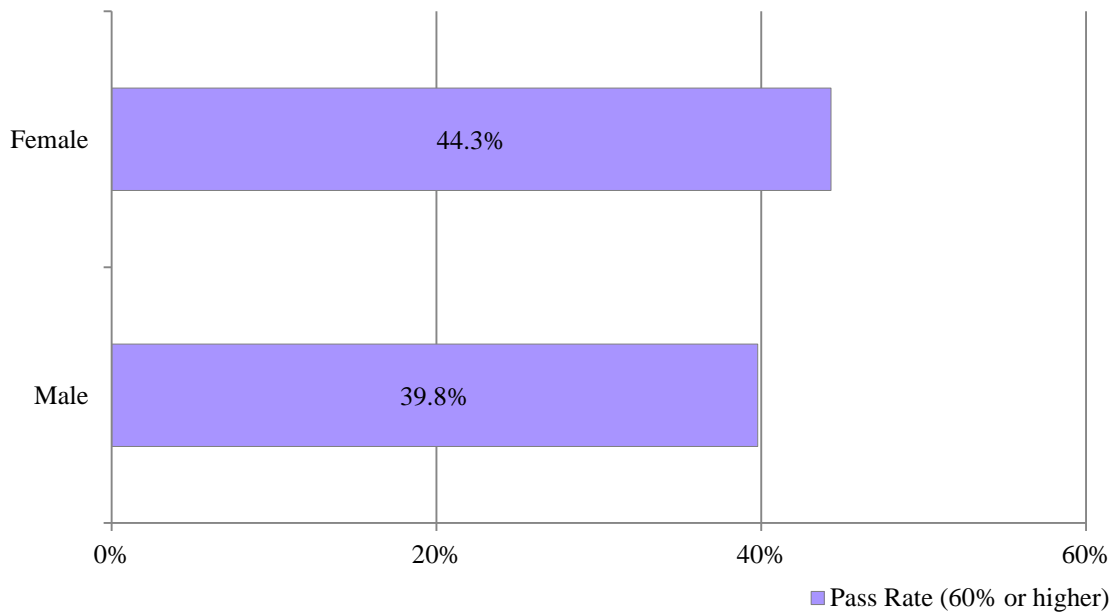


Figure A1 presents a “Box-and-Whiskers Plot” of the total score on the final examination for College Algebra I by school/college. The horizontal line in each plot represents the median or middle raw score distribution. There is minimum variability among the median scores. The School of Education had the highest median score, whereas, the School of Communications has the lowest median score.

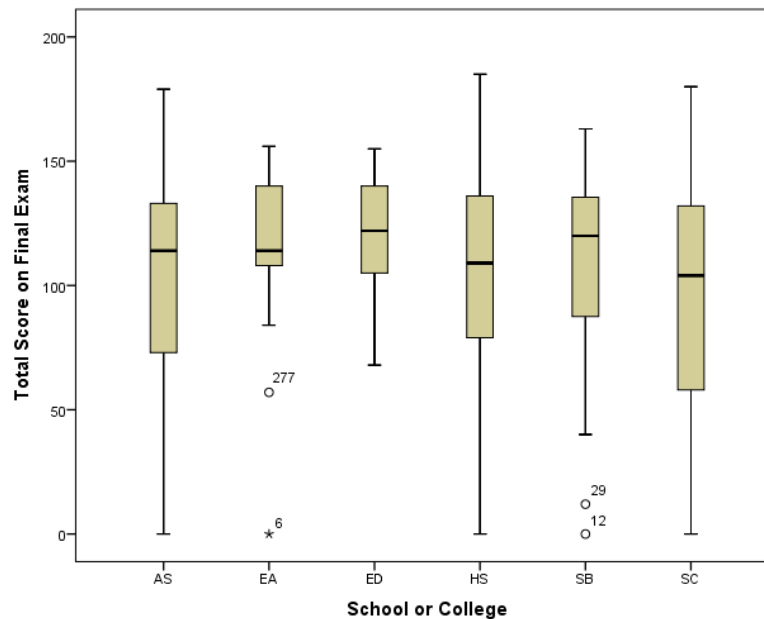


Figure A1. Exam Score by School/College: College Algebra I

Figure A2 presents a “Box-and-Whiskers Plot” of the total score on the final examination for College Algebra I by student classification. The median score for freshmen, sophomores, and juniors are noticeably higher than the median score for seniors

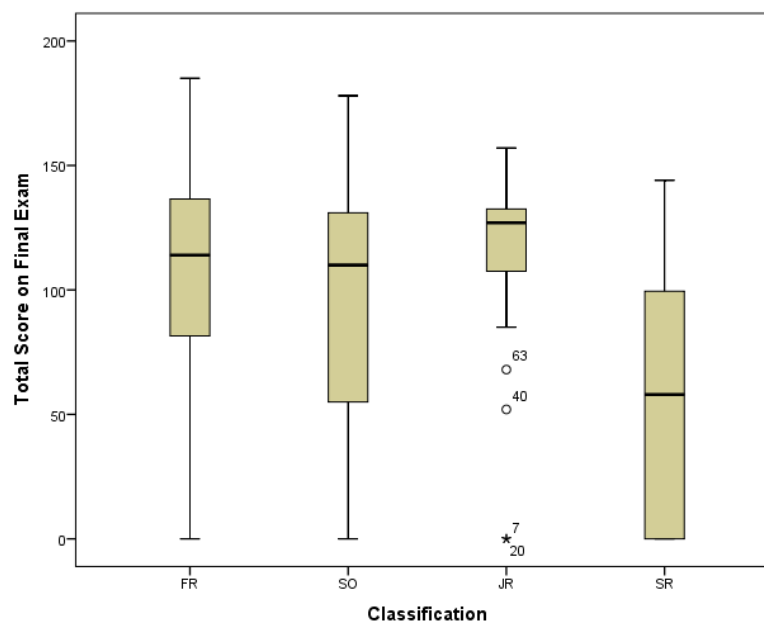


Figure A2. Exam Score by Student Classification: College Algebra I

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 females is slightly lower.

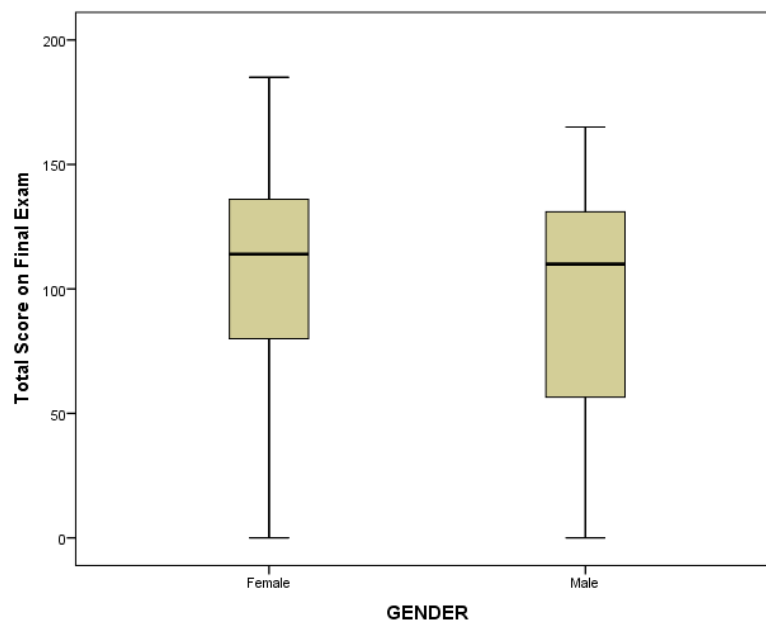


Figure A3. Exam Score by Gender: College Algebra I

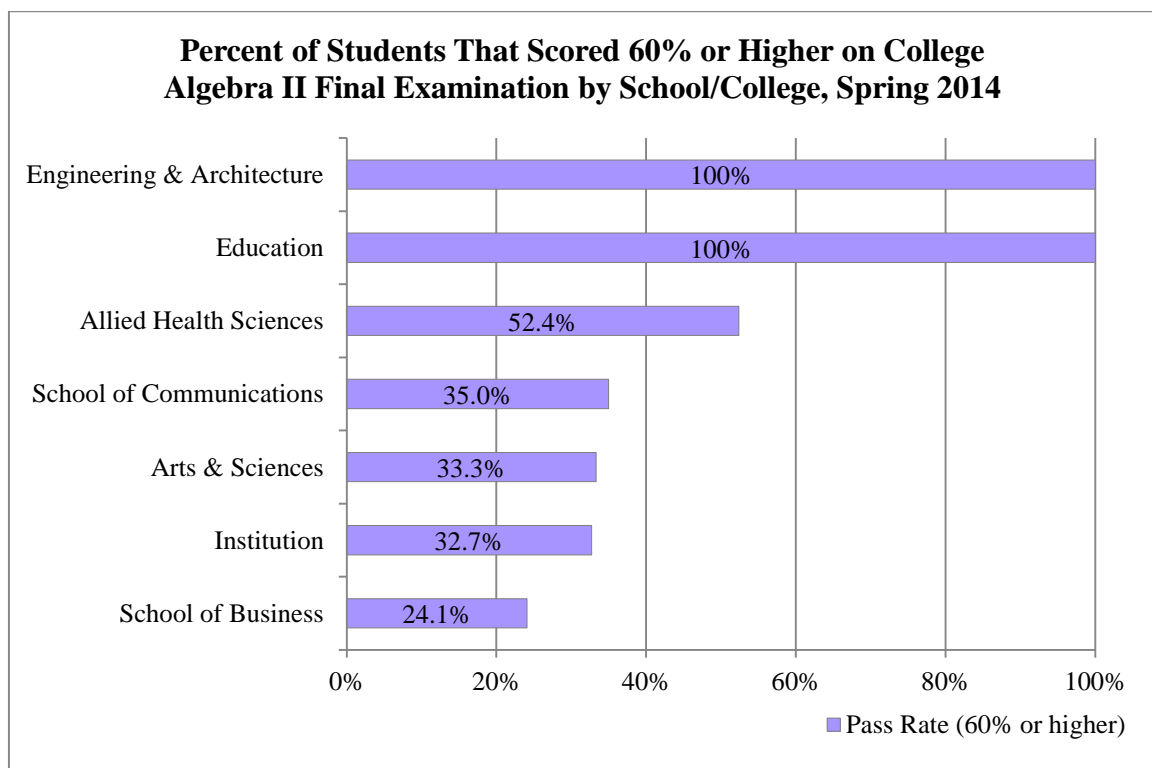
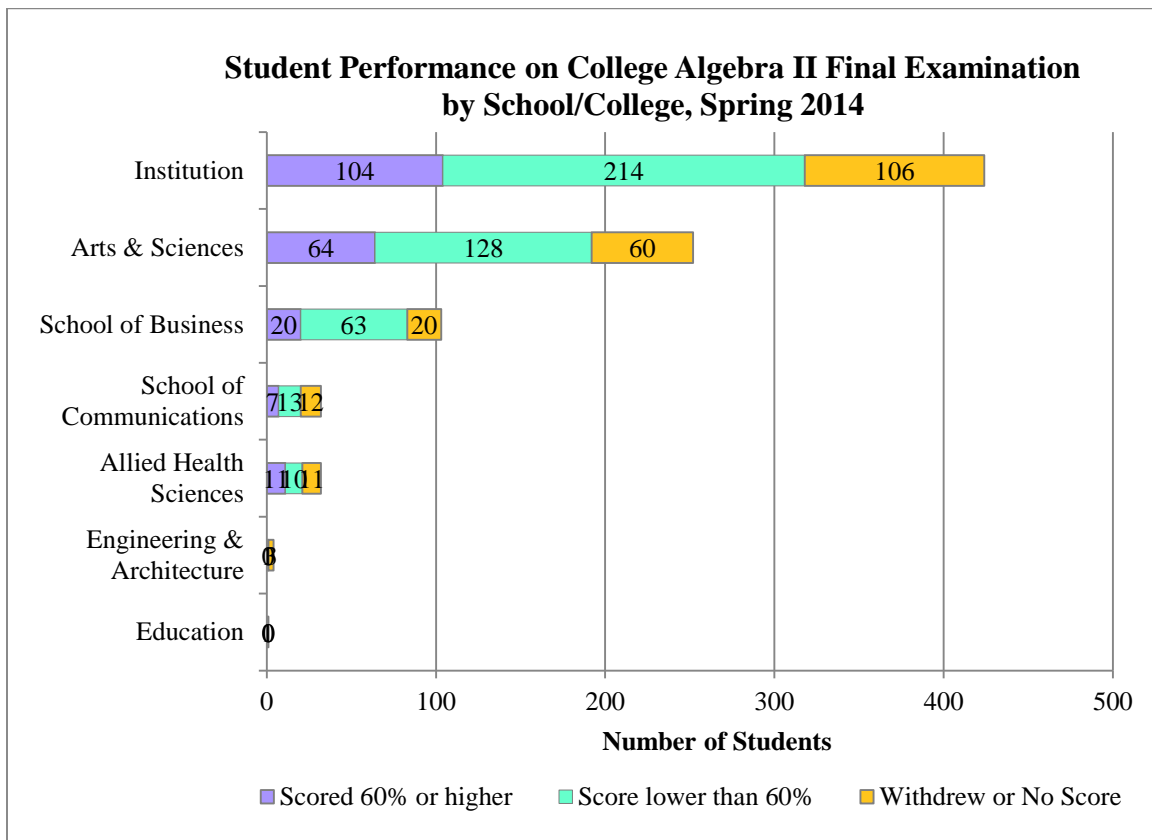
Instructions: This exam consists of 13 questions worth a total of 200 points. Answer all questions. Show all your work neatly for full credit. Calculators are not allowed.

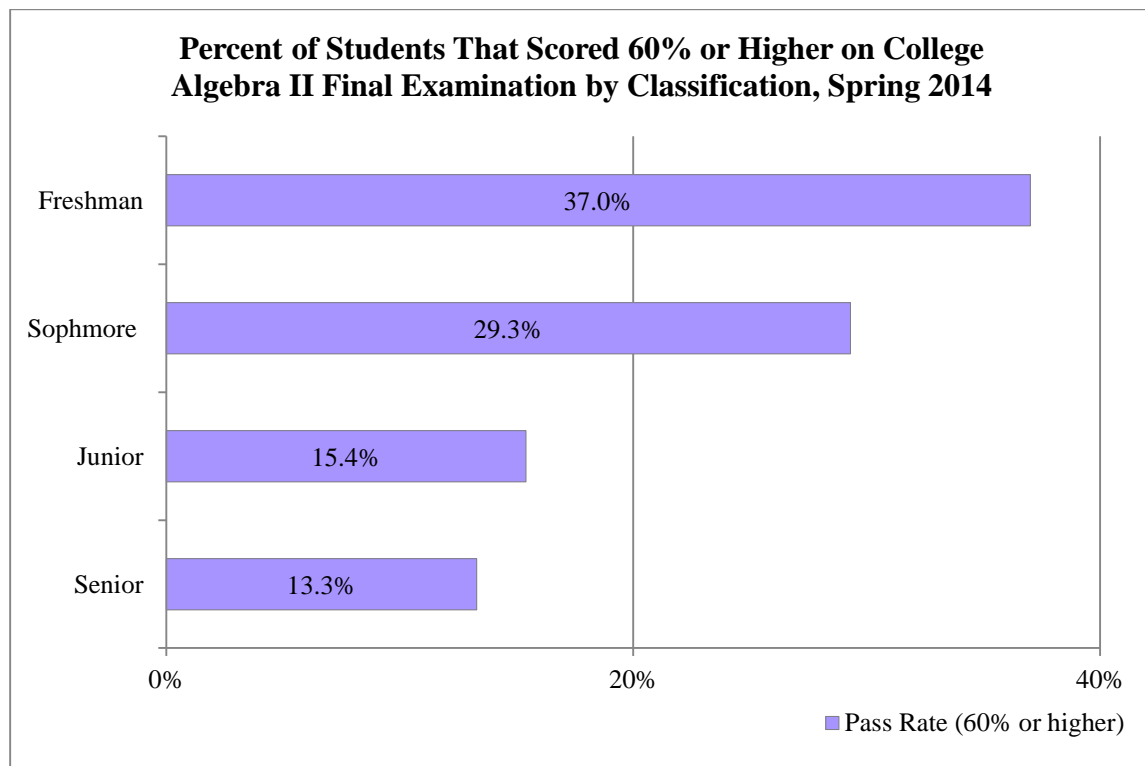
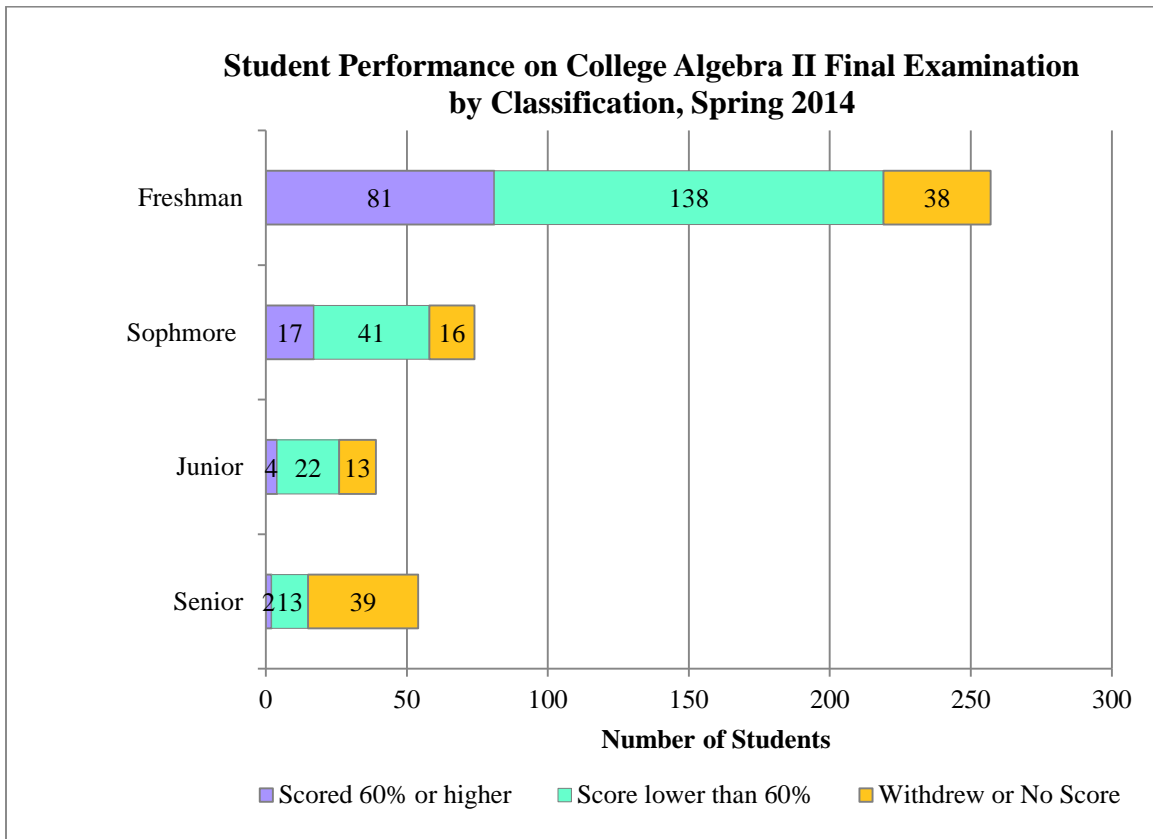
1. (20 pts) The function $f(x)$ is a piecewise defined function given by

$$f(x) = \begin{cases} 2x & \text{if } x < 0 \\ x+2 & \text{if } 0 \leq x \leq 2 \\ x^2 & \text{if } x > 2 \end{cases}$$

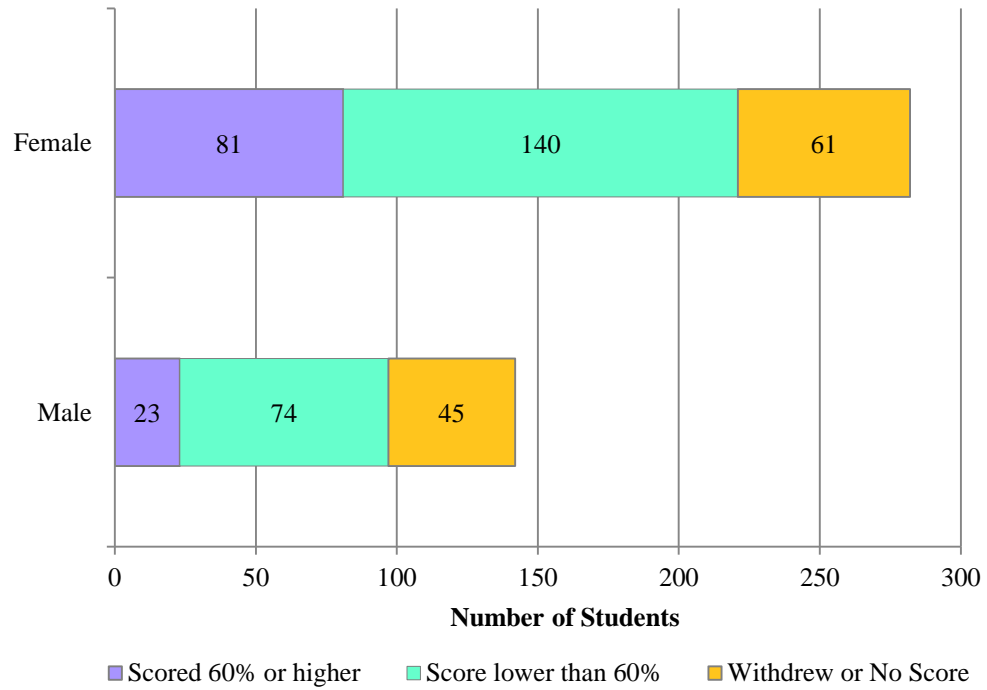
- (a) Find $f(-1)$, $f(0)$, $f(1)$, $f(2)$ and $f(10)$.
(b) Draw the graph of f .
2. (10 pts) Find the domain of $f(x) = \sqrt{x^2 - 4}$.
3. (20 pts) Given that $f(x) = 2x + 1$, $g(x) = (x - 1)/2$ find the following:
(a) $f(0)$, $f(1/2)$.
(b) $(f \circ f)(x)$ and $(f \circ g)(x)$.
4. (20 pts) Given that $f(x) = 2x^2 + 3x + 1$ find the following:
(a) The vertex, axis of symmetry and the intercepts of the parabola that is the graph of the function.
(b) The graph of the function.
5. (20 pts) (a) Factor the polynomial $x^3 - 9x^2 + x - 9$ and find its zeroes.
(b) Find the x and y -intercepts of the graph of the equation $y = x^3 - 9x^2 + x - 9$.
6. (20 pts) The revenue from selling a product is given by multiplying the number of units sold by the price.
(a) If the price is p then $100 - p$ units are sold. Write an expression $R(p)$ for the revenue function.
(b) Find the revenue when the price is \$10.
(c) Find the price p at which revenue is maximum.
7. (10 pts) Solve $4^{1-x} = \frac{1}{8x}$ for x .
8. (10 pts) Solve the equation $3x + 2 = 6x - 7$.
9. (15 pts) Solve the equation $x^6 + 7x^3 - 8 = 0$.
10. (15 pts) Solve the inequality $\frac{3x-1}{2x+1} \leq 0$, writing your answer in interval notation.
11. (10 pts) Find the distance between the points $(3, -1)$ and $(2, 5)$.
12. (15 pts) Find the center and radius of the circle with equation $x^2 - 4x + y^2 + 6y + 12 = 0$.
13. (15 pts) Find an equation of the line through the point $(1, -2)$ which is perpendicular to the line with equation $2x + 3y = 5$.

Appendix B. College Algebra II





**Student Performance on College Algebra II Final Examination
by Gender, Spring 2014**



**Percent of Students That Scored 60% or Higher on College
Algebra II Final Examination by Gender, Spring 2014**

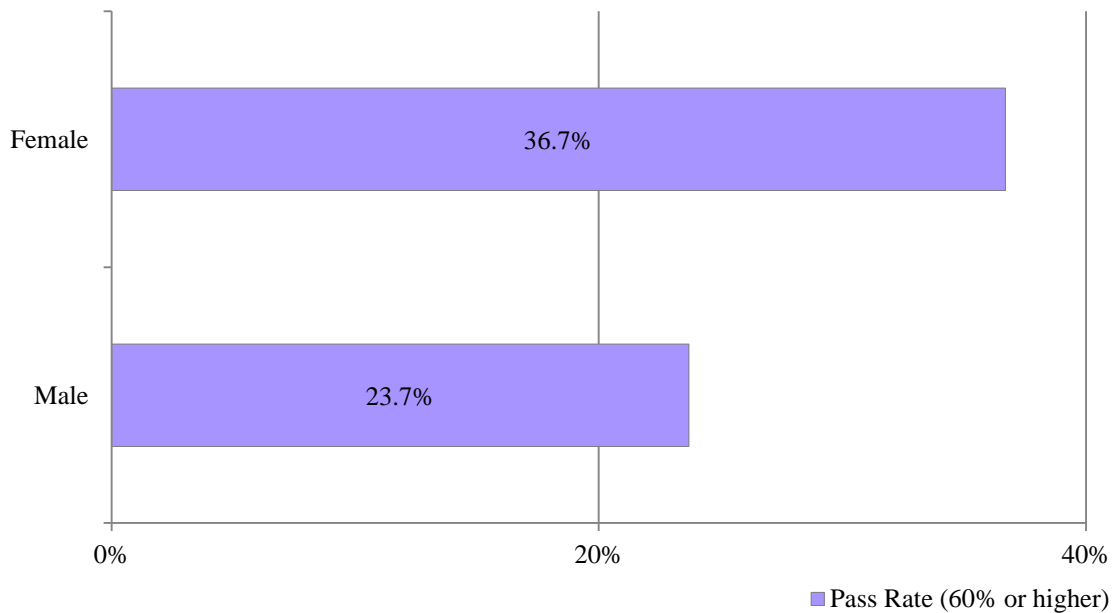


Figure B1 presents a “Box-and-Whiskers Plot” of the total score on the final examination for College Algebra II by school/college. The median for the School of Education is the highest, whereas, the School of Business has the lowest median scores.

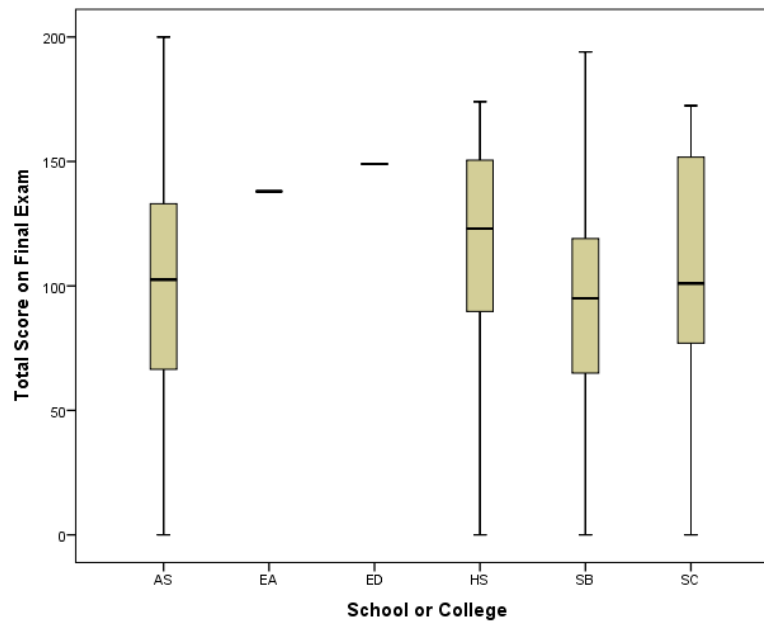


Figure B1. Exam Score by School/College: College Algebra II

Figure B2 presents a “Box-and-Whiskers Plot” of the total score on the final examination for College Algebra II by student classification. There is minimum median variation across classification, however freshmen had the highest median score.

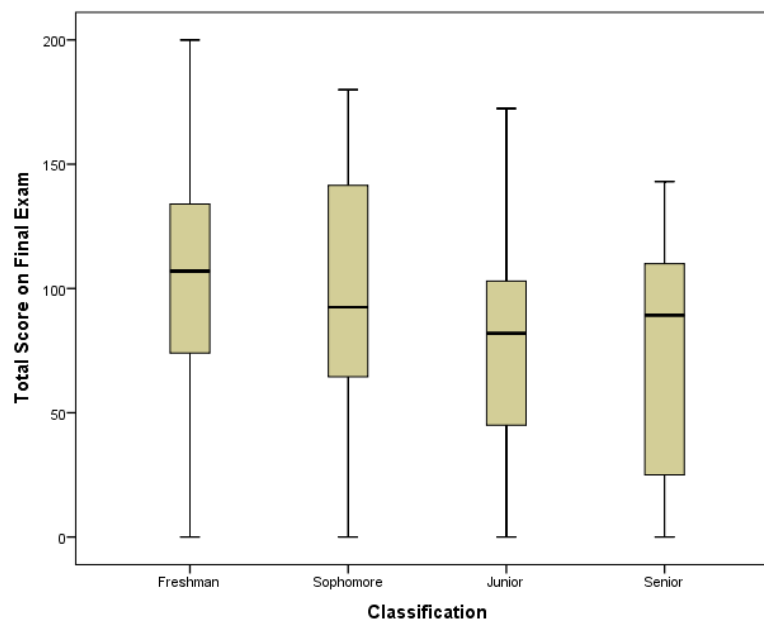


Figure B2. Exam Score by Student Classification: College Algebra II

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.

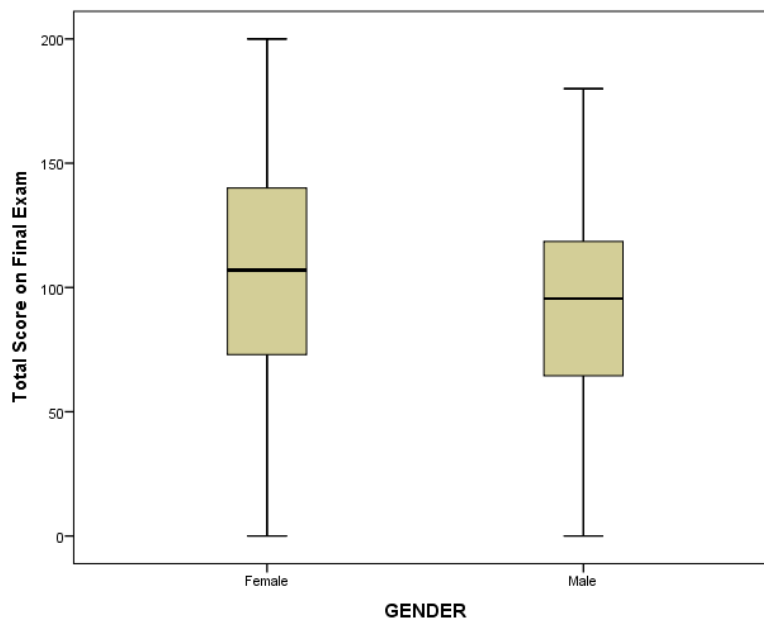


Figure B3. Exam Score by Gender: College Algebra II

College Algebra II (Math 010) Spring 2014 Final Exam
Howard University Department of Mathematics
29 April 2014

Name: _____

Show all your work in the bluebook provided. No work, No credit. Best Wishes!

PART I: Do all of the problems in part I.

- 10points 1. Solve the following equations for x

$$\log_5 x + \log_5(x+1) = \log_5 20$$

- 10points 2. Write the following expression as a sum and/or difference of logarithms, express all powers as factors.

$$\ln \left[\sqrt{\frac{x^2 + 4}{(x^2 + 1)(x^3 - 7)^2}} \right]$$

- 20points 3. For the rational function

$$R(x) = \frac{x^3 + 1}{x^2 + 2x}$$

Find

- (a) The Domain (interval or set notation)
- (b) The x- and y- intercepts (if any)
- (c) The Vertical asymptotes (if any)
- (d) The Horizontal or Slant asymptotes (if any)

- 15points 4. Solve the following system using **Cramer's Rule**, if applicable. If Cramer's Rule is not applicable, say so.

$$\begin{cases} 4x - y = 0 \\ 2x + 7y = 1 \end{cases}$$

- 20points** 5. A^{-1} is the inverse of the coefficient matrix of the system of equations below. Use A^{-1} to solve this system of linear equations.

$$A^{-1} = \begin{bmatrix} 3 & -2 & -4 \\ 3 & -2 & -5 \\ -1 & 1 & 2 \end{bmatrix}$$

$$\begin{cases} x + 2z & = 6 \\ -x + 2y + 3z & = -5 \\ x - y & = 6 \end{cases}$$

- 20points** 6. Graph the feasible region defined by the following constraints, and maximize the objective function $P(x, y) = 2x + y$ over this region.

$$x \geq 0, \quad y \geq 0, \quad x + y \leq 3, \quad x + y \geq 1, \quad 2x + y \leq 4$$

- 20points** 7. Find the center, foci, and vertices of the following ellipse and sketch its graph.

$$(x + 5)^2 + 4(y - 4)^2 = 16$$

- 5points** 8. Find the first term and the common difference of the arithmetic sequence whose 9th term is 36 and 12th term is 45.

- 5points** 9. Find the common ratio and write out the first four terms of the geometric sequence whose general term is $a_n = \frac{2^{n-1}}{4}$.

- 15points** 10. Use the indicated matrices to compute; (a) $3A + B$, (b) AC , and (c) B^2 .

$$A = \begin{bmatrix} 0 & 3 & -5 \\ 1 & 2 & 6 \end{bmatrix}, \quad B = \begin{bmatrix} 4 & 1 & 10 \\ -2 & 3 & -2 \end{bmatrix}, \quad C = \begin{bmatrix} 4 & 1 \\ 6 & 2 \\ -2 & 3 \end{bmatrix}$$

PART II: Do **ONLY FOUR** of the problems in part II.

- 15points** 11. Find all rational zeros of the polynomial, and write the polynomial in factored form.

$$H(x) = x^3 + 2x^2 - 5x - 6$$

15points 12. Use any method to solve

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

15points 13. Sketch the graph of any two of the following:

$$a) (x+4)^2 = 16(y+2) \quad b) 9(x-3)^2 + (y+2)^2 = 18 \quad c) 4x^2 - 16y^2 - 64 = 0$$

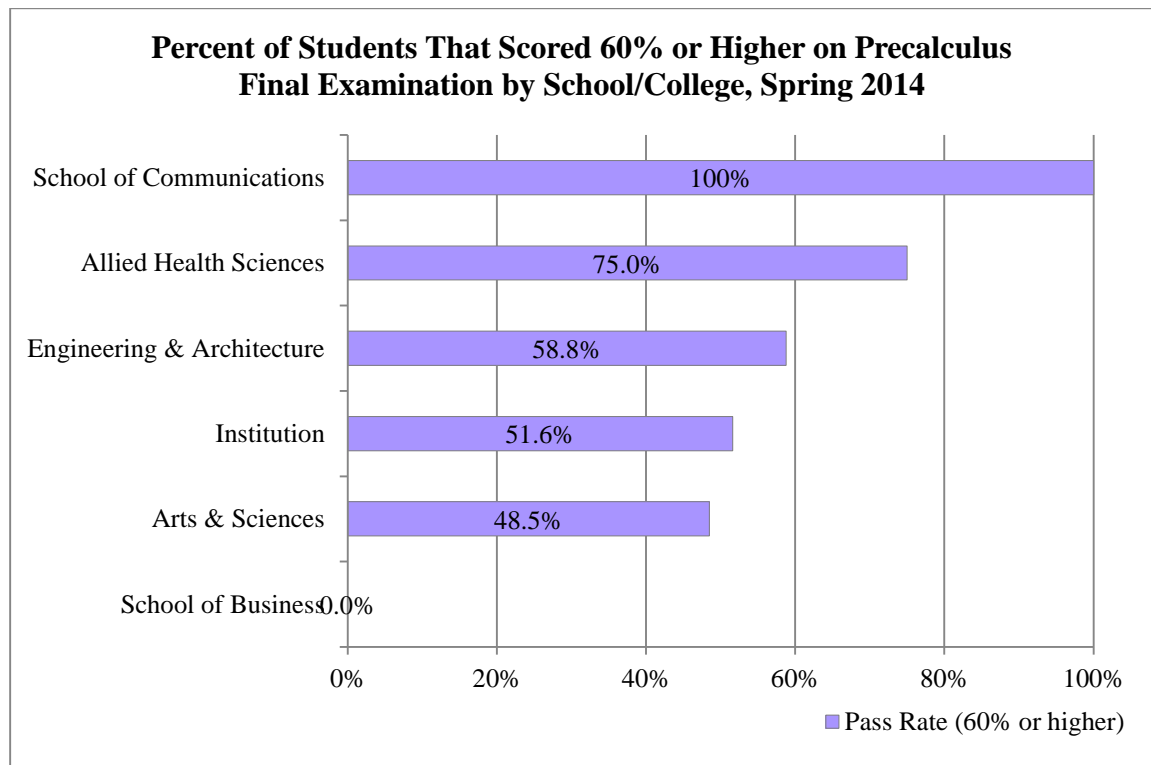
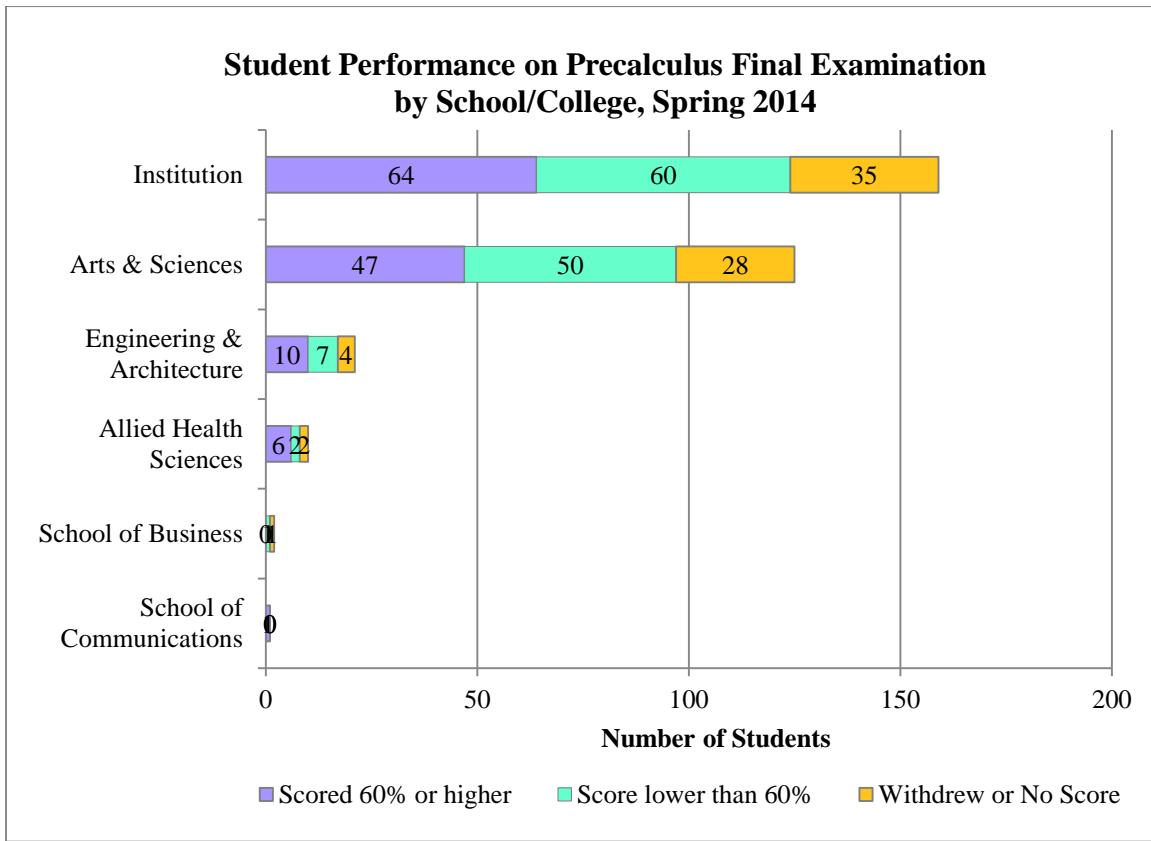
15points 14. Determine whether the infinite geometric series is convergent or divergent. If it is convergent, find its sum.

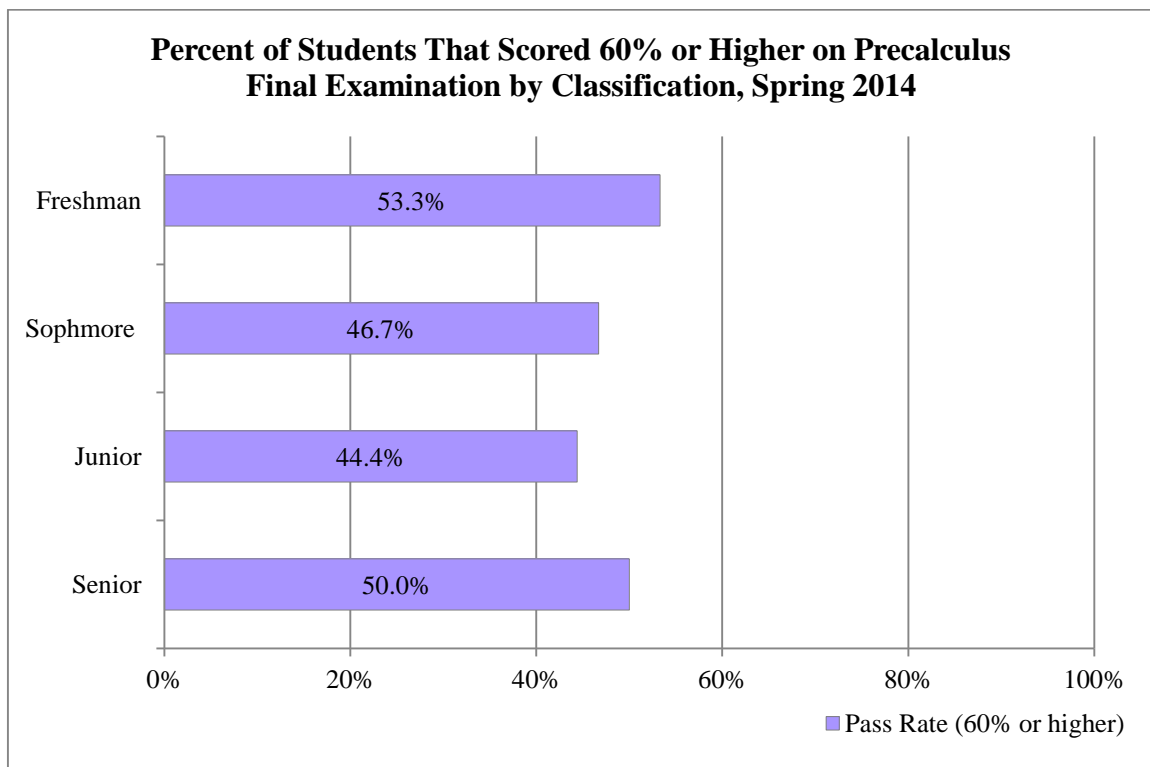
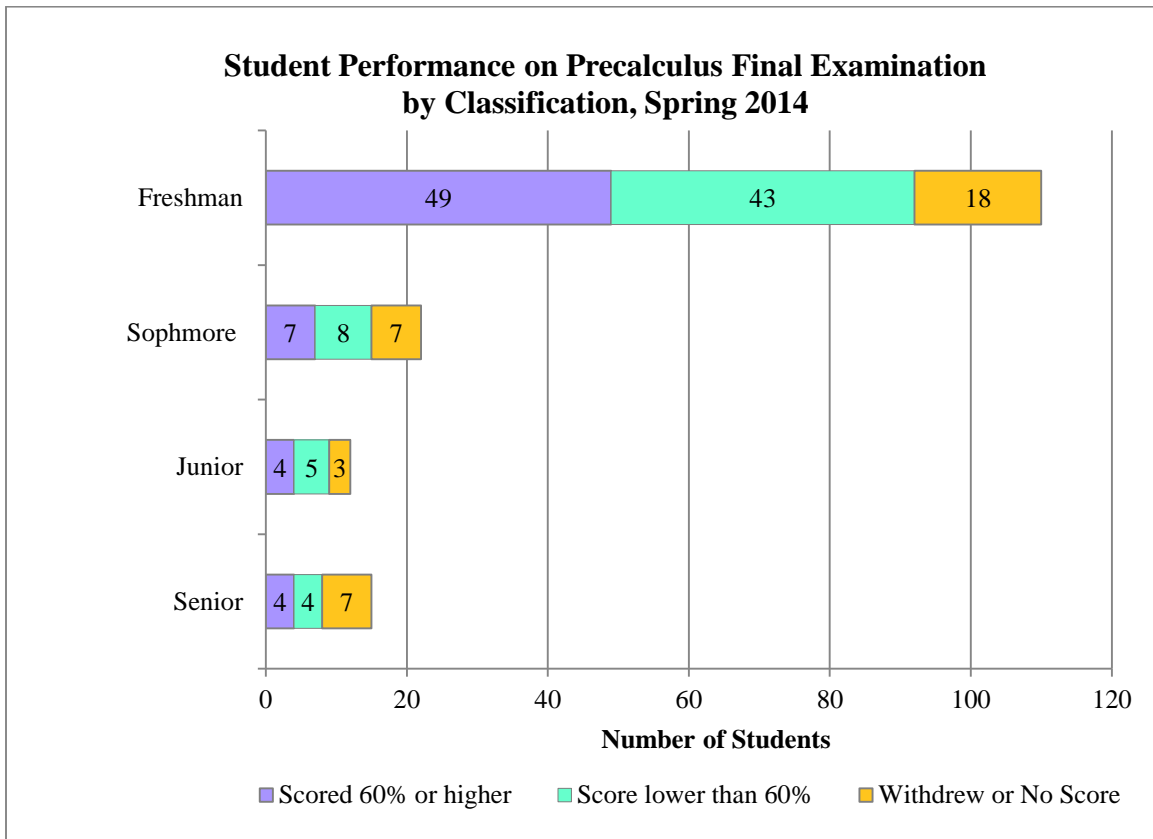
$$1 - \frac{1}{2} + \frac{1}{4} - \frac{1}{8} + \dots$$

15points 15. A committee of seven - consisting of a chairman, a vice chairman, a secretary, and four other members - is to be chosen from a class of 20 students. In how many ways can this committee be chosen ?

15points 16. What is the probability that a card drawn at random from a standard 52-card deck is either a face card or a spade ? Face cards are the Ace, King, Queen, and Jack.

Appendix C. Pre-calculus





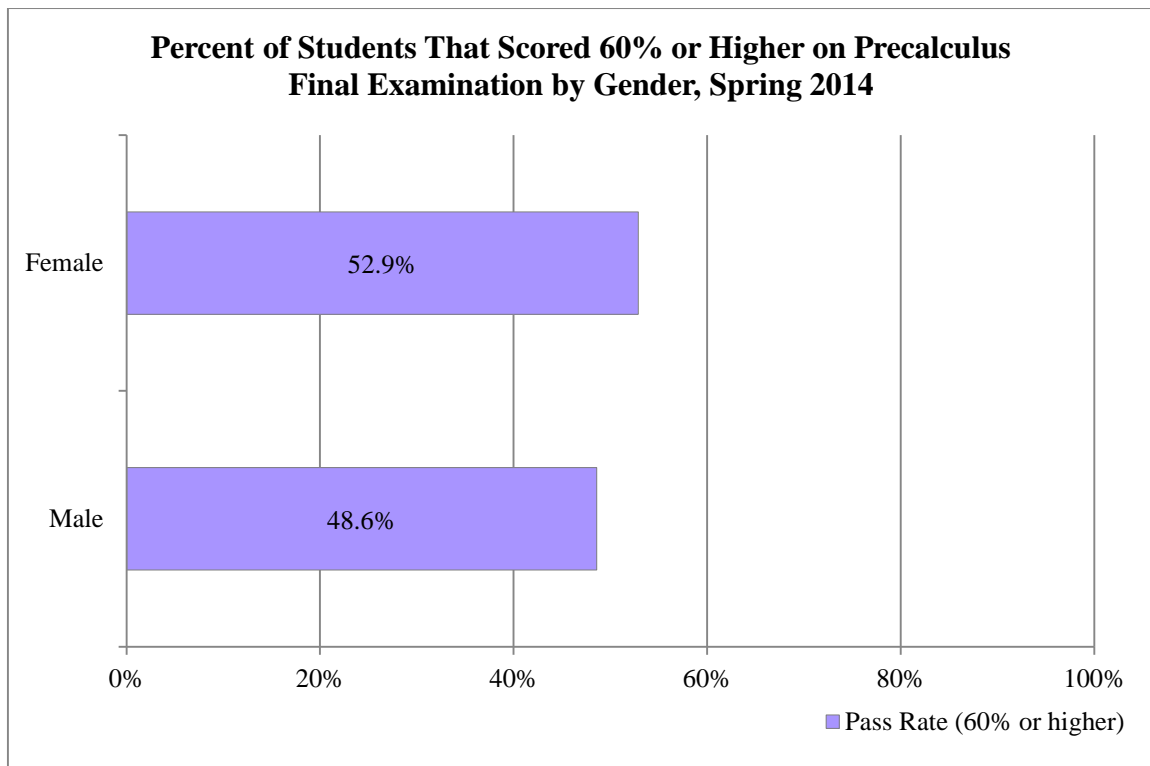
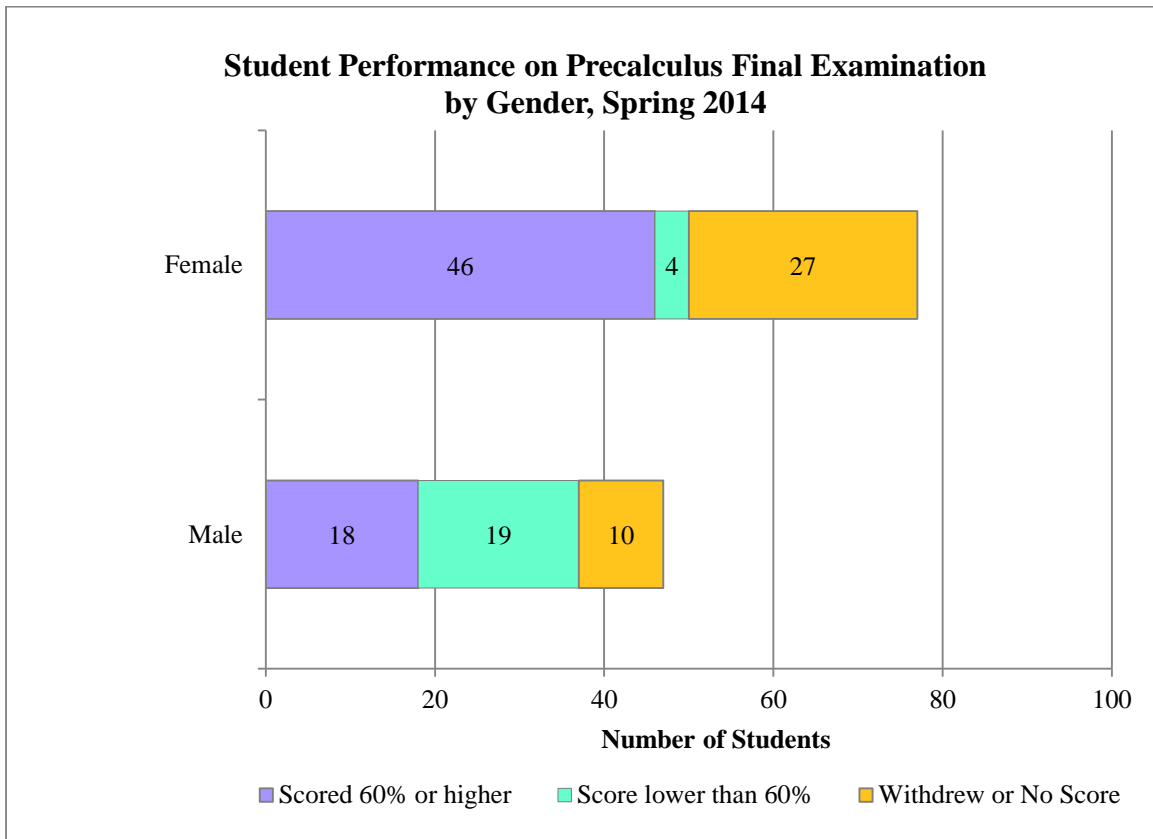


Figure C1 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Pre-Calculus by School/College. Health Sciences has the highest median score, whereas the School of Business has the lowest median score.

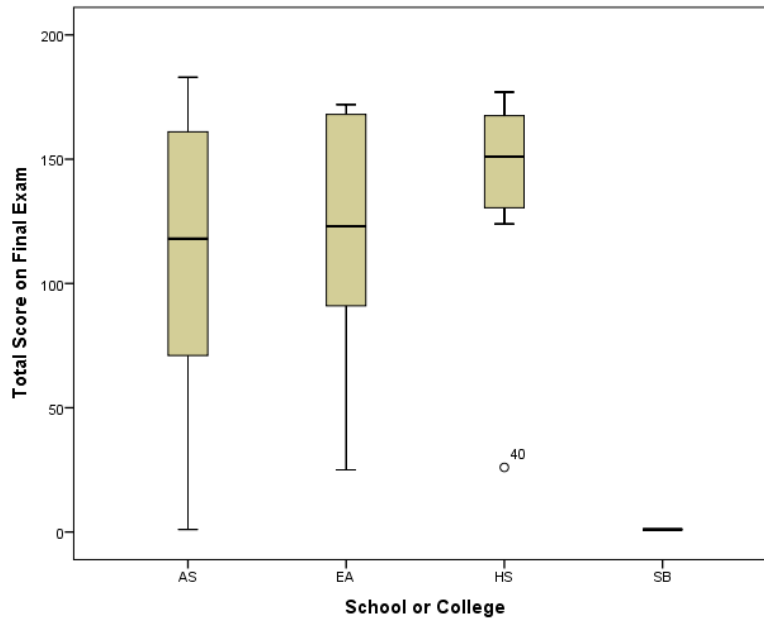


Figure C1. Exam Score by School/College Pre-Calculus

Figure C2 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Pre-Calculus by student classification. Seniors had the highest median score, whereas sophomores had the lowest median score.

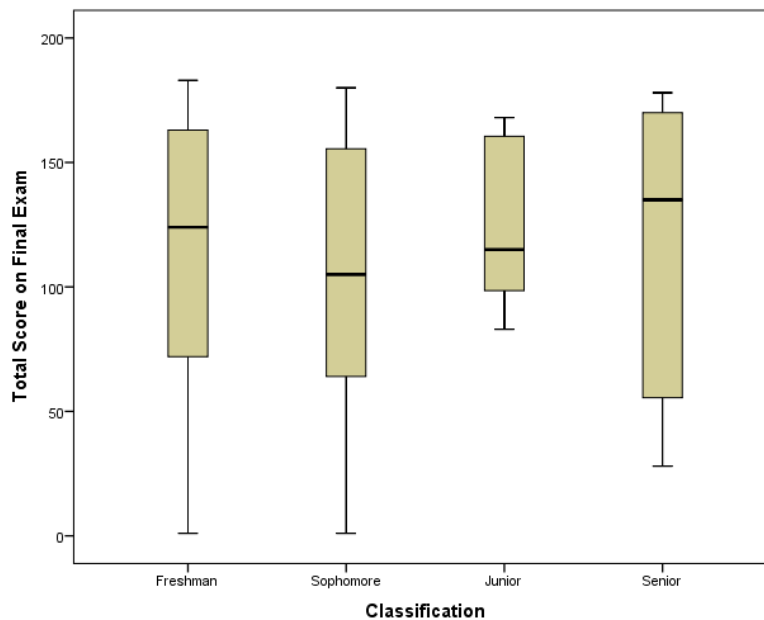


Figure C2. Exam Score by student classification: Pre-Calculus

Figure C3 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Pre-Calculus by gender. The median for males and females are almost identical, however, the female median score was slightly higher than the male median score.

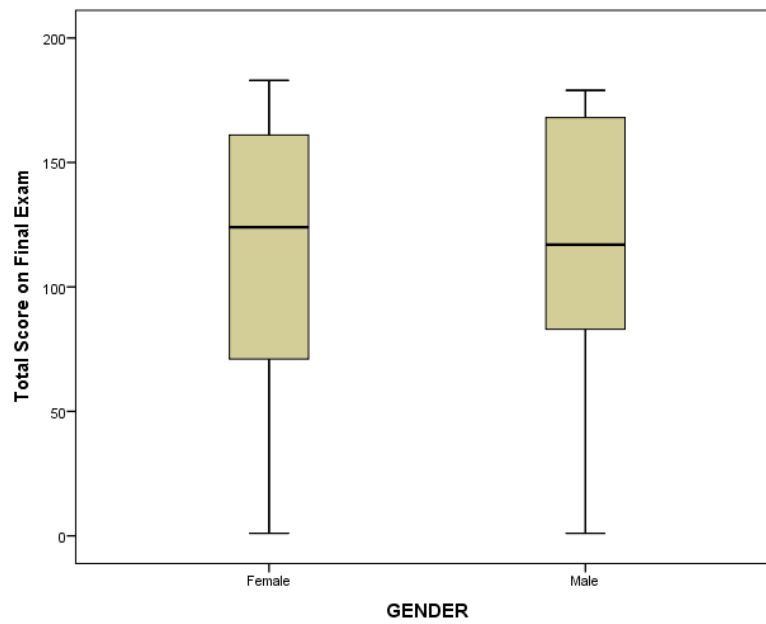


Figure C3. Exam Score by Gender: Pre-Calculus

PreCalculus (Math 007) Spring 2014 Final Exam
Howard University Department of Mathematics
April 29, 2014

Name: _____

This exam consists of 12 questions. Show all your work on the bluebook. Do not write more than two question per page. No work, no credit. Good Luck!

20points 1. For the rational function

$$G(x) = \frac{3x^3 + 6x^2}{x^2 - x - 2}$$

- (a) find the domain.
- (b) find the x intercepts(s) and the y intercepts of f if any.
- (c) find all the vertical and horizontal or slant (oblique) asymptote(s) of the graph of f if any.

15points 2. Let $F(x) = x^2 + 1$

- (a) What is the range F , if the domain is $[0, 1]$?
- (b) What is the range F , if the domain is $[-1, 1]$?
- (c) Sketch the graph F for both domains.
- (d) Does F have an inverse function if the domain is $[-1, 1]$? Why or why not? If it does find its inverse, sketch its graph and find the range of the inverse?
- (e) Does F have an inverse function if the domain is $[0, 1]$? Why or why not? If it does find its inverse, sketch its graph and find the range of the inverse?

20points 3. (a) Solve the equation: $\log_2 x + \log_2(x - 2) = \log_3 27$

- (b) Use the laws of logarithms to expand $\log\left(\frac{x^5\sqrt{x-1}}{2x-3}\right)$

10points 4. Find the exact values of:

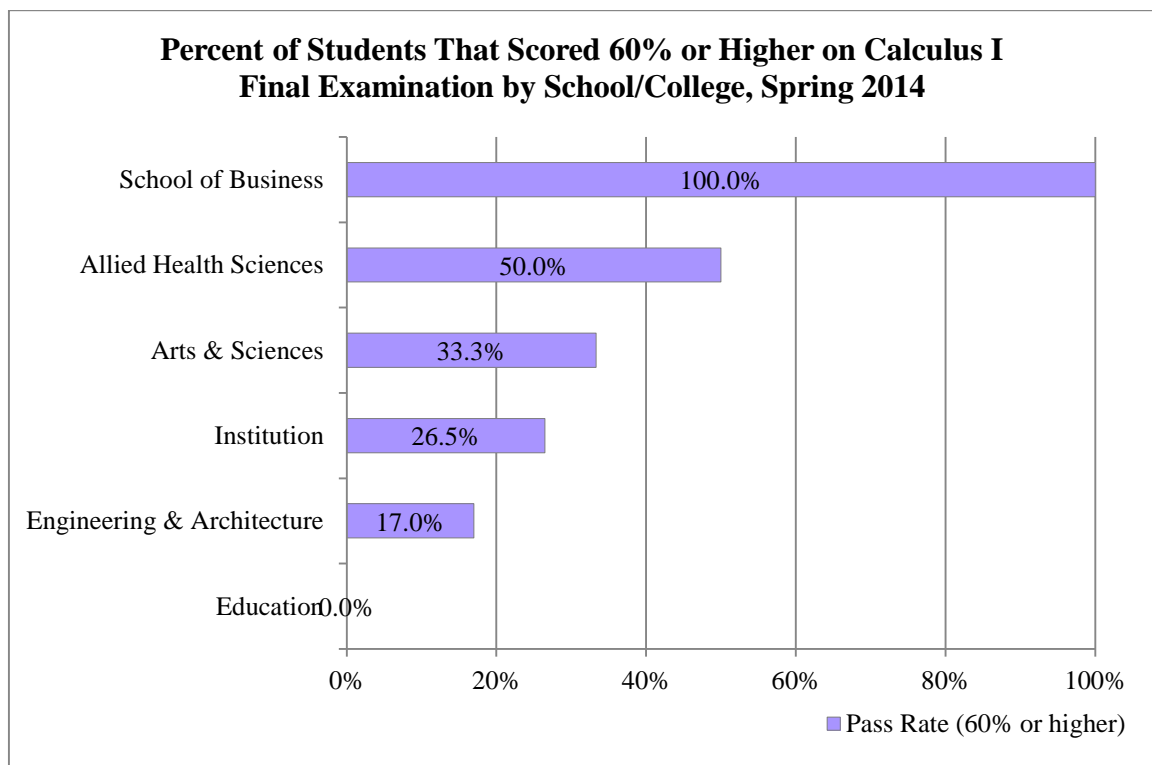
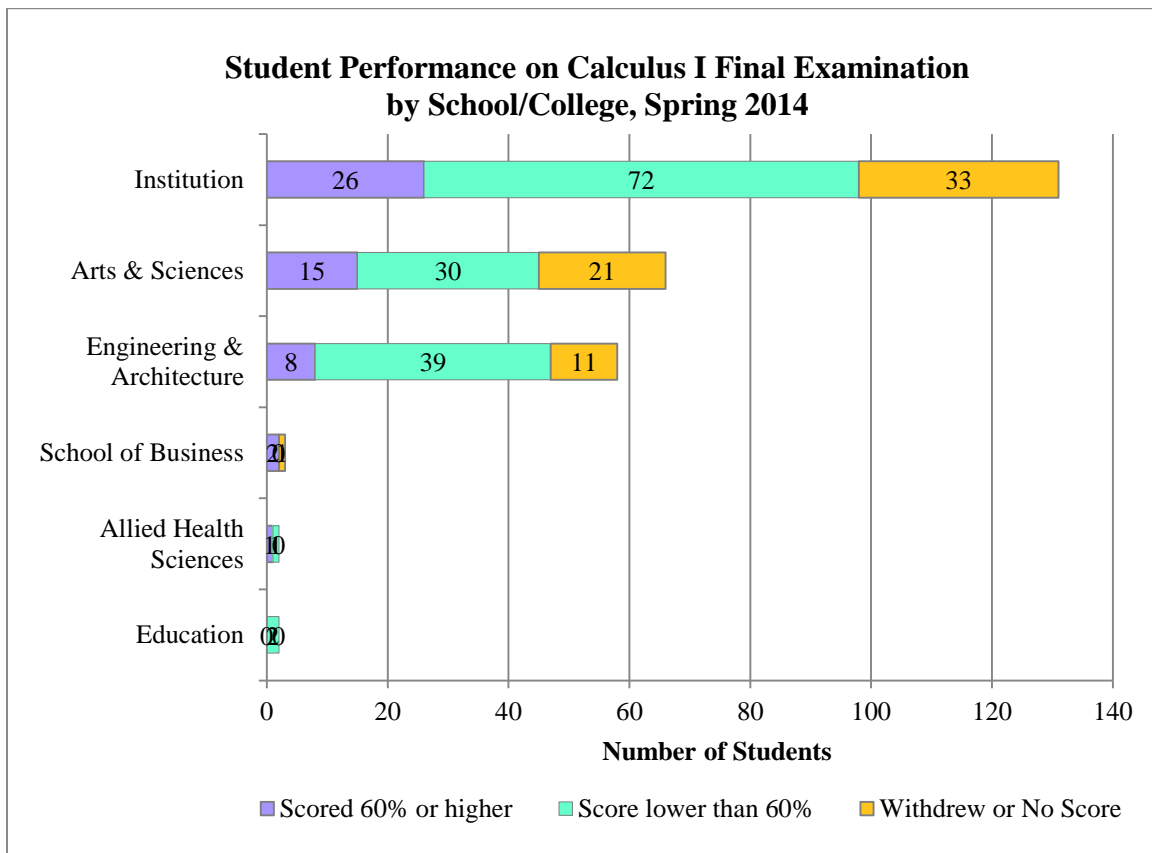
- (a) $\log 0.0001$
- (b) $e^{2\ln 4 + \ln 2}$

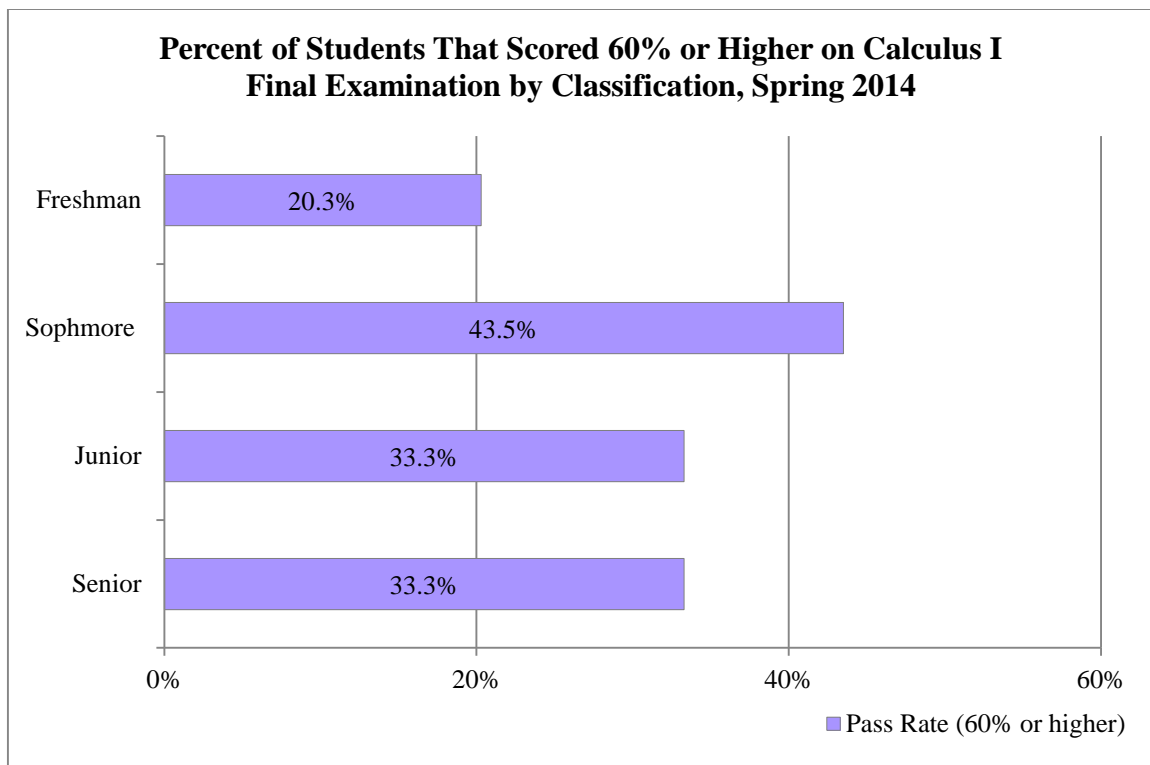
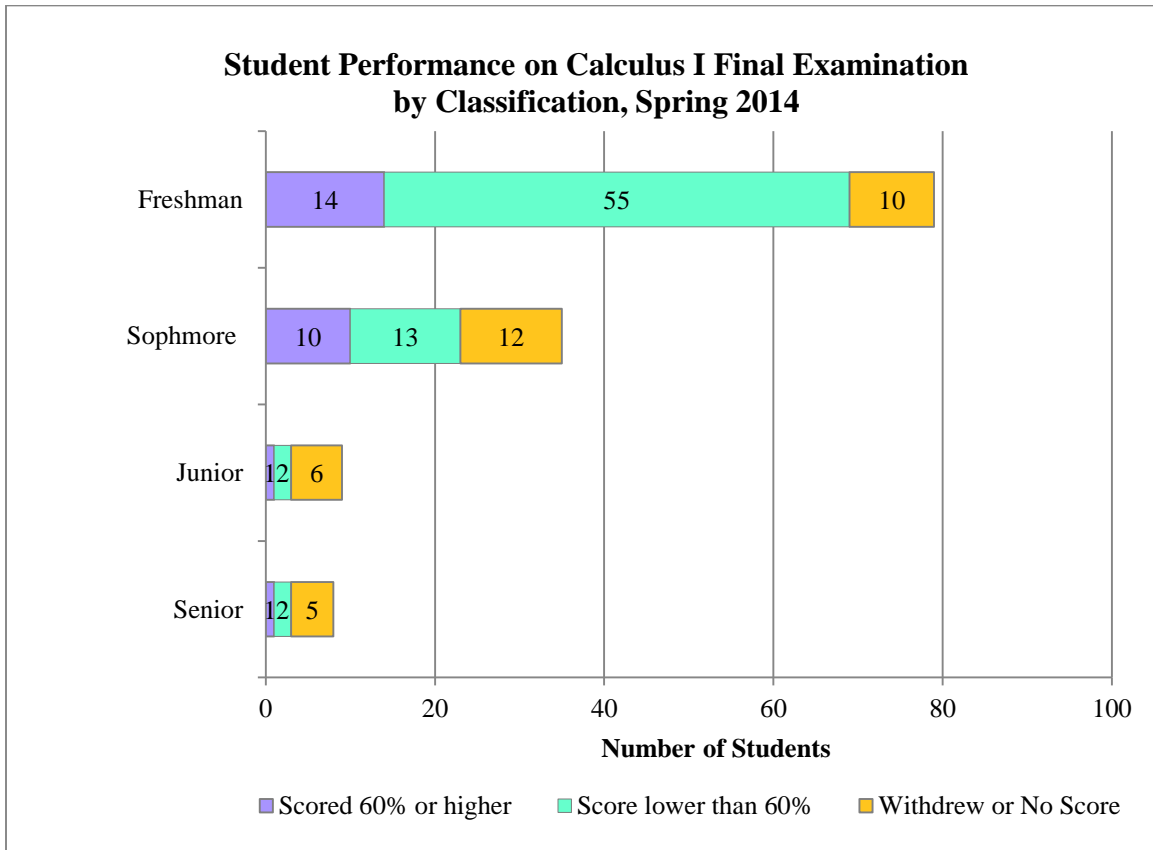
15points 5. Find all solutions of the following system of linear equations:

$$\begin{cases} x + y + z &= 1 \\ x + 2y + 3z &= 4 \\ -4x - 5y - 6z &= -7 \end{cases}$$

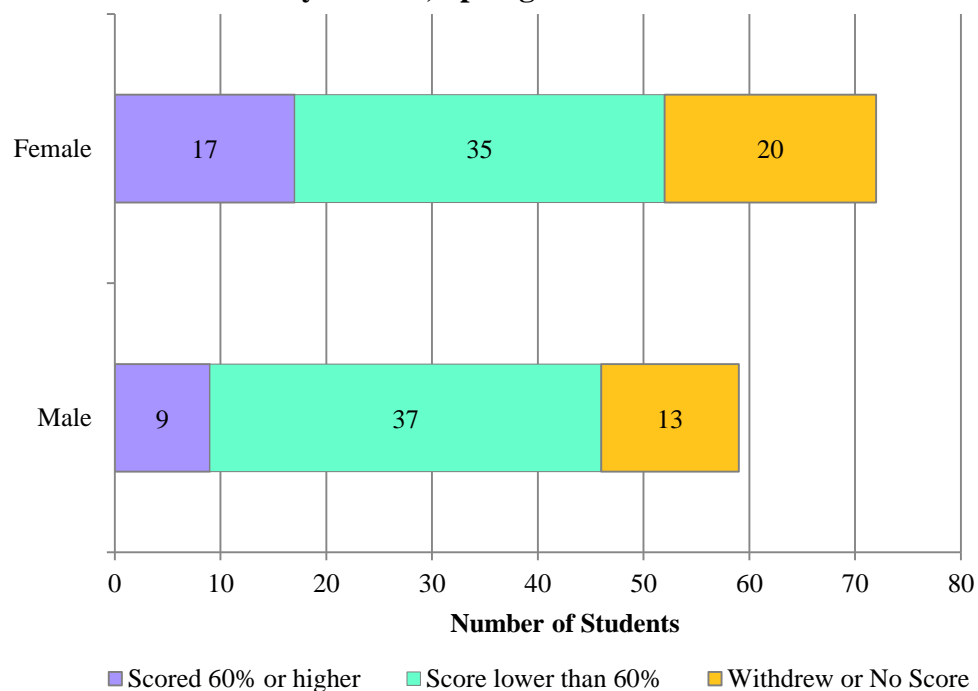
- 10points 6. Find the exact value of $\cos^{-1}(\cos \frac{11\pi}{6}) + \sin^{-1}(\csc \frac{11\pi}{3})$.
- 20points 7. If $\tan \alpha = -\frac{3}{4}$, $\cos \alpha > 0$, $\sin \phi = \frac{3}{4}$, ϕ in quadrant II , find the exact values of:
- $\sin(\alpha + \phi)$
 - $\cos 2\alpha$
 - $\sin \frac{\alpha}{2}$
- 10points 8. Find all solutions of the trigonometric equation $4\cos^2 \theta - 4\cos \theta + 1 = 0$ for θ .
- 20points 9. Find the amplitude, period and phase shift of $f(x) = -3\cos(3x - \frac{\pi}{2})$ and sketch one complete period. Carefully label the maximum points, the minimum points and the intercepts of the graph of f .
- 20points 10. Prove the following identities:
- $\sec x - \sin x \tan x = \cos x$.
 - $\frac{\tan x + \tan y}{\cot x + \cot y} = \tan x \tan y$.
- 20points 11. Suppose that \$12,000 is invested in a savings account paying 5% interest per year.
- Write the formula for the amount in the account after t years if the interest is compounded monthly.
 - Find the amount in the account after 3 years if the interest is compounded daily.
 - How long will it take for the amount in the account to grow to 20,000 if the interest is compounded continuously.
- 20points 12. (a) Graph the feasible region described by the following constraints:
- $$\begin{cases} x \geq 1, \\ y \geq 0, \\ x + y \leq 6, \\ 2x - 3y \geq -3. \end{cases}$$
- (b) Find the maximum and the minimum values of the objective function $P(x, y) = 2x + 3y + 60$ over the feasible region of part (a.)

Appendix D. Calculus I





**Student Performance on Calculus I Final Examination
by Gender, Spring 2014**



**Percent of Students That Scored 60% or Higher on Calculus I
Final Examination by Gender, Spring 2014**

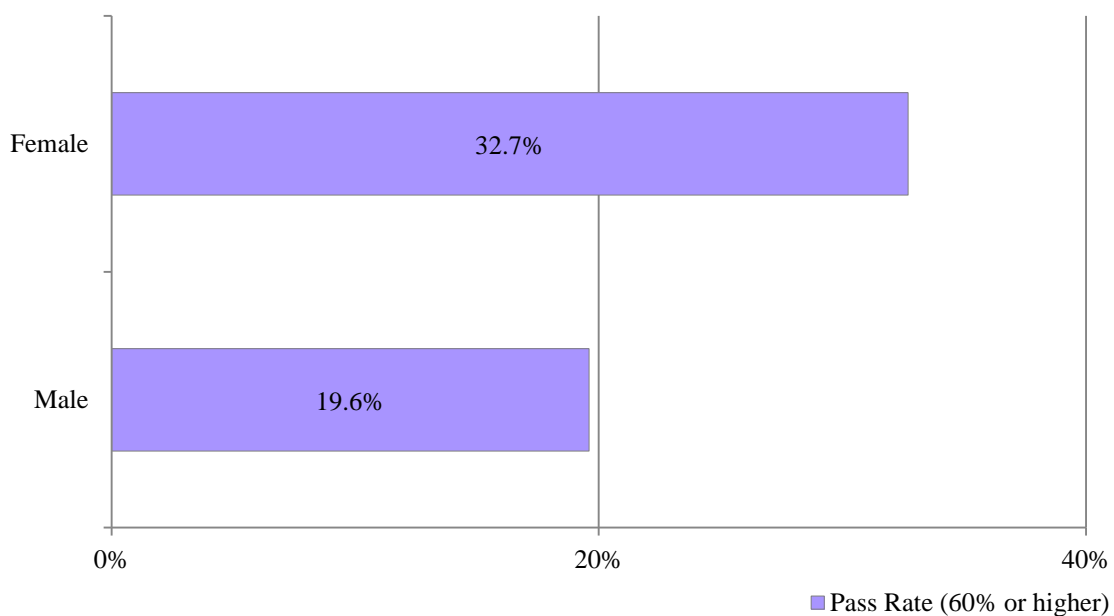


Figure D1 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Calculus I by School/College. The School of Business had the highest median score, whereas the School of Education had the lowest median score.

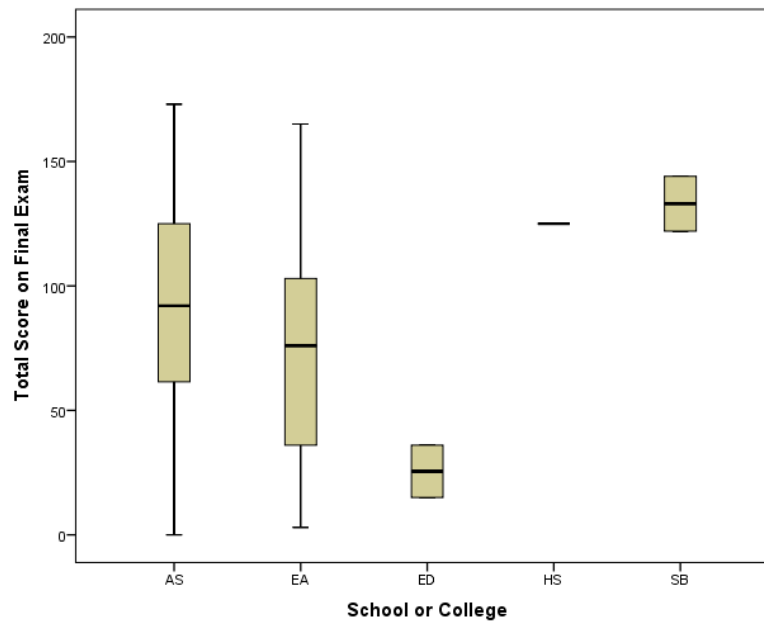


Figure D1. Exam Score by School/College Pre-Calculus

Figure D2 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Calculus I by student classification. Sophomores have the highest median score, whereas juniors have the lowest median score.

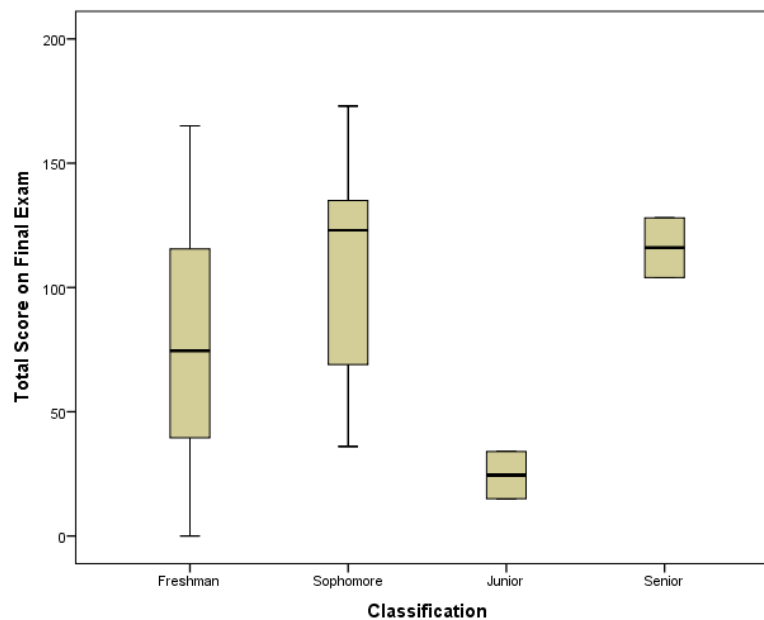


Figure D2. Exam Score by student classification: Pre-Calculus

Figure D3 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Calculus I by gender. The female median score was higher than the male median score.

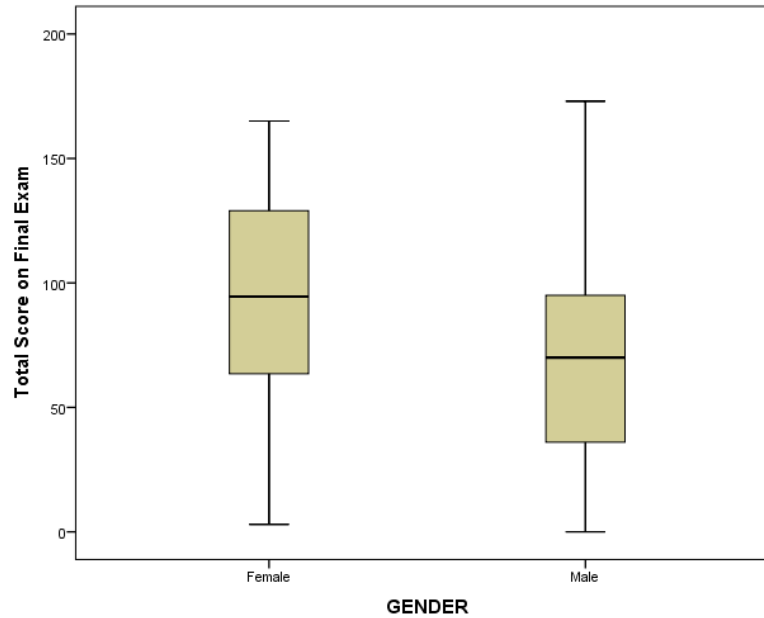


Figure D3. Exam Score by Gender: Pre-Calculus

SHOW ALL WORK. Justify your answers!

Each problem is worth 20 points. The exam total is 200 points.

Part I: Solve all problems in this part.

1. Find each limit that exists (a finite limit or $+\infty$ or $-\infty$). Otherwise, give reason(s) why the limit does not exist.

(a) $\lim_{x \rightarrow 0} \frac{x^2 - 4x + 4}{x^3 - 5x^2 + 14x}$

(c) $\lim_{h \rightarrow 0} \frac{(x+h)^2 - x^2}{h}$

(b) $\lim_{x \rightarrow \pi^-} \csc x$

(d) $\lim_{x \rightarrow \infty} \frac{3x^2 - 4x + 10}{2x^2 - 1}$

2. Find the derivative $y' = dy/dx$ for the following explicitly or implicitly defined functions $y = y(x)$.

(a) $y = x \tan^{-1} x - \ln \sqrt{x^2 + 1}$

(c) $xy = x - e^y$

(b) $y = \cos(\cos(e^x))$

(d) $y = x^{x^2}$

3. A small balloon is released at a point 150 feet away from an observer, who is on level ground. If the balloon goes straight up at a rate of 6 feet per second, how fast is the distance from the observer to the balloon increasing when the balloon is 50 feet high?

4. Let $f(x) = 6x^{4/3} - 3x^{1/3}$, $-1 \leq x \leq 1$.

(a) Find the two critical points of f in the interval $[-1, 1]$.

(b) Find the absolute minimum and maximum values of f on the interval $[-1, 1]$.

5. Sketch a graph of the function $f(x) = x^4 - 4x^3 + 27 = (x-3)^2(x^2 + 2x + 3)$ using the following steps:

(a) Identify where the local extrema and inflection points of f occur.

(b) Determine the intervals on which f is increasing and the intervals on which f is decreasing.

(c) Determine the open intervals where f is concave up and where f is concave down.

(d) Plot the x -intercept(s), y -intercept, local maxima, local minima, and inflection points of f . Then sketch the curve.

6. Evaluate the following integrals.

$$(a) \int \sin^2 x \cos x \, dx$$

$$(c) \int_0^1 \frac{1}{1+x^2} \, dx$$

$$(b) \int \frac{1-2t^3}{t^3} \, dt$$

$$(d) \int_{-1}^2 (x^2 - x - 2) \, dx$$

Part II: Solve any 4 of the problems in this part.

7. Let $y = f(x) = \frac{x^2 - 49}{x^2 + 5x - 14}$.

- (a) Determine all points at which f is NOT continuous.
- (b) Which of the discontinuities of f is/are removable? How would you re-define f at those points to remove the discontinuities?

8. (a) Show that the equation $\cos x = x$ has a solution in the interval $(0, 1)$. *Note:* You do not need to find the solution. *Hint:* Use the Intermediate Value Theorem for the function $f(x) = x - \cos x$ on $[0, 1]$.

- (b) Use the Newton's method to approximate $\sqrt[3]{2}$. Let $f(x) = x^3 - 2$, $x_0 = 1$, and find x_2 .

9. A closed rectangular container with a square base is to have a volume of 225 cubic inches. The material for the top and bottom of the container will cost \$2 per square inch, and the sides will cost \$3 per square inch. Find the dimensions of the container of least cost.

10. (a) Find the average rate of change of e^x on the interval $[0, a]$, where $a > 0$.
 (b) Use the Mean Value Theorem to show that $e^x > 1 + x$ holds for all $x > 0$.

11. Let $f(x) = \sqrt[3]{x}$.

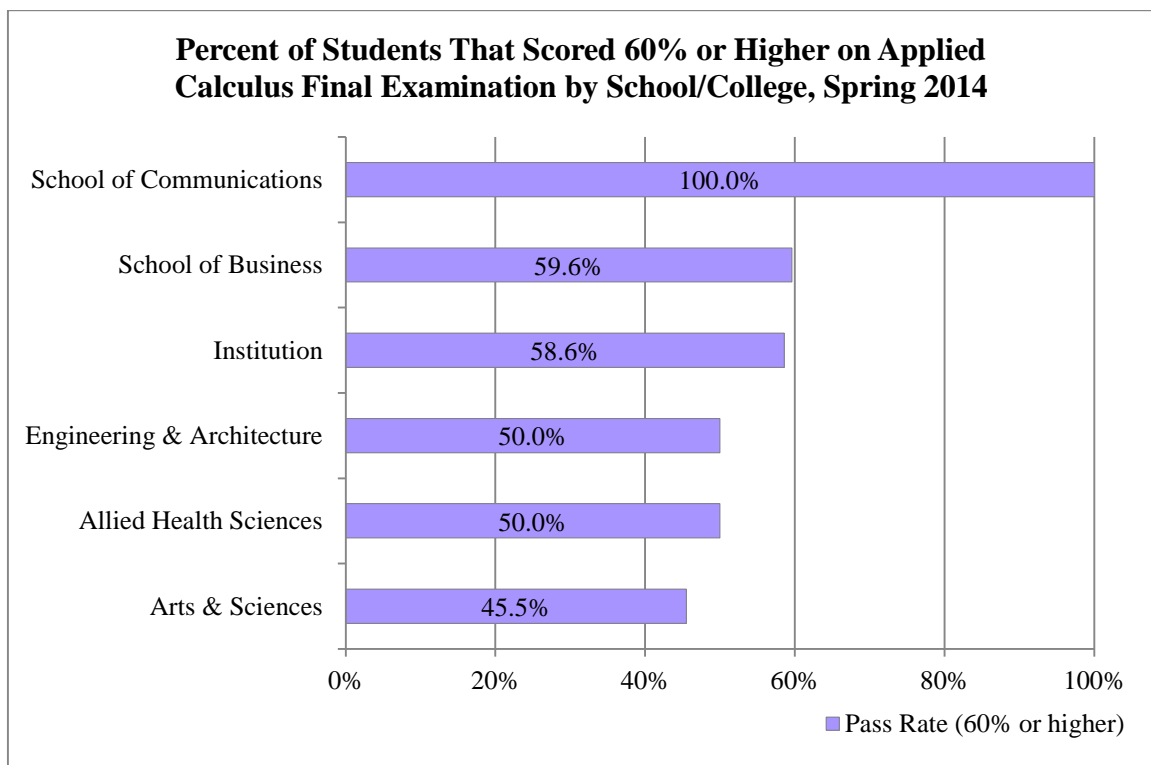
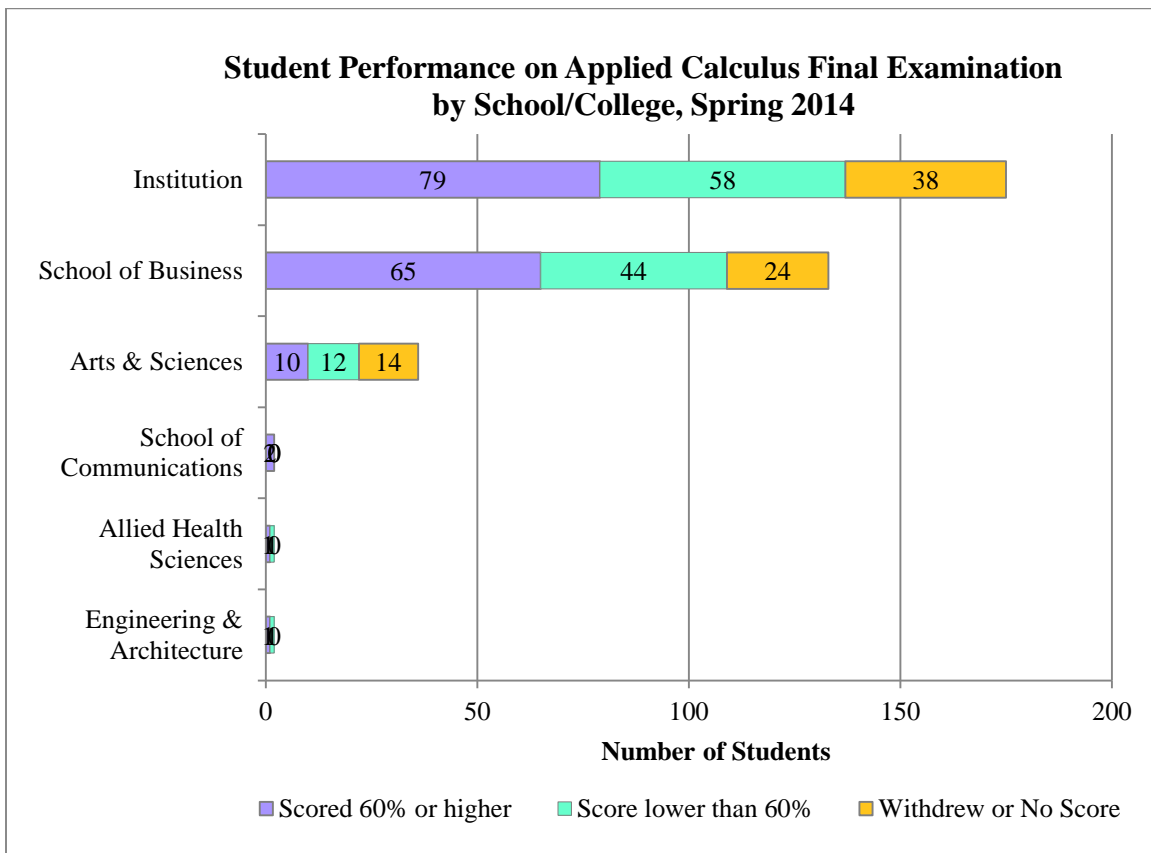
- (a) Find an equation of the tangent line to the graph of f at $x = 8$.
- (b) Find the standard linear approximation of the function $f(x)$ at $x_0 = 8$.
- (c) Use calculus, e.g. the result above, to approximate $\sqrt[3]{8.6}$ without a calculating utility.

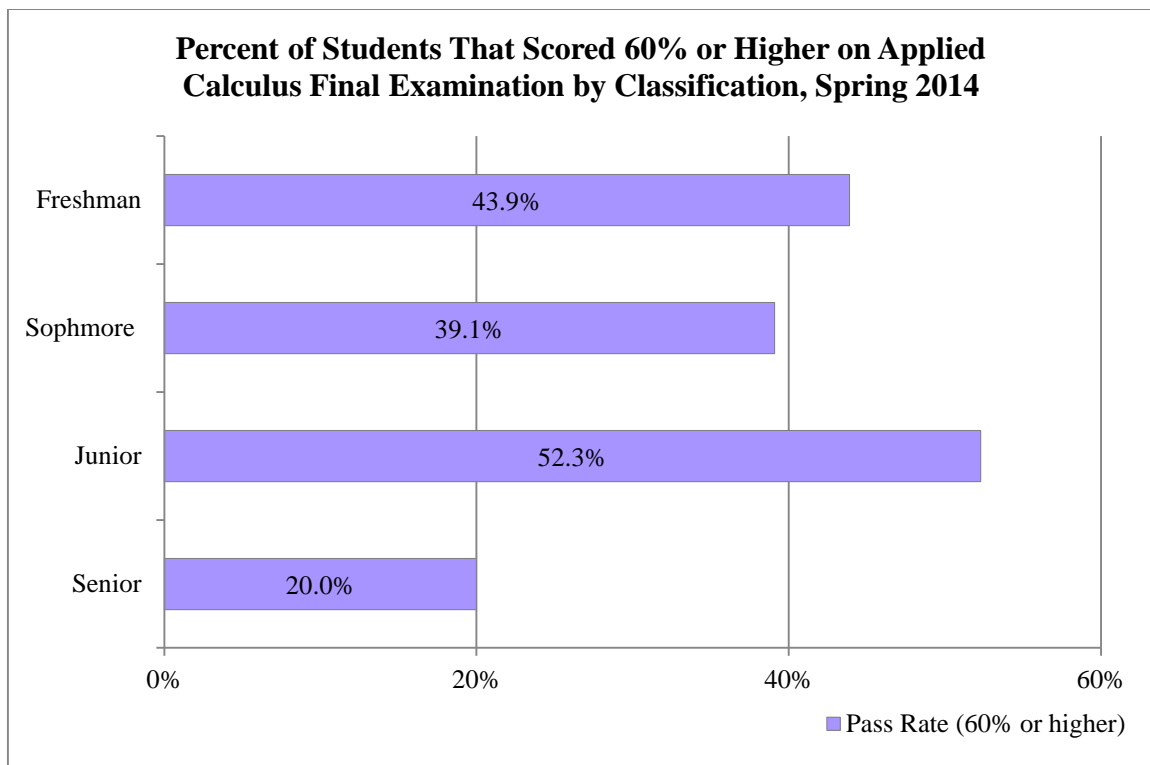
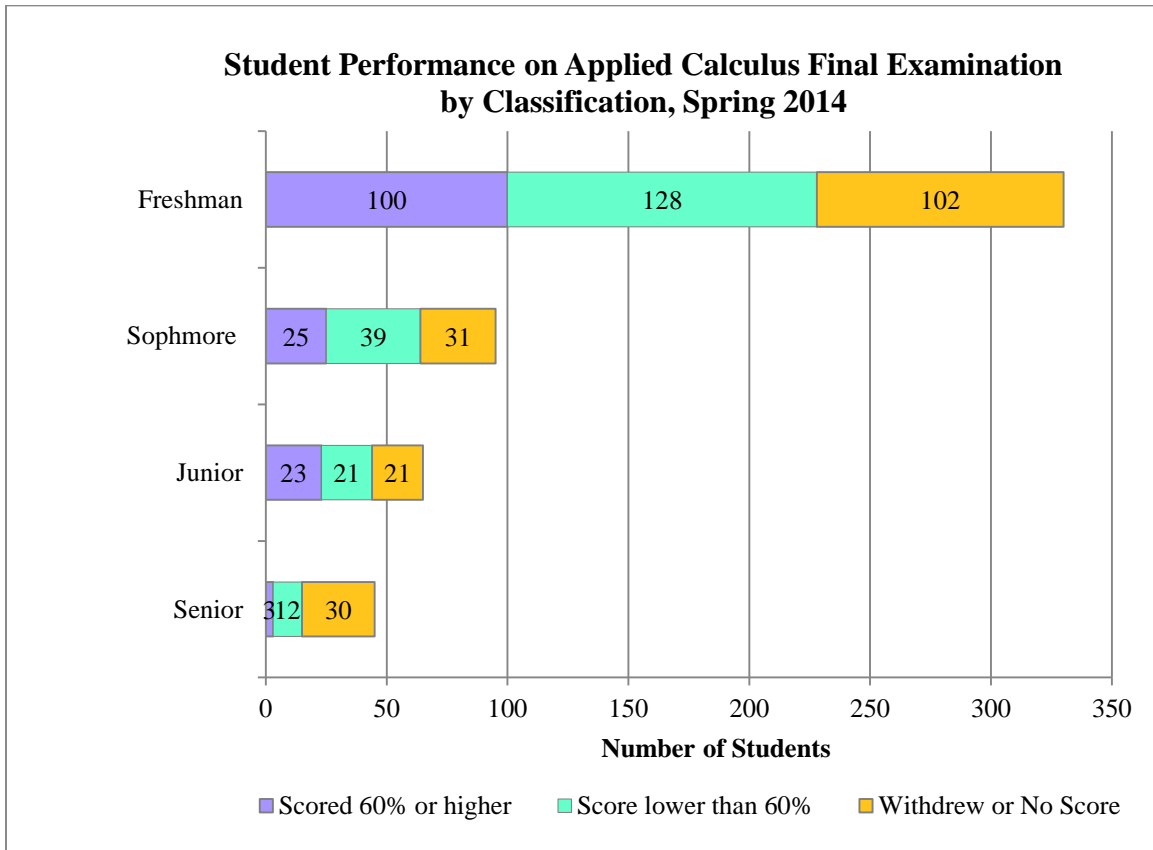
12. Let $g(x) = x + \sin x$, $0 \leq x \leq \pi$.

- (a) Find the area under the graph of g and over the interval $[0, \pi]$.
- (b) Find the average value of $g(x)$ on the interval $0 \leq x \leq \pi$.

13. Let $F(x) = \int_4^x \sqrt{t^2 + 9} \, dt$. Calculate $F(4)$, $F'(4)$ and $F''(4)$.

Appendix E. Applied Calculus





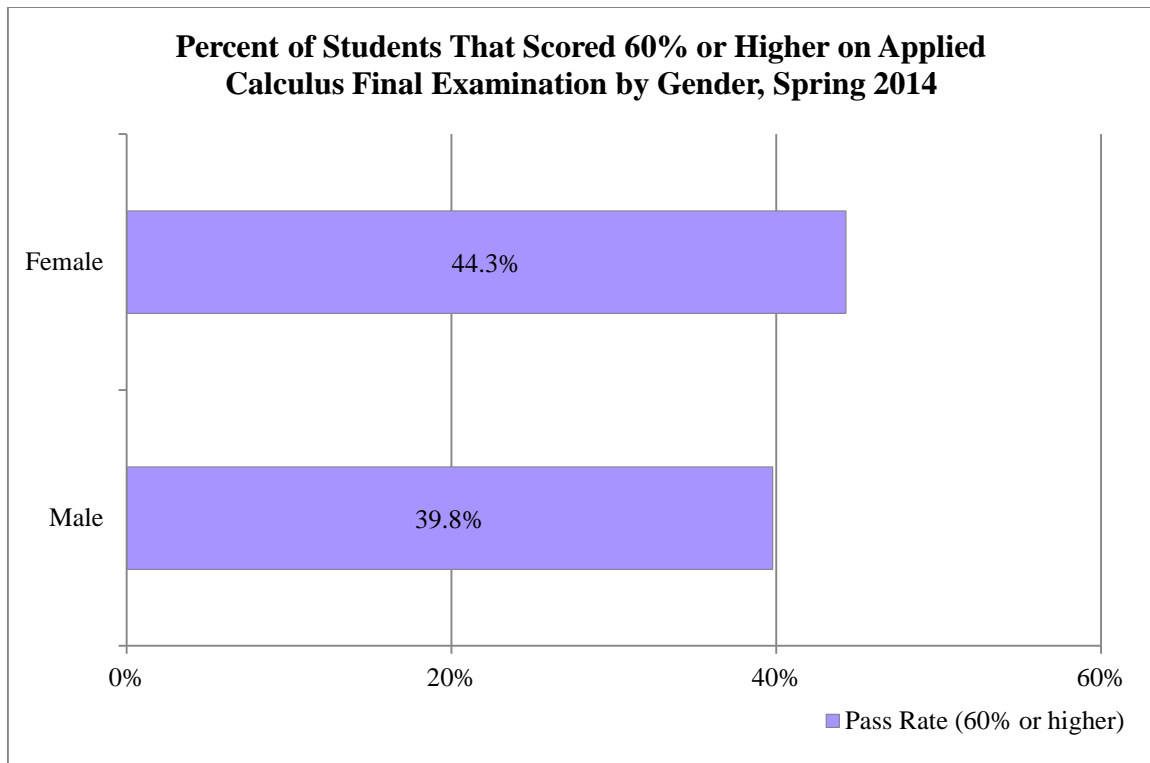
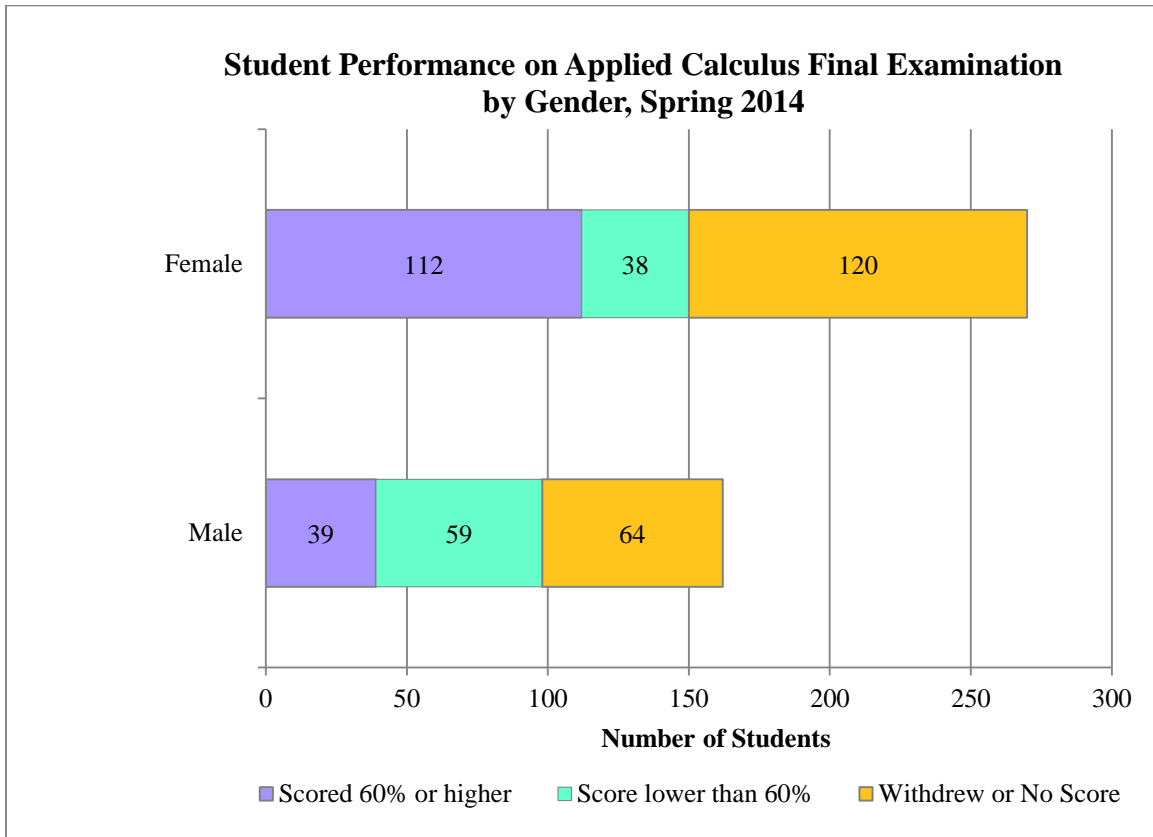


Figure E1 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Applied Calculus by School/College. The School of Communications had the highest median score, whereas the College Engineering, Architecture & Computer Science had the lowest median score.

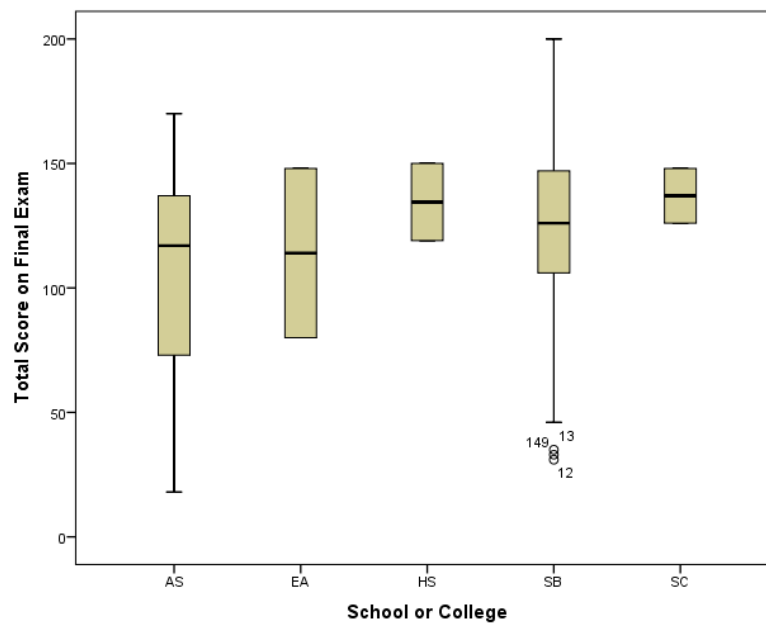


Figure E1. Exam Score by School/College Pre-Calculus

Figure E2 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Applied Calculus by student classification. Freshmen had the highest median score, whereas seniors had the lowest median score.

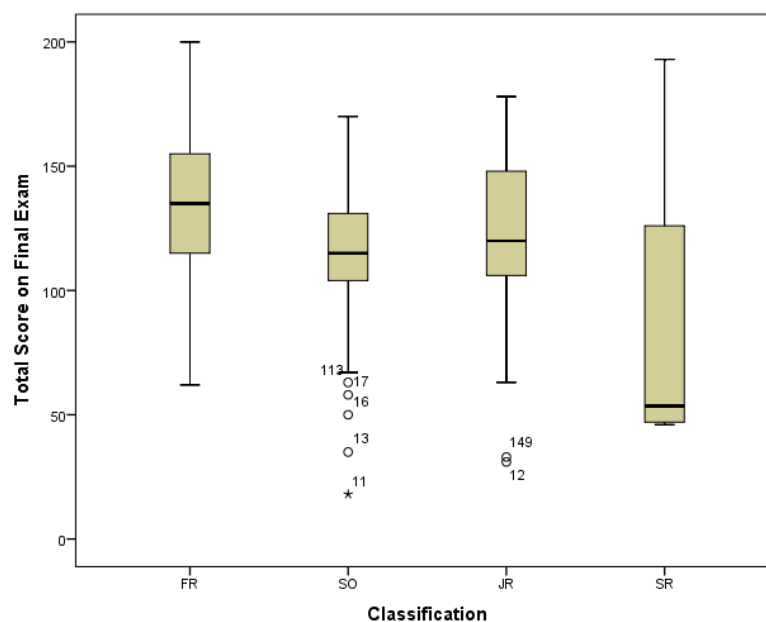


Figure E2. Exam Score by student classification: Pre-Calculus

Figure E3 presents a “Box-and-Whiskers Plot” of the total score on the final examination for Applied Calculus by gender. The female median score was slightly higher than the male median score.

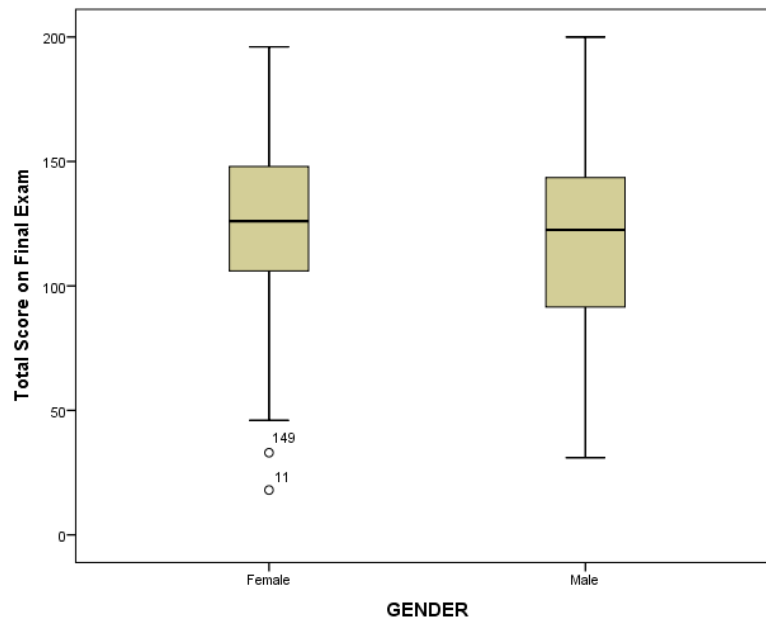


Figure E3. Exam Score by Gender: Pre-Calculus

HOWARD UNIVERSITY
Department of Mathematics
Final Examination
Applied Calculus (Spring 2014)

Each problem is worth 20pts. Answer any 10 problems. Only 10 will be counted for your grade.

1. (a) Find an equation of the line through $(1, -2)$ with slope 3.
(b) Find an equation of the line through the points $(3, 1)$ and $(2, -1)$.
(c) Find the slope-intercept form of the line through the points $(-2, 1)$ and $(4, 5)$.

2. Find the derivative of the following functions:

(a) $f(x) = e^{2x^2-5x-3}$ (b) $f(x) = \ln(5x^2 - 6x - 2)$.

3. Consider the curve whose equation is given by

$$2y^2x^3 - 6x^2 + 3x + 8 = 4y.$$

- (a) Use implicit differentiation to find $y'(0)$.
 - (b) Find the equation of the tangent line to the graph passing through the point $(0, 2)$.
4. The perimeter of a rectangular field has a perimeter of 320 feet. Express the area of the field as a function of the length of one of its sides (call it L). Find the L that maximizes the area? What is the corresponding area?
 5. Determine the intervals on which the function $g(x) = x^2e^x$ is concave up.
 6. A total cost function, in thousands of dollars, is given by $C(q) = q^3 - 6q^2 + 15q$, where q is in thousands and $0 \leq q \leq 5$.

- (a) Graph $C(q)$.

(b) Graph the average cost function $a(q) = \frac{C(q)}{q}$.

- (c) Determine the exact value of q at which average cost is minimized.

7. (a) Write the equation of a line that is parallel to the line $x - y = 5$ and goes through the point $(-2, 1)$.
 (b) Write the equation of a line that contains the point $(1, 5)$ and is perpendicular to the line $y = 2x - 6$.
8. Graph the cost function $C(q) = 24000 + 7q$ and the revenue function $R(q) = 15q$ on the same axes. For what values of q does the company make money? [Hint: a company makes money when its profit function $P(q) > 0$].
9. Find the absolute maximum and the absolute minimum of the function $g(x) = 3x^2 - 2x + 10$ for $0 \leq x \leq 4$.
10. Consider the function defined by $f(x) = \frac{x^2}{x-1}$.
- Find the intervals where the function is increasing and decreasing.
 - Find all intervals where the function is concave up and concave down.
 - Find all relative extrema and classify them.
 - Find all points of inflection.
 - Find x and y -intercepts.
 - Find horizontal and vertical asymptotes.
 - Find sketch the graph of $f(x)$ noting all points and asymptotes found in the previous parts.
11. Compute
- $\int \frac{1}{\sqrt{x+1}} dx$
 - $\int x^3 e^{2x^6} dx$.
12. Evaluate $\int_{-1}^2 (6x^2 + 2x - 10) dx$.
13. Find the area between the curves $y = x^2$ and $y = 2 - x$.
14. Draw a sketch of the region represented by the following definite integral.
- $$\int_0^1 \sqrt{4-x^2} dx.$$
15. Sketch the graph of the function. Be sure to show all key features such as intercepts, critical numbers, etc.
- $$f(x) = 3x^4 - 4x^3.$$