Comfort, Complexity and Competence: Quantitative Reasoning at Harold Washington College

HWC ASSESSMENT COMMITTEE
Christopher Sabino, Jeffrey Swigart & Michael Heathfield.

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Methodology

1. Overview

This report outlines the methodology, key findings and recommendations from the Quantitative Reasoning Assessment undertaken by the Harold Washington College Assessment Committee (HWCAC) in the fall semester of 2009. Over 1,100 students completed the survey during assessment week of fall 2009 and provided data in three distinct areas of questioning.

The first area gathered demographic details and data allowing us to methodologically sort students in to three primary cohorts charting their different journeys through math class levels both here and at other institutions of higher learning.

The second area of questioning collected data in the affective realm. The preliminary set of questions for this area asked students to identify their comfort level with core general education disciplines: science, math, writing, reading and the arts. This was then followed with twenty more specific affective questions seeking data about quantitative reasoning and student approaches to learning in this discipline.

The third and final section asked students to demonstrate their specific math skills through a carefully crafted set of direct questions. There were twelve specific items covering such things as: percentages, interpreting graphic data, calculating the mean, calculating area, linear equations and geometry.

2. Assessment Process

As has been the protocol in the past, the HWCAC began with the first step of the assessment cycle by defining our student learning outcomes for quantitative reasoning. The following definition and outcomes were approved in February 2009 by the HWCAC. We acknowledge the contributions of Art DiVito, Chao Lu, Kurt Sheu and the entire 2008-2009 HWCAC for the definition and student learning outcomes (SLO's).

Our general education objective for Quantitative Reasoning was stated as follows: "To use mathematics for computation, reasoning and problem solving." The detailed definition states: "Quantitative Reasoning involves the ability to use the elements of mathematics* for the purpose of computing effectively, interpreting and analyzing data, math modeling, and reasoning within abstract and contextual structures to make predictions, judgments and decisions. The ability to employ quantitative reasoning results in what is called Quantitative Literacy, or Numeracy."

**By Elements of Mathematics, is meant prerequisite skills (arithmetic and algebra), number sense, symbolic representation, algorithms, spatial reasoning and measurement.*

The consequent Student Learning Outcomes (SLO's) were finalized and approved as follows:

"The student will be able to:
1. Interpret mathematical models such as formulas, graphs, tables, and schematics.
2. Represent mathematical information symbolically, visually, numerically, and verbally.
3. Apply arithmetical, algebraic, geometric or statistical methods in order to solve problems.
4. Estimate and check answers to mathematical problems for the purpose of determining reasonableness, identifying alternatives, and selecting optimal results.
5. Recognize limitations of mathematical and statistical methods."

3. Assessment Tool Design

These SLO's were formally approved in February 2009 and were used for the search and design process for the quantitative reasoning assessment (QRA) tool. Math faculty and Assessment Committee members Invested considerable time in seeking out relevant tools to gather data pertinent to our agreed outcomes. As has become the custom and practice of HWCAC, the final tool became an amalgam of elements freely adapted from other publicly available tools (James Madison University, Wellesley College and Virginia Commonwealth University) and our own in-house questions specific to our particular needs and context. The first half of the assessment tool, the indirect and affective portion, was created by HWCAC including a demographic survey that the HWCAC has used and honed over our past few assessments. The questions were modified slightly in order to differentiate students at different points in their mathematics journey. In the end, the assessment tool consisted of 41 questions (30 demographic/affective and 11 cognitive). The majority of the cognitive questions were multiple-choice, though we also included some (3) open-ended questions. These methodological choices were made for a range of reasons.

Firstly, no one assessment from elsewhere adequately measured our specific SLO's. Secondly, we have always collected a range of affective data believing that there is research evidence showing there is a link between perceptions of learning and actual outcomes; and this is could also be supported in the study of mathematics and mathematics achievement. Also, assessment research shows that mixed assessments (direct and indirect) can often be more informative than those that are strictly direct or indirect. With respect to the open-ended questions, the HWCAC math faculty all agreed that mathematics is more than just multiple-choice questions with a single, 'clean' answer. As such, the open-ended questions were crucial to provide insight into student thinking specifically around mathematics.

4. Implementation Data

At the end of the spring 2009 semester, we attempted to pilot this assessment, after it was formally approved. The purpose of the pilot was to gauge the amount of time the QRA would take, and to see if we needed to tweak any of the wording. We had a very low turnout, but were able to see a few areas that could use some fine-tuning. Due to the low turnout, we administered a 2nd pilot during the summer semester. We used these pilot assessments as a means of beginning the process of creating grading rubrics for the open-ended questions. After the pilots, we were pleased with the tool and ready for the full-scale administration in the fall 2009.

In fall 2009 (November 9th through November 14th), the Quantitative Reasoning Assessment (QRA) was administered to 1132 students. Over 30 faculty members volunteered their 61 class sections and, for the first time, we gave students the option of volunteering to take the assessment on their own. To entice them to take the assessment, given the societal perceptions of mathematics, all participating students were entered into a raffle in which the prizes were ten iPod Nanos and twenty iPod shuffles. We were grateful to HWC administration for supporting this 'incentive' scheme. This approach was debated considerably within the committee and views differed as to whether we might be establishing a precedent that we may not be able, or wish to continue with regard to student participation in assessment activities. Ultimately, the belief that more persuasion might be required to get students to undertake a math 'test' won out and we wanted to experiment with persuading students to take the assessment of their own volition rather than the more usual, and successful methodology of faculty volunteered sections. In fact, the incentives did not seem to influence the number of students taking the QRA by their own volition: of the 1148 student respondents only 35 were individual 'walk-in' students. This represents a mere 3% of our surveyed students. We cannot ascertain whether the incentives, which were widely publicized in every classroom, actually persuaded faculty to volunteer their sections. The total number of student participants is in the high range for HWCAC assessments, if not one of the highest.

This was a paper and pencil test with a heavily scheduled assessment room, to which faculty brought their classes at requested times. The allocation of volunteered sections endeavored to capture students from across the catalogue, through diverse subject areas and from the full range of timetabled classes including evenings and Saturday classes. A complex roster of HWCAC members throughout the week proctored the assessment room. Specific participation data, projected and actual, is represented in the table on the following page.

Ranking	Day	Projected	Actual	Difference	# Walk-Ins
1	Tuesday	307	369	+62	12
2	Wednesday	278	316	+38	8
3	Monday	252	265	+13	6
4	Thursday	156	138	-18	7
5	Saturday	43	37	-5	0
6	Friday	21	23	+2	Not open
Totals		**1,057**	**1,148**	**+91**	**35**

- There was an average 69% participation rate for students in scheduled classes and we surpassed our 1,000 student revised target by 9%.
- 65 class sections were eventually scheduled of which 4 were 'no-shows' (0.6%).
- 8 student surveys were excluded for duplication or other reasons – 0.07% of students.
- Mondays, Tuesdays and Wednesdays were peak traffic days and as the week progressed student numbers fell below projections.

5. Demographic Data

In fall 2009 there were 7,725 total students at HWC. The sample of students taking the QR assessment was 1,132, which was 14.65% of the student population at the time, making this a statistically significant sample. Below are tables showing comparisons of students taking the assessment versus HWC students overall by gender, age, race/ethnicity, and full-time versus part-time. Notice that while the sample of students taking the assessment was statistically representative of HWC students overall, there are some slight demographic differences in the student profile. Full-time students were over-represented in the sample of students taking the assessment, which makes sense because these students were on campus more often and thus had a much stronger probability of being in a class in which their instructor had selected to ask them to take part in the assessment. As can be seen below, this sample was less Asian, American Indian, Alaskan Native, Native Hawaiian, less black and white, and slightly more Hispanic than the HWC student population at the time of the data collection.

Race/Ethnicity					
Students Taking Assessment			**HWC Overall**		
American Indian, Alaska Native	0.09%		American Indian, Alaskan Native	0.4%
Asian, Hawaiian, Pacific Islander	9.55%		Asian, Hawaiian , Pacific Islander	11.8%
Black, African American	34.72%		Black Non-Hispanic	37.7%
Hispanic, Latino	36.57%		Hispanic	28.1%
White	14.13%		White	19.5%
Multi-Racial, Multi-Ethnic	4.42%		Unknown	2.5%
Blank	0.53%			

Gender				
Students Taking Assessment			HWC Students Overall	
Female	60.07%		Female	60.7%
Male	39.58%		Male	39.3%
Blank	0.35%			

Age				
Students Taking Assessment			HWC Overall	
25 or Under	77.47%		24 or Under	61.5%
26 to 40	17.84%		25 to 40	28.6%
41 and Above	4.24%		41 and Above	9.8%
Blank	0.44%		Unknown	0%

Full-Time Versus Part-Time				
Students Taking Assessment			HWC Overall	
Full-Time (12 or More Credits)	80.48%		Full-Time (12 or More Credits)	58.6%
Part-Time (Fewer Than 12 Credits)	18.99%		Part-Time (Fewer Than 12 Credits)	41.4%
Blank	0.53%			

Below are the tables showing data for the sample of students taking the assessment in which we asked students to identify the college math level, as indicated through their placement and success in the college math sequence of courses. This sample profile indicates that these students were, in large part, relative novices and inexperienced in terms of their college mathematics journey.

College Level Credit Hours Passed at HWC	
0	25.62%
1-15	36.22%
16-30	22.08%
31+	15.19%
Blank	0.88%

College Level Credit Hours Passed at Other Colleges	
0	44.88%
1-15	21.64%
16-30	14.66%
31+	16.08%
Blank	2.74%

Current Math Class or Math Class Eligible For	
PC Math 3001 - Math 99	49.65%
Math 118 - Math 140	30.83%
Math 141 - Math 212	12.90%
Blank	6.63%

Math Courses Successfully Completed at HWC	
0	52.12%
1-2	36.66%
3+	8.57%
Blank	2.65%

Math Courses Successfully Completed at Any College	
0	55.30%
1-2	18.02%
3+	5.12%

Repeated a Math Course?	
Yes	21.47%
No	77.83%
Blank	0.71%

The student profile indicates the majority of this sample was really at the outset of their college-level math journey and indeed half had tested into pre-credit math classes. This indicates that these students did not come to HWC math classes with a strong history or culture of math success. Over 20% of this sample had indeed failed a math course at HWC or another higher education institution. This provides an interesting context in which the specific math competence assessment results should be viewed.

6. Grading and Data Analysis

As explained previously, we attempted to break the participants into cohorts based upon their mathematics level at CCC. Our initial plan was to do this in two ways. Firstly, we would get District to sort all of our students, using PeopleSoft student id's, into three categories using math level data. Secondly, on the QRA demographic portion, there was a question asking students to self-report their current (or most recent) math class. The original plan was to use the District data as a reliability check on the student self-reports of math level. It was also an acknowledgement that we knew that sometimes students are unaware of class levels, labels and categories that we are so familiar with. In the end, when compiling the data, the PeopleSoft id numbers coupling with the list from District Office proved to be too cumbersome and unhelpful. As such, we relied upon the student's self-reporting, which runs the risk of having some inconsistencies. At the very least, the PeopleSoft student identification database allowed us to ensure that students didn't take the assessment more than once. The predetermined analytical cohorts, designed to group students into different stages of a successful mathematics journey at HWC, were as follows:

- Cohort 1: FS Math 3001-2 (formerly PC Math 3001-2), Math 98, Math 99
- Cohort 2: Math 118, 121, 122, 125, 140
- Cohort 3: Math 141, 144, 146, 204, 207, 208, 209, 210, 212

The hypothesis behind these cohort groupings was that we would be able to distinguish students who were at the beginning of their math skills journey, at a mid-point, and at the more advanced level with regard to college-level math. This cohort level distinction is a method we have used successfully before in a range of assessments. Although we have never labeled these cohorts before, it might be both a fair categorization and a reasonable hypothesis to label these artificial student groupings as 'beginning', 'competent' and 'proficient'.

For the multiple-choice questions, the grading was essentially automatic once the key for the cognitive questions was created. As for the three open-ended questions, the grading was split amongst four math faculty on the HWCAC. The grading rubrics for open-ended questions (numbers 9i and 11) appear at the end of this document in Appendix B. Rubric creation was a communal process, using a five-point scale for each of these answers. Each question counted for two points with half point intervals allowing for five possible scores (0, .5, 1, 1.5, and 2). Individual faculty graded specific questions to help keep the consistency and reliability from student to student high within the direct math skills elicited by distinct questions. During the grading process, graders conferred with one another about the rubrics to make sure that there was consistency in awarding grades. Additionally, graders each flagged problems that would benefit from a second read. With these problematic answers graders consulted and came to a consensus. In general, the final score, after the second read and grade, was determined by the key faculty grading that problem given their accumulated expertise on the specific math problem. The grading was turned around extremely quickly, by late spring/early summer 2009, which was a testament to the HWCAC faculty working on this aspect of the assessment. Also, for the open-ended questions the questionnaire design included grade score boxes that could be read by computer program, thus easing the electronic translation of all responses, including answers that were manually graded by faculty. This allowed them to be scanned rather than inputted manually and again made this a very speedy data collation process. It would have been done even more quickly if not for one unexpected issue.

Given that the scoring criteria for the open-ended questions included the possibility for a score of 0, we needed to distinguish between a score of 0 based upon merit and a score of 0 due to the student skipping the question. As such, we went through the thousand plus surveys and noted those assessment numbers that had blank responses for one or more of the open-ended questions. When the data was inputted, the blanks were coded as 'BLANK' so as not to influence the mean. This was a decision we made. Ultimately, if we do consider these as zeros, then the means will decrease for each question. Notably, question 9i, the graphic design question on the concept of linear reasoning was the least skipped (27 out of 1132 – 0.024%), but 9ii, a second follow up question on linear reasoning using the same practical example, was the most skipped (122 out of 1132 – 11%). Perhaps, the second question demanded more complex skills and our students were impatient to move on through the test. The question remains, "What motivates a student to skip a question: fatigue, confusion, carelessness, lack of effort?" These data cannot answer this question, unfortunately. This is a methodological design issue we have incorporated in future assessment questionnaire design and grading schemes. Also, when we revisit our next quantitative reasoning assessment, we should carefully consider the placement of the most frequently skipped questions.

Findings

7. Comfort Levels of Various Subjects

Students were asked to identify their comfort in five different subjects, each on a scale of 0 to 3. The following key was used: Highly Uncomfortable = 0, Uncomfortable = 1, Comfortable = 2, Highly Comfortable = 3. The results are below.

Subject Comfort	Mean (On a scale of 0 to 3)
Comfort with Reading	2.35
Comfort with Writing	2.14
Comfort with Arts	2.13
Comfort with Science	1.76
Comfort with Math	1.72

It is clear from these data that these students report being the least comfortable with Math, confirming the anecdotal data about student resistance and reticence toward Math classes in general. Also, the majority of these students have not had a college level math class in which hopefully their comfort level could increase as practice, skills and success accumulate.

8. Appreciation of the Complexity of Mathematics

Students were asked 20 affective questions to ascertain their appreciation of the complexity of mathematics. These questions also sought to illuminate the kinds of approaches to learning they felt relevant to being successful in math and whether they believed math skills were relevant to other areas of their lives. The questions were worded in such a way that agreement meant positive, deeper and more complex attitudes towards math. The answers were coded using the following scale:

- Strongly Agree: 3
- Agree: 2
- Disagree: 1
- Strongly Disagree: 0

Below is a table showing the mean scores out of 3 for each question, in order from highest mean score to lowest mean score.

Question	Mean (Scale of 0 to 3)
Being able to read and understand a word problem is critical to being able to solve it.	2.48
If I work at it, I can do well in math.	2.46
Solving some mathematical problems involves knowing different strategies to try.	2.27
Learning mathematics involves more than simply memorizing.	2.27
There are often many ways to solve a mathematics problem.	2.22
Mathematics is useful in more ways than simply preparing me for my next math class.	2.22
To do mathematics is more than just calculating answers to problems.	2.18
Mathematics is useful not only to people who do specialized work but also to everyday life.	2.12
Mathematics is more than simply a set of rules for solving problems.	2.06
I need a good understanding of math to achieve my career goals.	2.02
For me, mathematics involves exploration, investigation, or experimentation.	1.9
Math helps me understand the world around me.	1.85
After I've forgotten all the formulas, I'll still be able to use the ideas I've learned in math.	1.83
Mathematical thinking helps me make intelligent decisions about my life.	1.74
Doing mathematics raises interesting new questions about the world.	1.74
When I get an answer to a math problem, I can sense if it is right or wrong before being given the solution.	1.73
In mathematics you can be creative and discover things for yourself.	1.71
Many mathematics problems can be solved with little formal mathematical training.	1.69
There may be more than one correct answer to a mathematics problem.	1.69
Mathematics has been an important tool to help me learn other subjects	1.66

These data provide a complex picture of student attitudes towards math, approaches to learning and the utility and relevance of math skills. The two questions with the strongest agreement are indeed questions not necessarily specific to quantitative reasoning. These students identify *reading* and *understanding* as the most important skills required to be successful in math and that hard work is a primary driver for success. It could be inferred from this that our students believe that acquiring math skills is a matter of persistence more than anything else. These students also have an understanding that learning math skills can involve a range of learning and application strategies.

There is much less strength to support the notion that these students believe math skills have relevance or application to other areas of their lives. In these responses we may be able to see explanations as to why students have some resistance and reticence towards math, and these data support the earlier finding that math is the least 'comfortable' academic area for our students.

The lowest agreement grouping of questions indicate that students believe there is a level of expertise required for successful math skills, that this has to be *acquired,* and that these skills are discreet and unconnected from both themselves and other academic disciplines. In a somewhat contradictory manner, these students acknowledge the creativity and diversity needed to solve math problems while feeling that these processes must lead to a singular *correct* answer. These students clearly see math as disconnected from success in learning other disciplines. Perhaps, since these students believe that math problems always have one answer, it might be difficult to believe math could apply to other subjects that are more connected to the messiness of life outside of the discreet area of college level math classes. These students seem unable to see much connection between math skills and broader aspects of their lives. Surface learning is more likely to be used and retained in one context, these data suggest students keep math skills in one context and do not carry them with them for application across diverse contexts.

9. Competence

This section consisted of twelve items (eleven questions, one of which had two parts). Questions one through eight were multiple-choice and were scored either correct for 2 points or incorrect for 0 points. Questions nine (i), nine (ii), ten, and eleven were short written open answer questions. Partial credit was given when appropriate, and these items were scored out of 2 points in increments of 0.5. The graders made a rubric for each of these items, carefully detailing the difference between scores of 0, 0.5, 1, 1.5, and 2. The rubric is the Appendix.

In the table below, the mean scores for each question are given as percentages. For questions one through eight, each mean score can be thought of as the percentage of students who were correct for that question. For questions nine (i), nine (ii), ten, and eleven, the graded scores of 0, 0.5, 1, 1.5, and 2 have been translated to the percentages 0%, 25%, 50%, 75%, and 100%. The mean scores for these questions can then be presented in their percentage format, as shown in the table below.

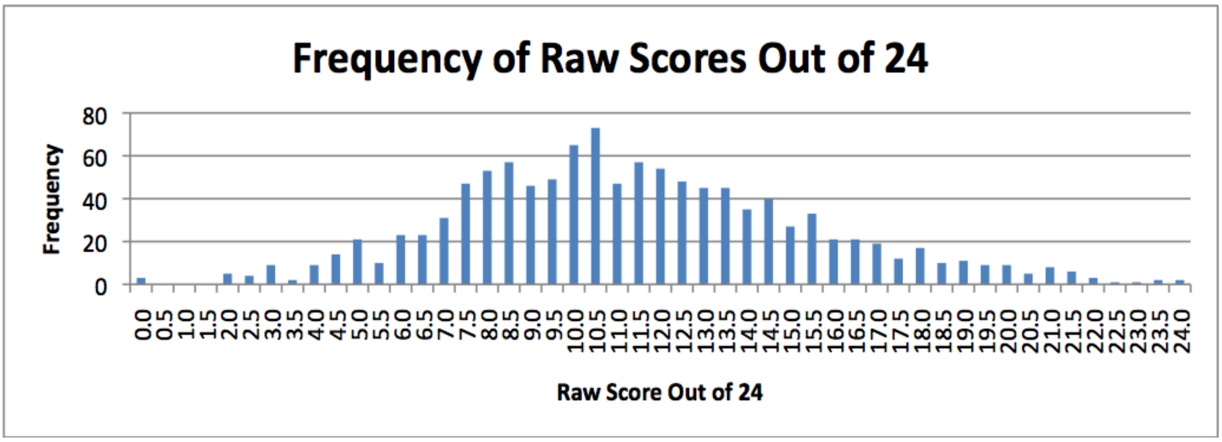
Question	Mean as a Percent
Question #1: Percentages	11%
Question #2: Linear Versus Exponential Reasoning	30%
Question #3: Basic Statistics	25%
Question #4: Area	42%
Question #5: Percentages	28%
Question #6: Graphs	87%
Question #7: Graphs	92%
Question #8: Graphs	83%
Question #9i: Linear Reasoning	44%
Question #9ii: Linear Reasoning	20%
Question #10: Perimeter and Area	27%
Question #11: Area	39%

If the questions are reordered from highest to lowest mean, the following table results.

Question	Mean as a Percent
Question #7: Graphs	92%
Question #6: Graphs	87%
Question #8: Graphs	83%
Question #9i: Linear Reasoning	44%
Question #4: Area	42%
Question #11: Area	39%
Question #2: Linear Versus Exponential Reasoning	30%
Question #5: Percentages	28%
Question #10: Perimeter and Area	27%
Question #3: Basic Statistics	25%
Question #9ii: Linear Reasoning	20%
Question #1: Percentages	11%

The above table shows that students do relatively better with graphs and have a much stronger ability to interpret visually presented data. Since most concepts can be taught with graphs, instructors should use graphs as a teaching tool whenever possible, even if the textbook does not. Also, students need work at percentages, which can be taught in all classes, even non-math classes. For example, one percentage question asked about the meaning of an increase of 180%, which many students interpreted as approximately doubling. In fact, this is approximately tripling. This is because increasing by 0% means staying the same, increasing by 100% means doubling, and increasing by 200% means tripling. These are simple yet easily mistaken concepts that can be explored in many types of classes, even non-math classes. Perhaps one reason students struggled with this is that many math textbooks focus on very mechanical lessons about percentages rather than exploring the nuances such as approximating using strong conceptual knowledge about percentages. It may also be the case that outside of math classes, students have limited opportunities to practice and understand percentages with relevance to their daily lives.

The raw score of the competence section was out of 24 points (12 items at 2 points each). The mean score was 11.35 out of 24, which translates to 47.30%. Below is graph showing the distribution of raw scores out of 24.



The distribution is fairly normal without any discernible skew. In fact, an inspection of the graph shows that most scores were less than or equal to 15.5/24 = 65%. This speaks to the relative difficulty of this assessment for students. Possible reasons for the low scores could be: the subject, motivation (there was no grade associated with this), the assessment itself (wording, length, etc.), fatigue, and lack of connection with their coursework. Since we have no comparative data with which to judge this performance, we may be looking at a competence level that identifies these relatively novice college math students.

An interesting question about the assessment as a whole is how the results could have changed if students had been allowed to use calculators. This may be explored in the future. The calculator use is again another issue for debate when we revisit our quantitative reasoning assessment in the future. An interesting and anecdotal adjunct to this discussion would be the state of the tables in the room in which these 1,132 students completed the paper assessment: they were covered in pencil calculations that had to be cleaned a number of times during Assessment Week. Students were informed that all their working out could be done on the paper survey, indeed this might be helpful for grading some questions. In large numbers, these students chose to use the desks for their working out calculations. Perhaps another indication for these students that the answer was all-important and arriving at it was not considered integral and important to share on the test paper.

10. Competence and Cohort

As previously discussed, students were asked to identify their math level according to three cohorts of math classes.

- Cohort 1: FS Math 3001-3002 and Math 098,099
- Cohort 2: Math 118, 121, 122, 125, 140
- Cohort 3: Math 141,144, 146, 204, 207, 208, 209, 210, 212

The mean competence scores out of 24 for each cohort are shown in the table below.

Cohort	Mean Score (Out of 24)
Cohort 1	10.637
Cohort 2	12.166
Cohort 3	11.223

Interestingly, the middle cohort showed the strongest math competence. Perhaps this is because the middle math classes best remembered the basic math knowledge that this particular assessment focused on. Perhaps this also illustrates the need to come back to basic concepts from time to time in higher math classes.

In comparing the statistical difference in the mean scores of each cohort, an analysis of variances or ANOVA was performed. ANOVA is appropriate for this data since each of the cohorts consists of independent measurements which are normally distributed with near equal variances. This method was also preferred over the standard Student's t-test since multiple hypotheses are being tested simultaneously and a univariate statistical testing method may lead to Type 1 errors, or falsely rejecting the null hypothesis.

This method results in a p-value, which is a common measurement of statistical significance, with lower p–values representing higher statistical significance. Chosen cut-off values for significance vary according to context, but most often 0.10, 0.05, or 0.01 are used. For this study, a moderate cut-off value of 0.05 will be used, meaning p-values of 0.05 or less represent statistical significance, and p-values of greater than 0.05 represent lack of statistical significance.

The results of the analysis was that at least one pair of cohorts was statistically significant different. The p-value for this analysis was .00000009978, well below the .05 cut-off. However, ANOVA does indicate which pair or pairs of data are different, and thus a Post-Hoc multiple comparison procedure was needed. For this analysis the Tukey-Kramer method was chosen. This method utilizes the student range distribution and was chosen since the samples were independent, there was near equal variances across cohorts, and it allows for testing unequal sample sizes. This analysis becomes more conservative with larger discrepancy between sample sizes. So with sample sizes varying up to a factor of five this statistical power of this test becomes very strong.

Here are the results of the Tukey-Kramer procedure for comparing the mean scores among cohorts.

Statistical Comparison	P-Value <.05
Increase From Cohort 1 (10.637) to Cohort 2 (12.166)	Significant
Decrease From Cohort 2 (12.166) to Cohort 3 (11.223)	Insignificant
Increase From Cohort 1 (10.637) to Cohort 3 (11.223)	Insignificant

First, in considering the increase in mean competence scores from cohort 1 to cohort 2, the analysis shows that students in cohort 2 did statistically significantly better than students in cohort 1. In comparing cohort 2 to cohort 3, cohort 2 did better than cohort 3 on average, but it was not statistically significantly. Although this result was not significant, this is still one of the most surprising results of the entire assessment. As discussed above, this may be due to students in the middle math classes best remembering the concepts included in this assessment. It also may be possible that students in higher level math classes, as represented in cohort three, are embedded in more complex mathematical skills and thus are more distant from the basic skills tested by the assessment.

Also surprising is the lack of significant rise in score from cohort 1 to cohort 3. Students in cohort 3 scored better than cohort 1 on average, but not statistically significant compared to a cut-off of 0.05. We would expect students in the highest math classes to score much higher than students in the lowest math classes, but the difference in score was actually minor. These results may have been related to the low number of samples in cohort 3, only 146 compared to the 562 in cohort 1. Either way, these findings should form the basis of healthy dialogue amongst math faculty and faculty in general.

11. Competence and Repetition of a Math Class

Students were asked whether or not they had ever had to repeat a math course. The following table shows the mean competence scores out of 24 for students who had repeated a math course versus students who had not.

Repeated a Math Class?	Mean Score (Out of 24)
Yes	9.798
No	11.804

Notice that the mean score of those who had not repeated a math course is much higher. When including this in the ANOVA analysis we found these means were significantly different.

Statistical Comparison	P-Value <.05
Increase From Students Who Had Repeated a Math Class (9.798) to Students Who Had Not Repeated a Math Class (11.804)	Significant

Students who have repeated a math class had statistically significant lower scores than students who had not repeated a math class. Also, this vale was far outside the confidence interval indicating very strong statistical significance. One potential lesson here is for math instructors to take special note of students who have repeated a math course, for it appears a strong indicator of future competence.

12. Competence and Comfort

As discussed above, students were asked to identify their comfort in math on a scale of 0 to 3 according to the following key: Highly Uncomfortable = 0, Uncomfortable = 1, Comfortable = 2, Highly Comfortable = 3. The table below shows the mean competence scores out of 24 for each group of students.

Level of Math Comfort	Mean Score (Out of 24)
0	9.623
1	10.686
2	11.313
3	12.826

Notice that the mean competence scores increased with each increase in math comfort level. The table below shows the significance of the statistical comparisons for each adjacent pair of math comfort levels.

Statistical Comparison	P-Value <.05
Increase From Comfort 0 (9.383) to Comfort 1 (10.629)	Significant
Increase From Comfort 1 (10.629) to Comfort 2 (11.452)	Significant
Increase From Comfort 2 (11.452) to Comfort 3 (13.229)	Significant

All the means show statistical significance. This means that each increase in students' self-identified math comfort is related to a statistically significant increase in their math competence. One potential lesson here is that students are, in fact, self-aware of their math competence. This would also indicate a significant and cumulative link between competence and confidence for these students.

13. Competence and Complexity (First Statement)

As previously discussed, students were asked to identify their level of agreement with a series of 20 statements about mathematics, each on a scale 0 to 3, such that higher numbers represented higher level of agreement, and such that higher level of agreement represented deeper appreciation of the complexity of mathematics. The first statement was the following: "Math helps me understand the world around me." Graded using the following key: Strongly Disagree=0, Disagree=1, Agree=2, Strongly Agree=3.

The table below shows the mean competence scores out of 24 for each group of students.

Level of Agreement	Mean Score (Out of 24)
0	9.623
1	10.686
2	11.313
3	12.826

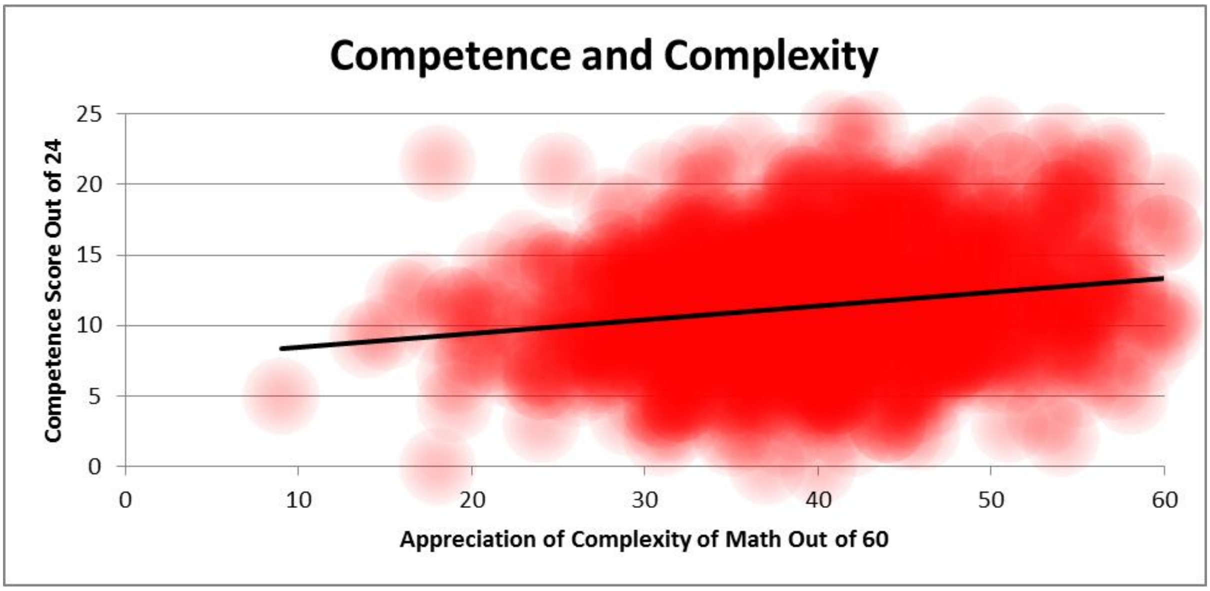
Notice that the mean competence scores increased with each increase in level of agreement, indicating that a deeper and more complex view of mathematics had a relationship to direct competence. The table below shows the p-significance of the statistical comparisons for each pair of agreement levels.

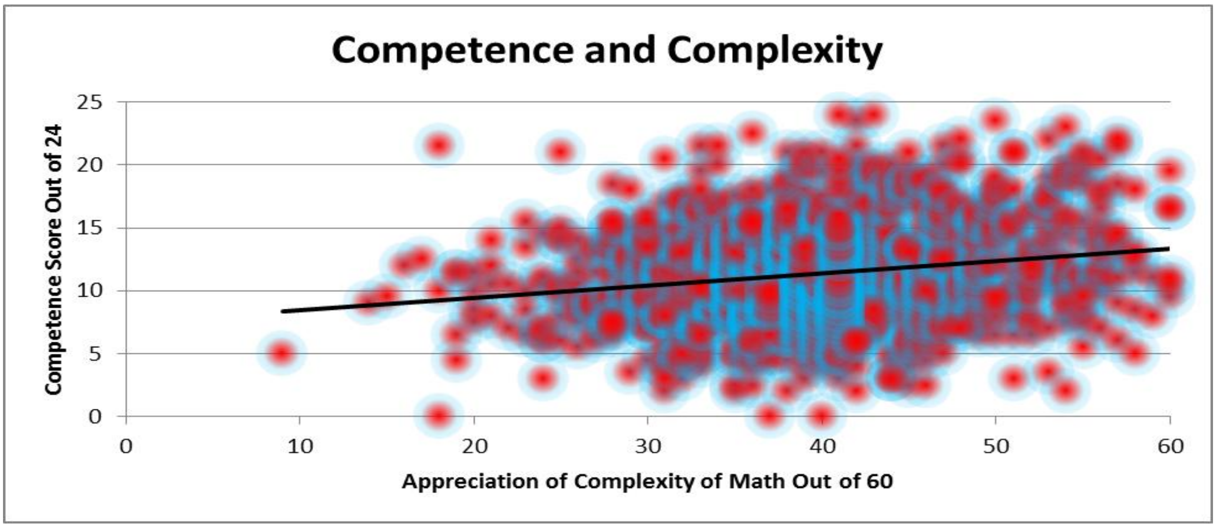
Statistical Comparison	P-Value <.05
Increase From Agreement of 0 to Agreement of 1	Insgnificant
Increase From Agreement of 0 (9.623) to Agreement of 2 (11.313)	Significant
Increase From Agreement of 0 (9.623) to Agreement of 3 (12.826)	Significant
Increase From Agreement of 1 (10.686) to Agreement of 2 (11.313)	Insgnificant
Increase From Agreement of 1 (10.686) to Agreement of 3 (12.826)	Significant
Increase From Agreement of 2 (11.313) to Agreement of 3 (12.826)	Significant

All of the above increases show statistical significance when comparing comfort scores two or more apart. In addition, there is significance between the highest levels of comfort. This means that each increase in students' self-identified level of agreement of math helping them to understand the world around them is related to a statistically significant increase in math competence. This is strong evidence of a significant relationship between attitude toward math and competence in math. Student with a deeper, more complex perception of math are better at demonstrating direct math skills.

14. Competence and Complexity (All 20 Statements)

When looking at all 20 statements on appreciation of the complexity of mathematics, a sum score was taken of the 20 statements, each on a scale 0 to 3, giving a total complexity score out of 60. Below is a scattergram comparing total complexity out of 60 to total competence out of 24, each dot representing a student.





The existence of a correlation would visually mean that in the scattergram above, high complexity scores are associated with high competence scores. Sometimes, however, this is difficult to see visually. It is easier in this case to consider the p-value, which can be calculated based on the linear correlation coefficient of r=0.1958 for n=1130 students. (Two students left the entire complexity section blank and thus were not factored in to this calculation.) Although this correlation is low, a correlation is definitely present. The p-value for this correlation based on this information is less than 0.000001, which is extremely statistically significant.

One of the primary hypotheses for this assessment was that math appreciation would be correlated to math competence. Such a correlation was, in fact, found to be present. Formally stated, there is sufficient evidence to conclude a positive correlation between appreciation of the complexity of mathematics and competence in mathematics. Put another way, this means that higher complexity scores are related to higher competence scores. Note that this does not imply that one causes the other, only that they are positively related to each other.

15. Other Comparisons

We looked within the data for a range of other useful relationships, however, nothing was found with the range of significances outlined above. This is a large data set with considerable opportunity for further exploration. Time and resources limit our capacity to explore further. The following comparisons yielded no strong results:

- Comparing HWC Number of Classes and Competence Score
- Comparing Number of Classes Elsewhere and Competence Score
- Comparing HWC Versus Elsewhere Classes and Competence Score
- Comparing Number of HWC Credits and Competence Score

Conclusion

16. Building our QR Body of Knowledge

HWAC has a seven-year assessment schedule and in the fall of 2011, after completing our Effective Writing assessment, will have assessed at least once, all seven of our key general education learning outcomes. This puts HWCAC in the enviable position of being able to begin to revisit our general education student learning outcomes and establish a comparative and in-house set of data about our own students. It is recommended that with regard to quantitative reasoning, we replicate the use of this tool. In this way we can accumulate comparative data and note any shifts in attitudes and skills with regard to math.

17. Recommendations

Successful graduation is dependent on many factors, not least of which is completion of the general education math requirements. Therefore, the findings here have a simple and direct relationship to both the mission of the college and the newer agenda for improving successful completion and graduation rates across the whole City College system.

So what did we learn from this assessment? First of all, the administration and grading of the assessment were extremely efficient. This will help to inform future assessments. We also learned that students, overall, had trouble with the questions on this assessment. This is not an indictment of the math instruction at HWC (or students' previous math instruction); it is just an observation grounded in our communal wish that our students perform well. The results of this assessment give us some basis on which to formally set our future general education math outcome expectations as we move forward. These results will be shared with the Mathematics department in order to spark some conversation about these types of questions and our students' efforts on them. In actuality, we contend that the conversation needs to go beyond the Mathematics department in order to embrace the idea of Mathematics across the curriculum. Especially since our students do not see connections between math and other subjects, as evidenced by the affective questions, perhaps a faculty-wide dialogue about the value and importance of math competence, beyond college courses, is something worth investing some time in. At the very least, faculty could have a conversation about how they see mathematics fitting into their curricula. Another administration of this assessment will be incredibly useful for comparisons sake. Before that point, however, some recommendations need to be made and implemented. The following are the HWCAC recommendations with regard to our general education outcomes for quantitative reasoning:

1. These findings should be shared specifically with math faculty so that the results can also be placed within a departmental context and set within the math teaching expertise and experience of all math faculty. While HWCAC will do this formally through institutional procedures, HWCAC math faculty members will also table the report at a departmental meeting. The Chair of HWCAC will also schedule a meeting with the Math Department Chairs to brief them on the key findings.
2. HWAC should produce a 'findings brief' and other student focussed materials that share key findings and encourage students to reflect on the culture that surrounds math skills, expectations and beliefs.
3. HWCAC should produce a poster campaign in which comfort, complexity and competence in math are explained in the context of important math outcomes for all students.
4. HWCAC should work with the Herald staff to obtain a feature article during fall semester 2011 to highlight QR assessment findings.
5. HWCAC should also invest specifically in sharing the QR results with Science faculty as a means of facilitating a formal conversation between math and science faculty about the mathematics used in the various sciences. Math skills are clearly important to success in the many of the sciences and we should overtly make this link at the faculty and department level.
6. The results should be shared with the faculty at large, via this report, a 'findings brief', Faculty Council and through the formal administrative structure of the Assessment Committee. Key findings can also be shared more informally, like at a CAST brown bag lunch event and posters in room 1046.
7. Further opportunities for dissemination and dialogue should be sought through such things as District and WC faculty development opportunities, conferences and publications. In-house workshops or presentations of findings should not be used, as we have historically never been able to engage faculty through these devices.
8. It would be interesting to see how students across CCC did on this assessment. Though there are not common general education outcomes from campus to campus, there are common courses. HWCAC officers, perhaps through the auspices of District Office, should initiate connection with our sister college's Assessment Committees to both share these findings and initiate district-wide assessment dialogue about improving student success and outcomes in quantitative reasoning.
9. HWCAC should administer this QR assessment again so as to create a comparative sampling of our students math capabilities.
10. Since this assessment was created in house, no comparison can be made nationally. It may be worthwhile to attempt to share this assessment with other community

colleges nationally. It also seems likely that these data and findings, when added into the national context, could provide a strong research opportunity for someone interested in a masters-level thesis related to community college students and math skills.

11. HWCAC should discuss and investigate how we can improve the connection between basic math skills and students perceptions of relevance to their daily lives. "Math counts everywhere" should be a college-wide discussion initiated by these findings.
12. HWC faculty and administrators should consider how it might be possible to change the cultural resistance our students have to math and lift their confidence levels outside of math classes.
13. We have found a surprising and complex relationship between experience and expertise – the more advanced the math class level the less the basic expertise becomes. This should be a conversation initiated with math faculty teaching advanced math courses. Do student learning outcomes for more advanced math courses build on and utilize basic math skills? How can basic math skills be reinforced throughout the full range of math sequence courses? Do more advanced math courses have crowded syllabi and outcomes that unintentionally increase the 'distance' between basic and more complex math competencies?
14. There are many further useful avenues of investigation with regard to math skills that are beyond the scope of this report and outside of the charge of the Assessment Committee. For example, what does placement testing tell us about our student body and their math skills on arrival at college? What strategies do we have in place, and can we build further, to improve math confidence and competence before students arrive at college level math? In the light of the new regime at CPS, this could be an interesting time to make further connections here.
15. Across the college, in a range of disciplines, there are courses and syllabi that use points systems to award grades to assignment and calculate a student's final grade. These courses only require students to use simple addition skills to calculate their grades. Courses and syllabi that use percentages for assignments and weighted percentages to calculate final grades are more complex and would require students to become more familiar and hopefully practice understanding and using percentages – the weakest skill identified in this assessment. This is a conversation for the whole college and puts basic math skills into every classroom, regardless of discipline or subject.
16. Are faculty using cumulative point systems in course grading 'dumbing down' basic math skills for our students?
17. As we move into a new era with more centralization of research functions at District Office, what are the implications for future assessments of this scale and complexity at HWC?

Appendices

A. Objectives for Quantitative Reasoning

The following are the objectives that were the focus of this assessment.

General Education Objective for Quantitative Reasoning: "To use mathematics for computation, reasoning and problem solving."

Definition of Quantitative Reasoning:
Quantitative Reasoning involves the ability to use the elements of mathematics* for the purpose of computing effectively, interpreting and analyzing data, math modeling, and reasoning within abstract and contextual structures to make predictions, judgments and decisions. The ability to employ quantitative reasoning results in what is called Quantitative Literacy, or Numeracy.
**By Elements of Mathematics, is meant prerequisite skills (arithmetic and algebra), number sense, symbolic representation, algorithms, spatial reasoning and measurement.*

Student Learning Outcomes:
The student will be able to:
1. Interpret mathematical models such as formulas, graphs, tables, and schematics.
2. Represent mathematical information symbolically, visually, numerically, and verbally.
3. Apply arithmetical, algebraic, geometric or statistical methods in order to solve problems.
4. Estimate and check answers to mathematical problems for the purpose of determining reasonableness, identifying alternatives, and selecting optimal results.
5. Recognize limitations of mathematical and statistical methods.

B. Matrix of Student Learning Outcomes and Topics

The following is a matrix showing what student learning outcomes (SLO's) and topics were covered by each item of the quantitative reasoning questions in section two.

As previously discussed, the SLO's are as follows. The student will be able to:

1. Interpret mathematical models such as formulas, graphs, tables, and schematics.
2. Represent mathematical information symbolically, visually, numerically, and verbally.
3. Apply arithmetical, algebraic, geometric or statistical methods in order to solve problems.
4. Estimate and check answers to mathematical problems for the purpose of determining reasonableness, identifying alternatives, and selecting optimal results.
5. Recognize limitations of mathematical and statistical methods.

	SLO1	SLO2	SLO3	SLO4	SLO5	Per-cents	Arith-metic	Geo-metry	Algebra / Functions	Data Analysis
#1			X	X		X	X			
#2	X	X		X		X			X	X
#3		X	X	X			X		X	
#4	X		X	X			X	X		
#5			X	X		X	X			
#6	X				X					X
#7	X				X					X
#8					X					X
#9i		X	X	X			X		X	
#9ii		X	X	X			X		X	
#10			X	X			X	X		
#11			X	X			X	X		

C. Categorization of Complexity Questions

The following is a categorization of the questions on appreciation of math complexity according to the following key: *P=perceptions, C=confidence and A=ability to see math as useful (in life and school).*

11. Math helps me understand the world around me. P,A
12. Many mathematics problems can be solved with little formal mathematical training. P
13. There are often many ways to solve a mathematics problem. P
14. When I get an answer to a problem, I can sense if it is right or wrong before being given the solution. P, C
15. If I work at it, I can do well in math. C
16. For me, mathematics involves exploration, investigation, or experimentation. P
17. Solving some mathematical problems involves knowing different strategies to try. P
18. To do mathematics is more than just calculating answers to problems. P
19. Mathematics is more than simply a set of rules for solving problems. P
20. Mathematics is useful in more ways than simply preparing me for my next math class. A
21. Being able to read and understand a word problem is critical to being able to solve it. P
22. I need a good understanding of math to achieve my career goals. A
23. After I've forgotten all the formulas, I'll still be able to use the ideas I've learned in math. C
24. Mathematics has been an important tool to help me learn other subjects A
25. In mathematics you can be creative and discover things for yourself. P
26. Mathematical thinking helps me make intelligent decisions about my life. A
27. Mathematics is useful not only to people who do specialized work but also to everyday life. P, A
28. There may be more than one correct answer to a mathematics problem. P
29. Learning mathematics involves more than simply memorizing. P
30. Doing mathematics raises interesting new questions about the world. P, A

D. Assessment Part 1 (Demographics and More)

1. Please indicate the total number of college level credit hours that you have passed:
   At HWC: O 0 O 1-15 O 16-30 O 31+

2. Please indicate the total number of college level credit hours that you have passed:
   At other colleges O 0 O 1-15 O 16-30 O 31+

3. Please indicate the math class you are currently enrolled in or (if you're not taking a class) eligible for.
   O PC Math 3001-002, Math 98, 99

   O Math 118, 121, 122, 125, 140

   O Math 141,144, 146, 204, 207, 208, 209, 210, 212

4. Not including this semester, how many Mathematics courses have you successfully completed:

   At HWC: O 0 O 1-2 O 3+

   At other colleges O 0 O 1-2 O 3+

5. At any point in your career at HWC, have you needed to repeat a Mathematics course?
   O Yes O No

6. Please indicate your sex:
   O Female O Male

7. Please indicate your race and/or ethnicity:
   O Black/African American O Native Hawaiian/Pacific Islander O White

   O Asian O American Indian/Alaska Native O Hispanic/Latino

   O Multi-racial/Multi-Ethnic

8. Please indicate your age:
   O 25 or under O 26-40 O 41-60 O 61+

9. Please indicate your current academic status:
   O Full time O Part time

10. Please indicate your comfort level with:	Highly Comfortable	Comfortable	Uncomfortable	Highly Uncomfortable
a. science.	O	O	O	O
b. math.	O	O	O	O
c. writing.	O	O	O	O
d. reading.	O	O	O	O
	O	O	O	O

e. arts.

Please indicate your level of agreement or disagreement with each statement. Be as honest as possible. There are no correct answers.	Strongly Agree	Agree	Disagree	Strongly Disagree
11. Math helps me understand the world around me.	O	O	O	O
12. Many mathematics problems can be solved with little formal mathematical training.	O	O	O	O
13. There are often many ways to solve a mathematics problem.	O	O	O	O
14. When I get an answer to a math problem, I can sense if it is right or wrong before being given the solution.	O	O	O	O
15. If I work at it, I can do well in math.	O	O	O	O
16. For me, mathematics involves exploration, investigation, or experimentation.	O	O	O	O
17. Solving some mathematical problems involves knowing different strategies to try.	O	O	O	O
18. To do mathematics is more than just calculating answers to problems.	O	O	O	O
19. Mathematics is more than simply a set of rules for solving problems.	O	O	O	O
20. Mathematics is useful in more ways than simply preparing me for my next math class.	O	O	O	O
21. Being able to read and understand a word problem is critical to being able to solve it.	O	O	O	O
22. I need a good understanding of math to achieve my career goals.	O	O	O	O
23. After I've forgotten all the formulas, I'll still be able to use the ideas I've learned in math.	O	O	O	O
24. Mathematics has been an important tool to help me learn other subjects	O	O	O	O
25. In mathematics you can be creative and discover things for yourself.	O	O	O	O
26. Mathematical thinking helps me make intelligent decisions about my life.	O	O	O	O
27. Mathematics is useful not only to people who do specialized work but also to everyday life.	O	O	O	O
28. There may be more than one correct answer to a mathematics problem.	O	O	O	O
29. Learning mathematics involves more than simply memorizing.	O	O	O	O
30. Doing mathematics raises interesting new questions about the world.	O	O	O	O

E. Assessment Part 2 (Competence)

Multiple Choice: Choose the answer that best answers each question.

1. If 0.58% of all U.S. tax returns are audited, approximately how many returns are audited for each 1000 returns filed?

   O 1 O 60 O 580 O 6

2. The population of Springfield, IL is around 100,000 people. ComEd predicts that the population will increase 5% per year (i.e. each year the population will be 5% larger than it was the previous year). Peoples Energy predicts that the population will increase by 5,500 each year. Which group's prediction method predicts the larger population in 20 years?

   O ComEd O Peoples Energy

   O both predictions are the same after 20 years

   O There is not enough information provided to answer the question.

3. Sarah loves to bowl. Her game average is 124. She usually bowls five games on league night at the bowling alley. This week her scores for the first three games were 117, 130, and 113. What does she have to average in her last two games to have an overall average of 124 for this week?

   O 124 O 130 O 120 O 129

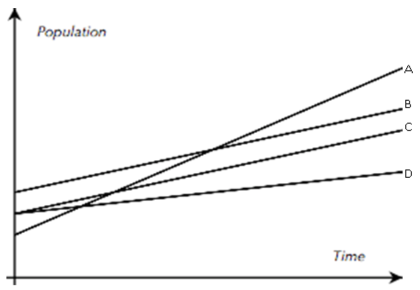
4. You want to paint the walls of a rectangular room that is 24 ft. by 15 ft. The walls of the room are 8 ft high. The room has two doors, one that is 2 ft. wide and 7 ft. high and another that measures 6 ft by 7 ft. You find the paint you like. It is only available in quart cans. On the can it says that one quart covers 200 square feet. What is the least number of cans that you need to buy in order to paint the room (assume only one coat is used)?

   O 1 O 2 O 3 O 4

5. According to several sources, the number of bankruptcies has increased by 180% from 2008 to 2009.This means that from 2008 to 2009 the number of bankruptcies has

   O stayed almost the same O almost doubled O almost tripled O more than tripled

Use the following information to answer questions 6,7 and 8. The graphs below describe the growth of four different populations (labeled A, B, C, and D) over some period of time.



6. Which two populations begin with the same number of members?

O A and B O B and C O C and D

O There is not enough information provided to answer the question.

7. After how much time do populations A and B have the same population?

O 5 years O 10 years O 20 years

O There is not enough information provided to answer the question.

8. Which two populations grow at the same rate?

O A and B O B and C O C and D

O There is not enough information provided to answer the question.

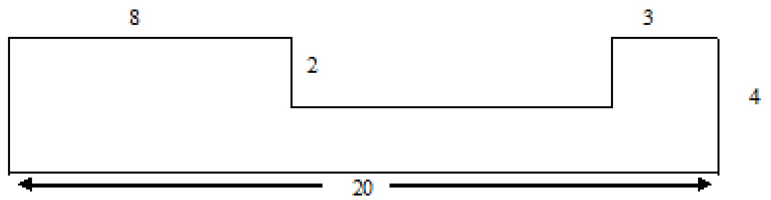
Short Answers: For 9, 10 and 11, please show all of your work. Read carefully.

9. A graphic designer needs to rent some high quality photographic equipment to create her designs. She considers two different types of equipment. The cost of renting and using the first type is $450 plus $2.00 per copy. The cost of renting and using the second type is $150 plus $5.00 per copy.

i) Which type of equipment is less expensive if the artist only needs to make a small number of copies, the first or the second? Explain.

ii) How many copies would the artist need to make before the other type of equipment becomes less expensive? Explain.

10. Find the perimeter and area of the shape below. The measurements are in meters. Write your final answers in the spaces provided. Please include appropriate units.



11. Which is the better deal: an 18-inch square pizza (that is, a square pizza in which the sides are each 18 in.) for $20 or two 12-inch square pizzas (that is, two square pizzas in which the sides of each pizza are each 12 in.) for $20? Explain.

F. Rubrics for Short Answer Questions

Rubric for Question 9i:

Chose second one with complete justification (equations, cost benefit analysis, choice of small number, etc.) Or either answer with valid real world explanation	Chose second one with near complete justification	Chose second one with incomplete justification or miscalculation	Chose second one with no justification OR completely incorrect justification	Left blank or first one with illogical explanation
2 points	1.5 points	1 point	.5 points	0 points

Rubric for Question 9ii:

Complete justification showing intersection of two linear situations	Near complete justification	Incomplete justification or miscalculation	No justification OR completely incorrect justification	Left blank or first one with illogical explanation
2 points	1.5 points	1 point	.5 points	0 points

Rubric for Question 10:

- Values
  - ½ Point for Correct Perimeter Value
  - ½ Point for Correct Area Value
  - If both values are incorrect but good work is shown, ½ point may be given overall for this category. Yet if only one of the two values is correct, give ½ point in this category no matter what.
- Units
  - ½ Point for Correct Perimeter Unit
  - ½ Point for Correct Area Unit
  - Do not budge in this category. Simply either right or wrong.)
- Other Notes
  - 2 Possible Points
  - For unexpected solutions, be appropriately flexible in scoring.
  - Correct Answers: Perimeter of 52 m and Area of 62 m^2

Rubric for Question 11:

The answer of 1 pizza is given and justified fully (i.e. there is a mention of area and a calculation/comparison of areas) **OR** Either answer is given with a justification based upon real life preferences with a correct consideration for geometric measurement **AND** All calculations and units are correct	The answer of 1 is given and justified (but is not fully formed or there are minor miscalculations or misused units or it is not spelled out (i.e. calculations are done correctly but the numbers aren't explained)) **OR** The answer of 2 pizzas is given with another justification with real world justification that is correct but not fully formed	Just the answer of 1 pizza is written with little to no justification or volume instead of area is used **OR** The answer of 2 pizzas is given with another justification with some real world validity **OR** A qualitative justification is given with missing math (e.g. slices) **OR** A spatial representation is given though incorrectly (e.g. #2 is chosen as a result of mis-scaling	The answer of 2 pizzas is given with a mention of perimeter or area (though misused) **OR** Another numerical/geometric justification is given for either choice	The problem is left blank or the answer does not relate to the problem **OR** Just the answer of 2 pizzas is written with little to no explanation
2 points	1.5 points	1 point	.5 points	0 points

Other Notes:

Only use one of the "Office Use Only" boxes. Use the one on the left. For future assessments take out the extra box on the right.)

- 2
- 1.5
- 1
- 0.5
- 0

G. Categorization and Solutions of Competence Questions

Below each of the competence items are categorized by student learning outcome (SLO) and topic according to the following key: SLO1, SLO2, SLO3, SLO4, SLO5, % (percents), R (arithmetic), G (geometry), DA (data analysis), X (algebra/functions). Also, the correct answers for each question are bolded.

As previously discussed, the SLO's are as follows. The student will be able to:

1. Interpret mathematical models such as formulas, graphs, tables, and schematics.
2. Represent mathematical information symbolically, visually, numerically, and verbally.
3. Apply arithmetical, algebraic, geometric or statistical methods in order to solve problems.
4. Estimate and check answers to mathematical problems for the purpose of determining reasonableness, identifying alternatives, and selecting optimal results.
5. Recognize limitations of mathematical and statistical methods.

1. If 0.58% of all U.S. tax returns are audited, approximately how many returns are audited for each 1000 returns filed? (%, R, SLO3, 4)

   O 1

   O 60

   O 580

   O 6

2. The population of Springfield, IL is around 100,000 people. ComEd predicts that the population will increase 5% per year (i.e. each year the population will be 5% larger than it was the previous year). Peoples Energy predicts that the population will increase by 5,500 each year. Which group's prediction method predicts the larger population in 20 years? (%, DA, X, SLO1, 2, 4)

   O ComEd

   O Peoples Energy

   O both predictions are the same after 20 years

   O There is not enough information provided to answer the question.

3. Sarah loves to bowl. Her average is 124. She usually bowls five games on league night at the bowling alley. This week her scores for the first three games were 117, 130, and 113. What does she have to average in her last two games in order to have an overall average of 124 for this week? (R, X, SLO2, 3, 4)

   O 124

   O 130

   O 120

O 129

4. You want to paint the walls of a rectangular room that is 24 ft. by 15 ft. The walls of the room are 8 ft high. The room has two doors, one that is 2 ft. wide and 7 ft. high and another that measures 6 ft. by 7 ft. You find the paint you like. It is only available in quart cans. On the can it says that one quart covers 200 square feet. What is the least number of cans that you need to buy in order to paint the room (assume only one coat is used)? (G, R, SLO1, 3, 4)

O 1

O 2

O 3

O 4

5. According to several sources, the number of bankruptcies has increased by 180% from 2008 to 2009. This means that from 2008 to 2009 the number of bankruptcies has… (%,R,SLO3, 4)

O stayed almost the same

O almost doubled

O almost tripled

O more than tripled

6. Which two populations begin with the same number of members? (DA, SLO1,5)

O A and B

O B and C

O C and D

O There is not enough information provided to answer the question.

7. After how much time do populations A and B have the same population? (DA, SLO1, 5)

O 5 years

O 10 years

O 20 years

O There is not enough information provided to answer the question.

8. Which two populations grow at the same rate? (DA, SLO1,5)

O A and B

O B and C

O C and D

O There is not enough information provided to answer the question.

9. A graphic designer needs to rent some high quality photographic equipment to create her designs. She considers two different types of equipment. The cost of renting and using the first type is $450 plus $2.00 per copy. The cost of renting and using the second type is $150 plus $5.00 per copy.

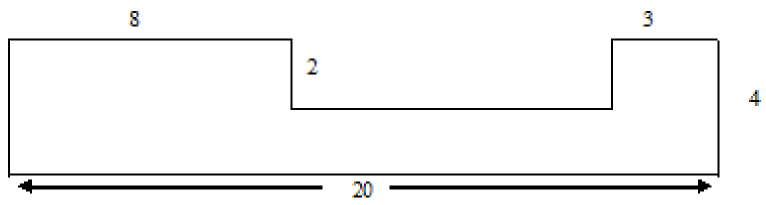
i) Which type of equipment is less expensive if the artist only needs to make a small number of copies, the first or the second? Explain. (R, X, SLO2, 3, 4)

Answers vary depending upon the interpretation of the word small but in most cases the 2nd is less expensive for a small number of copies given it's lower initial cost.

ii) How many copies would the artist need to make before the other type of equipment becomes less expensive? Explain. (R, X, SLO2,3,4)

Here there can be slight variation in the answer. This could be done algebraically. We looking for the number of copies for which the costs are equal. That will be the point at which the 1st machine becomes less expensive. We have 450+2c=150+5c where c is the number of copies. Solving this yields 300=3c … so c=100. Therefore, the answer is either 100 or 101, depending upon the justification.

10. Find the perimeter and area of the shape below. The measurements are in meters. Write your final answers in the spaces provided. Please include appropriate units. (R, G, SLO2, 3)



Methods vary. Perimeter=32 meters. Area=62 square meters.

11. Which is the better deal: an 18-inch square pizza (that is, a square pizza in which the sides are each 18 in.) for $20 or two 12-inch square pizzas (that is, two square pizzas in which the sides of each pizza are each 12 in.) for $20? Explain. (G, R, SLO2, 3)

Again, answers vary. Ideally, a student would compare the areas of the pizzas to determine which has more pizza. A conversation about crust and thickness of the pizza would be interesting. All things being equal between the pizzas other than their side lengths, we have

$Area_{18''}=18^2$=324 square inches vs. $Area_{12''}=12^2$=144 (for one) and 288 square inches for two. Therefore, the 18-inch pizza is the better deal since you get more pizza (56 in.^{2} more to be exact or a little over 6 more 3 inch by 3 inch slices.)