Mathematics Department
Unit-Level Assessment Liaison Report
Spring 2019

Math 118 Assessment
Liaison Project Start Date: Spring 2017
Liaison Report prepared by Camelia Salajean

I. Department Buy-In and Outcome Definition

Math 140 – College Algebra course is a prerequisite for college level mathematics-dependent courses such as business, accounting, science and engineering. At the beginning of Spring 2019 semester, the Mathematics Department started a new assessment process for this course. Math faculty considered "Solving polynomial equations and inequalities" a particularly important SLO students need to master for further courses in the mathematics curriculum. During this semester, we created and administered a pilot assessment addressing this SLO.

II. Assessment Research and Design

In contrast with our previous assessment that targeted Math 118, we have decided to start from scratch and create our own innovative pilot tool.
As a preliminary discussion amongst the math faculty, we devised a set of problems that best cover the full contents of the SLO while paying special attention to the most common mistakes that students make. We collected data from previously administered assignments in various courses, as related to this topic. It was interesting to find that across the data gathered, from various level of Math courses, and all instructors who participated, that there were a few recurrent and common errors that the students typically made. We decided to address all these common mistakes in our assessment.

By midterm, the math faculty created and designed a short online survey on Google Forms containing four exercises: solve a quadratic equation and a quadratic inequality algebraically, as well as solve an equation and an inequality graphically (see **Appendix A**).

As in our previous assessment, we have used Google Forms because it is browser independent and especially mobile friendly, which is a significant advantage for students. Another benefit in using Google form is the facility to export the responses into an Excel document that helps perform all appropriate analyses on collected data.

We created the pilot questions on Word document to make use of the Math editing tool available in that platform and not as efficiently offered in Google forms. In addition, the Google form interface did not allow for any math editing to properly display mathematical representation in the question itself. We responded to that setback by reiterating the expressions in a correct mathematical format and including them as images in the answer options from which the student would select.

III. Pilot Assessment Tools and Processes

At the start of the semester, we invited all faculty, including our adjunct colleagues, to be part of this project. All were introduced to the project via e-mail and in one-on-one discussion to emphasize the importance of their participation and encourage everyone to volunteer and urge their students to take the assessment survey. This pilot assessment was administered during the last three weeks of school, following Spring Break. We have been heartened to have so far collected an impressive 100 responses in this short period of time. We are planning to administer the pilot during the summer term as well.

IV. Administer Specific Assessment

During four regular semesters (Spring 2017, Fall 2017, Spring 2018 and Fall 2018), the Mathematics department assessed one of Math 118 (General Education Mathematics) common Student Learning Outcomes (SLOs): "*Interpret and draw inferences from mathematical models such as formulas, graphs, tables, and schematics*". Throughout that time, we have discussed findings, analyzed the results, revised the assessment tool and thought about useful ways of closing the loop and writing recommendations.

We started in Spring 2017 by creating a pilot assessment consisting of three mathematical problems designed to assess how students *get the information and draw inferences from a formula, a table and a graph*. We strived to limit the number of words of the contextual problems to make sure the tool would assess students on math, rather than on reading comprehension of the text. In Fall 2017, we decided to expand the pilot tool into two parts: a pre-test and a post-test and continued to administer these tests in the subsequent semesters since then. The pre-test and post-test have exactly the same questions but in a different order, only to give the impression of a "new" survey. We didn't want students to immediately realize that they were solving the same problems twice in a semester.

Math faculty members had been working closely to improve Math 118 assessment during these semesters by slightly modifying the questions on the survey from one semester to the next to ensure that they properly measure the targeted SLO. In Fall 2017, we modified the formula question to verify it was not privileging students who already knew about related content. In Spring 2018, we kept the same text, but we changed the graphs since students had difficulty addressing the graph interpretation question. Finally in the Fall 2018 assessment, we added percentage symbols next to the numbers in the table to underline the mathematical concept and help identify if students were struggling with the percent concept or with the way the information was provided. In this situation, the data were presented in a table (see Appendix B).

V. Data Analysis

Students performed similarly from one semester to the other when comparing pre- and post- tests results. Our hope was that students would do better in the post-test as compared to the pre-test; however, that did not materialize. Students' results were neither better nor worse. No statistically significant difference was detected between the two tests results in each semester. However, the changes we made to refine the assessment tool every semester resulted in an increase in the percentage of all students who took the post-tests and answered the questions correctly (see Appendix C). The modifications that were applied made

the formulation of the test questions more closely resemble the style of textbook questions they were used to; this apparently is a factor in the improvement of their comprehension.

For the first question of the assessment, interpreting and drawing inferences from a formula, students' results were the best. The percentage of students who answered this question correctly was as high as 97.14% in Fall 2018 pre- and post- tests compared to a lower result of 86.75% in Spring 2018 post-test. We were at first surprised by this finding since students always complain about memorizing and applying formulas in a math classes. Looking back at the entire assessment process and results, the construction of the formula question was the closest to what students are familiar or expect to see in a math test.

One of the challenges students had with this assessment was determining a percentage from a data table. Instead of computing 50% of 66 people, which amounts to 33 people, students selected the percent itself, 50, as an answer for the number of people. Therefore, in the Fall 2018 assessment, we included the percentage symbol next to the numbers in the table. The results for the Fall 2018 pre-test regarding this question improved. 36.54% of students got the correct answer compared to 10.53% in Fall 2017 pre-test and 1.90% in Spring 2018 pre-test. Even though this was encouraging, since many more students answered the question correctly in Fall 2018 semester, the concern remained since the majority, 55.6% of students in Fall 2018 pre-test still answered 50 instead of 33.

Students also have difficulties with interpreting and drawing inferences from a graph. After our modification in Spring 2018 assessment, the percentage of the correct answers increased over the past 3 semesters, from 33.83% in Fall 2017 pre-test, to 44.30% in Spring 2018 pre-test and then 50% in Fall 2018 pre-test. It is encouraging to remark that more than half of the students, precisely 57.35%, were successfully interpreting information from a graph in the post-test of Fall 2018.

In order to learn even more about how our students respond, we compared the results of students who took Math 99 (developmental course) at CCC versus students who did not take Math 99 at CCC. For Math 118 post-test assessment a Fisher's exact test of independence was performed for each question to see whether there was a statistically significant difference in the proportion of correct responses between the two groups. We performed this comparison out of a spirit of inquiry, since the data were available. We were surprised to find out that there is a statistically significant difference at the 0.05 level between the two groups, showing the students who took Math 99 responding more favorably. It is however important to mention that the data were examined in aggregate across categories of questions posed and thus does not necessarily corroborate this result (see Appendix D).

VI. Supporting Evidence-Based Change (Use of Findings)

It is clear to us that students struggle particularly with drawing information from reading graphs and the concept of inferring percentages from quantities presented in a table. This is a fact that other stakeholders should be aware of as well. We recommend that more focus should be paid to these two topics across the curriculum in the Mathematics Department as well as the rest of the college, since it relates to one of our General Education outcomes in Quantitative Reasoning.

Initially, we were planning to develop a shell on Brightspace containing the master syllabus, a variety of activities, and assessments for Math 118 in the hope of sharing the contents across many sections and instructors. As of yet, however, Brightspace is not allowing this feature. We hope to continue working on this and still post the collected information on an accessible platform for all, such as our departmental website.

Success Factors

During the Math 118 assessment process, half of the full time faculty of HWC Mathematics Department have worked jointly and successfully collaborated towards the same goal. We were able to get most part-time instructors teaching this course as well as online instructors from other colleges involved in this process. It is encouraging that the number of responses gathered for the Math 118 assessment was quite substantial, thus providing an adequate and reliable sample size.

Recommendations

It seems relevant that not only in Math 118, but also across all math courses, there should be more emphasis on connecting the tables and graph students see in class to real life and practical situations in their own experiences.

The concept of misleading graphs and tabular information should be introduced earlier in math courses. Furthermore, these concepts should be exemplified and discussed in every course in our college, regardless the discipline or subject. This could include, for instance, discussion of how scales, colors, formats and other factors affect reading graphs, and how the presence or non-presence of percentage symbols could induce the reader into error in reading a table, etc.

The concept of misleading graphs and tabular information should be introduced earlier, then mentioned and exemplified across other math courses. This could include, for instance, discussion of how scales, colors, formats and other factors affect reading graphs, and how the presence or non-presence of percentage symbols could induce the reader into error in reading a table, etc.

Appendix A

Math 140 Assessment **Spring 2019**

1) The following quadratic equation is solved 3t^2 – 12t – 15 = 0. Which of the following is the correct procedure and solution?

Option 1

$3t^2 - 12t - 15 = 0$

$3t^2 - 12t = 15$

$3t(t - 4) = 15$

$3t = 0 \quad t - 4 = 0$

$t = 0 \quad t = 4$

Option 2

$3t^2 - 12t - 15 = 0$

$3t^2 - 12t = 15$

$3t(t - 4) = 15$

$3t = 15 \quad t - 4 = 15$

$t = 5 \quad t = 19$

Option 3

$3t^2 - 12t - 15 = 0$

$3(t^2 - 4t - 5) = 0$

$3(t - 5)(t + 1) = 0$

$t = 3 \quad t = 5 \quad t = -1$

Option 4

$3t^2 - 12t - 15 = 0$

$$t = \frac{12 \pm \sqrt{(-12)^2 - 4 \cdot 3(-15)}}{2(3)}$$

$$t = \frac{12 \pm \sqrt{324}}{6}$$

$t = 2 \pm 18$

$t = 20 \quad t = -16$

Option 5

$$3t^2 - 12t - 15 = 0$$

$$\frac{3t^2 - 12t - 15}{3} = \frac{0}{3}$$

$$t^2 - 4t - 5 = 0$$

$$t = \frac{4 \pm \sqrt{(-4)^2 - 4 \cdot 1(-5)}}{2(1)}$$

$$t = \frac{4 \pm \sqrt{36}}{2}$$

$$t = \frac{4+6}{2} \qquad t = \frac{4-6}{2}$$

$$t = 5 \qquad t = -1$$

2) The solution for the inequality x^2 − 4 ≥ 0 in interval notation is (−∞, −2] ∪ [2, ∞).

Which of the following is the correct way of solving the inequality?

Option 1

$$x^2 - 4 \geq 0$$

Step 1: $x^2 \geq 4$

Step 2: $x \geq \pm 2$

Option 2

$$x^2 - 4 \geq 0$$

Step 1: $x^2 - 4 = 0 \quad x = \pm 2$

Step 2:

x		-2		2	
$x^2 - 4$	+ + +	0	− − −	0	+ + +

Option 3

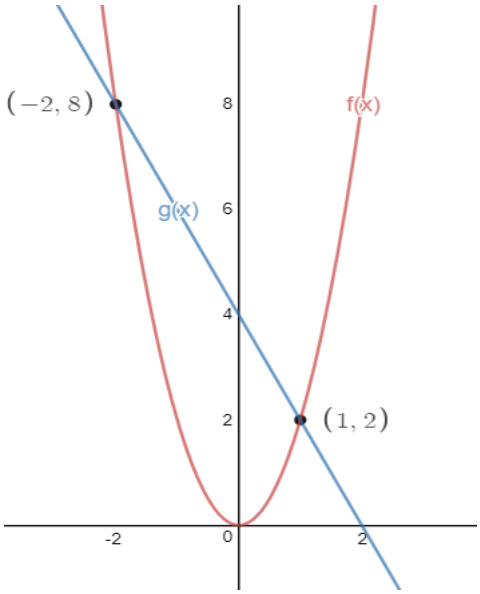
$$x^2 - 4 \geq 0$$

Step 1: $(x-2)(x+2) \geq 0$

Step 2: $x - 2 \geq 0 \qquad x + 2 \geq 0$

$x \geq 2 \qquad x \geq -2$

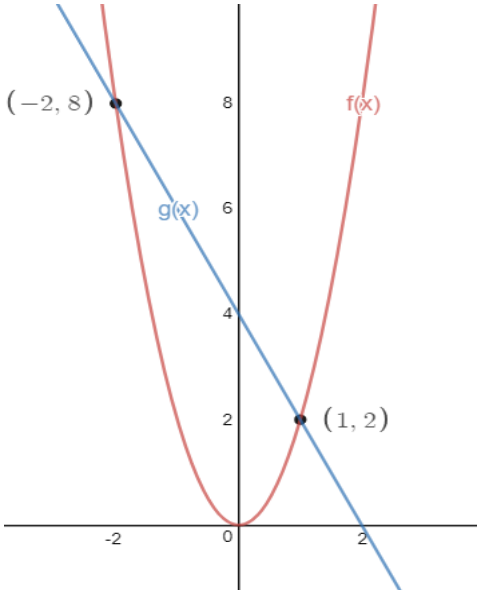
3a) Use the graph below to answer the following question.



What is the solution of the equation f(x) = g(x)?

1) **(-2, 8) and (1, 2)**
2) **x = -2 and x = 1**
3) **y = 2 and y = 8**

3b) Use the graph below to answer the following question.



What is the solution of the inequality f(x) < g(x)?

1) **(-2, 1)**
2) **(-2, 2)**
3) **$(-\infty, -2) \cup (1, \infty)$**

Appendix B

Math 118 Pilot Assessment Tool **Spring 2017**

1. Use the formula below that expresses the relationship between temperature in Celsius degrees, C, and Fahrenheit degrees, F, to answer the question below.

$$C = \frac{5}{9}(F - 32)$$

Water boils at 212°F. What is this temperature in Celsius degrees?

a) 100˚

b) 85.78˚

c) 32˚

Fall 2017 Modification

One of the highest temperature ever recorded in Chicago was 104°F. What is this temperature in Celsius degrees?

a) 40˚C

b) 25.78˚C

c) 219.2˚C

2. Study the table below and answer the following 3 questions.

Table 5. Reasons for Retirement by Age at Retirement

	Age at Retirement		
Reason for retirement	Under 62	Between 62-64	65 or older
Age	10.5	21.6	64.6
Ready to retire	10.5	50	14.6
Health problems	26.3	11.9	8.3
Plant closed	10.5	1.5	-
Benefits	10.5	3	-
Make way for younger workers	2.6	1.5	6.0
Bad work conditions/industry uncertainty	5.3	4.5	-
Family concerns	7.9	-	2.9
Enjoy life	7.9	1.5	2.1
Other	7.9	4.5	2.1
	100%	100%	100%
n =	76	66	48

Fall 2018 Modification

Table 5. Reasons for Retirement by Age at Retirement			
	Age at Retirement		
Reason for retirement	Under 62	Between 62-64	65 or older
Age	10.5%	21.6%	64.6%
Ready to retire	10.5%	50%	14.6%
Health problems	26.3%	11.9%	8.3%
Plant closed	10.5%	1.5%	-
Benefits	10.5%	3%	-
Make way for younger workers	2.6%	1.5%	6%
Bad work conditions/industry uncertainty	5.3%	4.5%	-
Family concerns	7.9%	-	2.9%
Enjoy life	7.9%	1.5%	2.1%
Other	8%	4.5%	1.5%
Total Percentage	100%	100%	100%
n=	76	66	48

2A. What is the total number of surveyed retirees on which Table 5 is based?

a) 76
b) 200
c) 190
d) 100

2B. For the surveyed retirees under age 62 from Table 5, what was the least mentioned reason for retirement?

a) Family concerns
b) Benefits
c) Health problems
d) Make way for younger workers

2C. How many of the surveyed retirees who were between 62 and 64 from Table 5 reported that their reason for retirement was that they were "Ready to retire"?

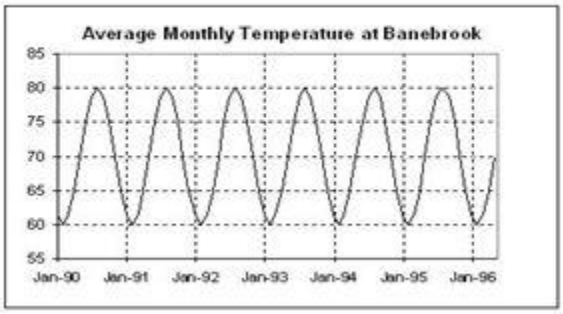
a) 10.5
b) 33
c) 50
d) 66

3. Regarding the two graphical displays given below, which of the following statements is correct?

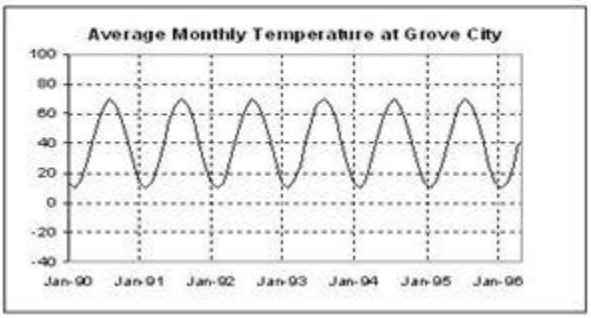
a) Banebrook (Graph 1) and Grove City (Graph 2) temperatures exhibit linear behavior through the year.

b) Banebrook (Graph 1) has the largest changes in temperature than Grove City (Graph 2) through the year.
c) Neither of the above.

Graph 1



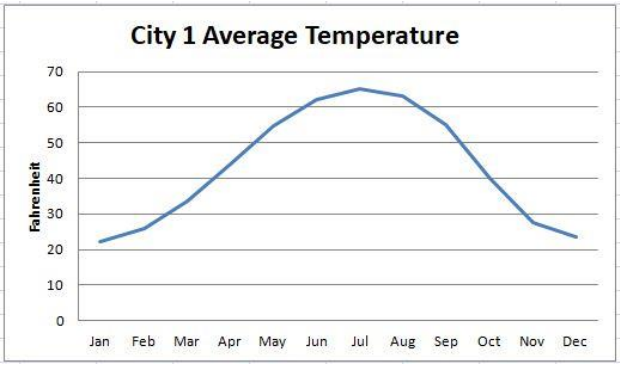
Graph 2

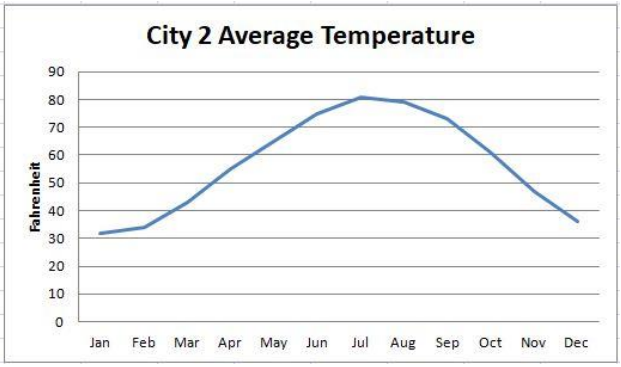


Spring 2018 Modification

3) Regarding the two graphical displays given below, which of the following statements is correct?

a) City 1 and City 2 average temperatures exhibit linear behavior through the year.
b) City 1 has larger change in temperature from winter to summer than City 2 through the year.
c) Neither of the above.





Adopted from 2017 Madison Assessment LLC.

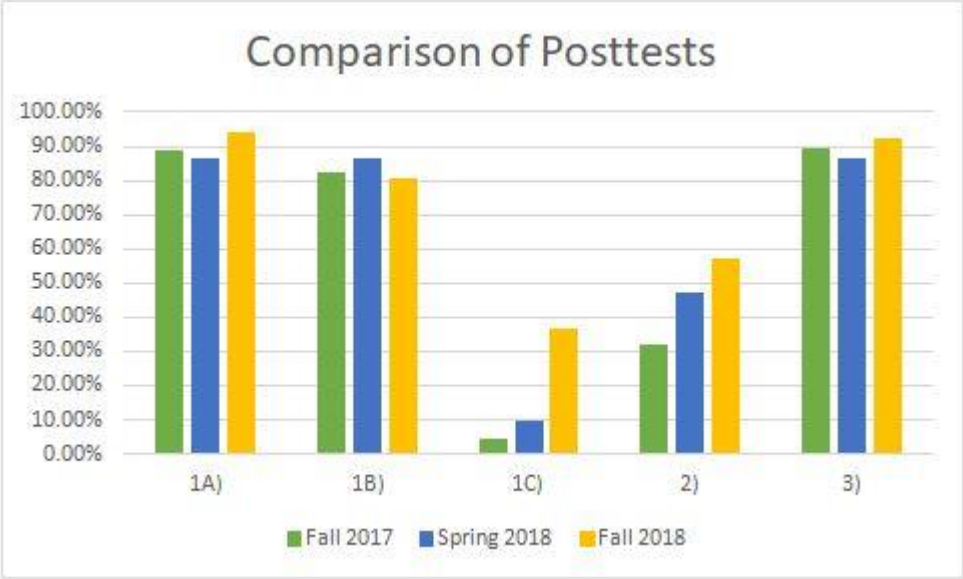
Appendix C

Visual Comparison of All Students Who Took Post-tests

(Fall 2017, Spring 2018, and Fall 2018)

Percentage of Correct Responses

Question Posttest/Pretest	Fall 2017	Spring 2018	Fall 2018
1A)=2B)	88.89%	86.39%	94.12%
1B)=2A)	82.35%	86.39%	80.88%
1C)=2C)	4.58%	9.52%	36.76%
2)=3)	32.03%	46.94%	57.35%
3)=1)	89.54%	86.39%	92.65%
TOTAL:	100.00%	100.00%	100.00%



Appendix D

Fall 2018 Posttest Comparison of results:

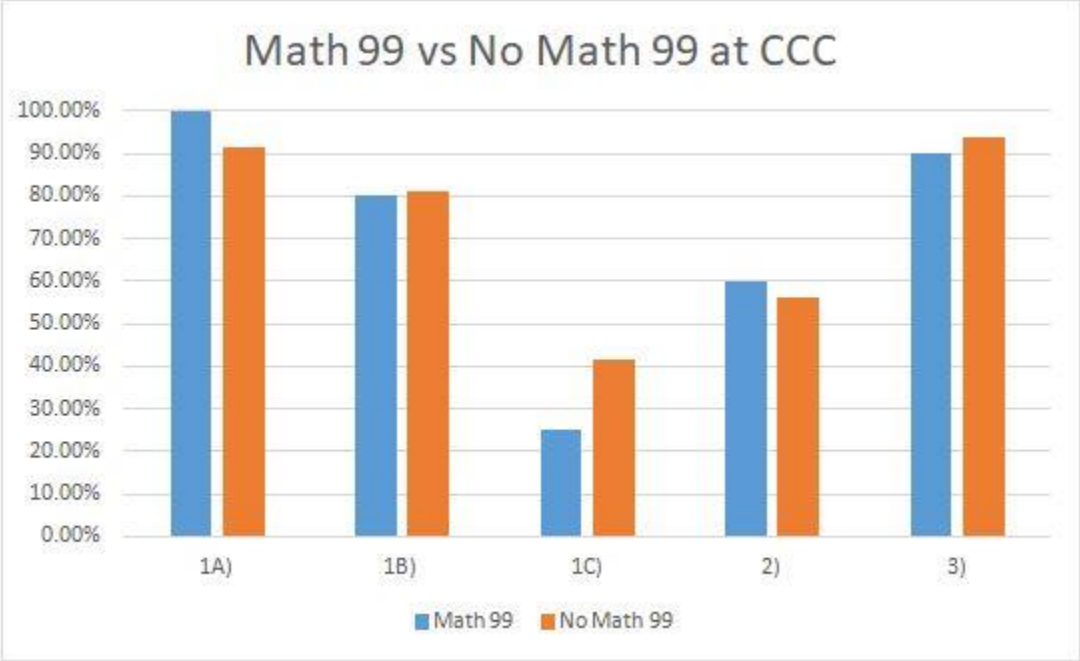
Students that took Math 99 at CCC vs the ones that didn't

Number of Correct Responses

Question	Math 99	No Math 99
1A)	20	44
1B)	16	39
1C)	5	20
2	12	27
3	18	45
TOTAL:	20	48

Percentage of Correct Responses

Question	Math 99	No Math 99
1A)	100.00%	91.67%
1B)	80.00%	81.25%
1C)	25.00%	41.67%
2	60.00%	56.25%
3	90.00%	93.75%
TOTAL:	100.00%	100.00%



A Fisher's exact test of independence was performed for each question to see whether there was a statistically significant difference in the proportion of correct responses between the two groups (students who took Math 99 at CCC vs students who did not take Math 99 at CCC).
There is a statistically significant difference (at the 0.05 level) between the groups in question 1A) (p-value = 6.644×10^{-5}), question 1B) (p-value = 0.0001031), question 1C) (p-value = 0.001541), question 2 (p-value = 0.0075), and question 3 (p-value = 5.974×10^{-6}).