Report on the Effectiveness of Mathnasium Learning Center Teaching on Student Performance on Standards-based Mathematics Tests

Report on 2010 Student Testing Data

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<u>Introduction</u>

Mathnasium is a learning center which students may attend after school to boost their math skills. The center is highly specialized; teaching only math. The program is for students in grades 2 through 8 and high school. Students attend the center once or twice a week, for about an hour. Like a gym or health club, members pay a monthly fee and can drop–in anytime. The goal is to significantly increase a student's math skills, understanding of math concepts, and overall school performance, while building confidence and forging a positive attitude toward the subject.

The company has sought to determine the effectiveness of its program, and has commissioned several qualitative and quantitative studies since 2004.

This study was conducted in 2011, using the results of 2010-year paired testing data for a cross-section of Mathnasium Center students. Using a single group non-experimental pre-posttest design, this study was to determine whether there exists a positive treatment effect on mathematics testing performance of elementary and middle school children as a result of their attending the Mathnasium teaching center for a period of approximately 6 months.

<u>The Study</u>

To see whether students' performance on tests of math skills are improving as a result of Mathnasium tutoring, two math tests were given to students, one at the beginning of the study period (pretest), and one at the end (posttest).

The students who participated in this study are Mathnasium customers who also attend local elementary schools, and represent a broad cross-section across all centers located in the United States.

Students are placed at a specific learning level within the Mathnasium curriculum based on an initial interview at the Mathnasium Center, a review (if possible) of recent testing results from school, and whether or not they are able to pass a pre-test at the level one lower than their current grade. These data are used to place the student at the level where they begin the Mathnasium learning process. This is the level where the subject's pre-test and post-test are given.

The instruments used in this study are the Mathnasium 'Check-up Tests'. These tests have been aligned to math standards from all States in which Mathnasium operates, including the State where Mathnasium is headquartered, California. A sample test is included in the Appendix. The pre- and posttests are equivalent, containing the same level and number of questions and testing the same exact skills. The tests have been independently validated by an experienced credentialed mathematics teacher, showing that they test at grade-level and that the content is consistent with the California State standards.

Between the two tests, each student attended the Learning Center a few times per week for mathematics tutoring. The treatment period averages 3 months.

The design of this statistical study is a 'Single Group Pretest-Posttest Design' (Figure 1). This design compares the same group of participants before and after the program. The purpose of the single group pretest-posttest design is to determine if participants improved after receiving the program. As is common with most any statistical work, there are limitations and threats to this design which are noted in the Conclusions and Recommendations section of this report.

Figure 1. Single Group Research Design based on Kerlinger (1973)

Students at the Mathnasium Learning Center form a single group. The group receives the treatment for a minimal period of three months.   O represents the pretest and posttest.

O   X   O

The null hypothesis of this study is that attending the Learning Center will have no positive causal effect on posttest performance. A *t-test* comparing matched pairs of pre- and posttest results was used to statistically determine if there is a significant difference between the two test scores across the study population. A one-tailed test was used because the effect of the Mathnasium tutoring treatment was assumed to be positive.

Analysis

Once the pre and posttest data was collected, the data were entered into Microsoft Excel, and manipulated to combine and match student pairs of data. This information was then sorted by test level. The original data set contained 3,144 records of individual students who have taken pre- and posttests, but data for students who attended a center for fewer than three months was removed prior to analysis, ensuring that only students who attended a center for at least 3 months would be included. The final overall count of students was 1,502.   Data for testing levels 1 through 10 were provided for this study and all levels were included. It was noted that the number of students (n = 11) in level 10 was much lower than the number of students in other groups, which ranged from n = 26 to n = 314.

The *t-test* analysis was performed on the data collected for test levels 1 through 10. The calculations were run using the Data Analysis Add-in statistical functionality within Microsoft Excel, and several of the statistical results were confirmed using TexaSoft Winks SDA 6.0.   A statistically significant difference in the testing scores between pre- and posttest is shown at the 95% confidence level (Table 1).
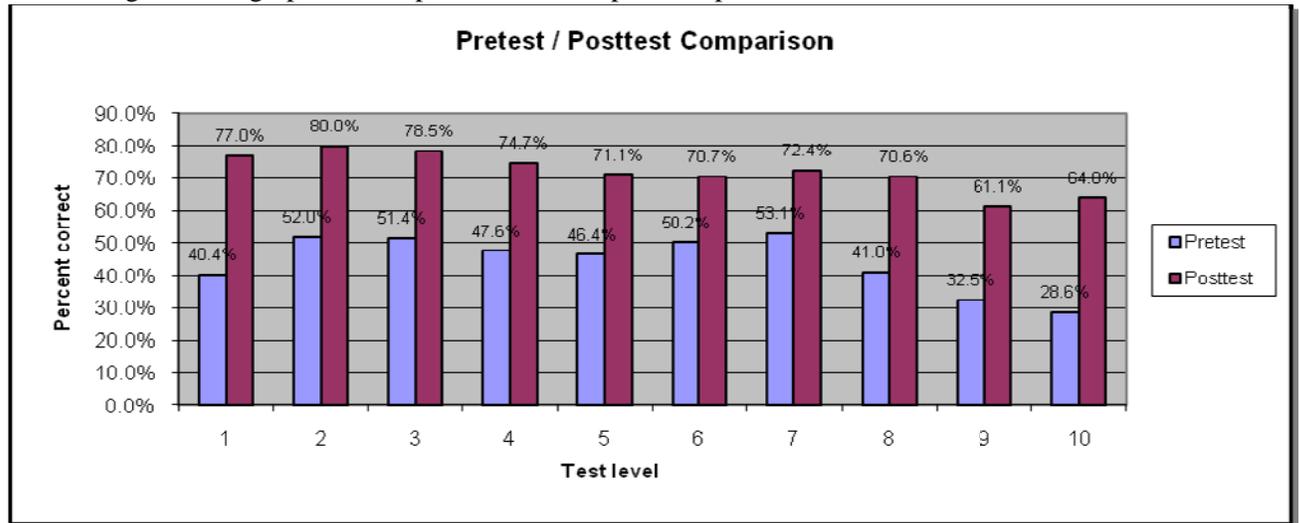
Table 1. Statistical results

Level	Test	Mean	Variance	n	df	t Stat	P (T<=t) one-tail	t Critical one-tail (at .05)
Level 1	*Pretest*	40.4%	0.0387	208	207	-27	2.05E-70	1.652
	Posttest	76.9%	0.0327	208				
Level 2	*Pretest*	51.9%	0.0257	289	288	-34	5.3E-104	1.650
	Posttest	80.0%	0.0180	289				
Level 3	*Pretest*	51.4%	0.0319	314	313	-34	2.4E-106	1.650
	Posttest	78.5%	0.0261	314				
Level 4	*Pretest*	47.6%	0.0304	229	228	-29	7.05E-80	1.652
	Posttest	74.7%	0.0321	229				
Level 5	*Pretest*	46.4%	0.0366	136	135	-23	1.76E-48	1.656
	Posttest	71.1%	0.0390	136				
Level 6	*Pretest*	50.2%	0.0486	97	96	-17	2.67E-30	1.661
	Posttest	70.7%	0.0415	97				
Level 7	*Pretest*	53.1%	0.0360	124	123	-22	1.75E-44	1.657
	Posttest	72.4%	0.0347	124				
Level 8	*Pretest*	41.0%	0.0241	61	60	-15	6.03E-23	1.671
	Posttest	70.6%	0.0236	61				
Level 9	*Pretest*	31.5%	0.0159	26	25	-10	1.29E-10	1.708
	Posttest	61.1%	0.0398	26				
Level 10	*Pretest*	28.6%	0.0262	11	10	-4	0.000625	1.812
	Posttest	64.0%	0.0342	11				

Conclusions

The statistical results show a positive treatment effect across all grades analyzed. The improvement in mean scores between pre and post-tests across all grades analyzed ranges from 19.3 to 36%. The students performed significantly better on a math posttest after receiving instruction through the learning center.

Figure 2. A graphical comparison of mean pre- and posttest results.

While these results show a positive treatment effect, there are a number of threats to the statistical results. The study is not experimental in design, and could benefit from a more controlled environment. This research is designed to supplement other studies to determine the effectiveness of the Learning Center. This design has inherent limitations, namely participants may improve over time without intervention of any kind, and these changes can be mistakenly attributed to the program under evaluation. This design could not indicate whether the program solely caused improvement in participants; as there is no way to distinguish between changes over time due to other factors and effects specific to the program. As a single group design, this study was easier to implement and less expensive study than experimental design, but did not include a control group, which could isolate the treatment effect and bias.

Another threat, and difference from previous studies for Mathnasium, is the length of the student treatment effect. This study has the average length of time between pre and post-test as about 6-7 months, which certainly overlaps time when students are attending regular math classes in school. In previous reports prepared by for Mathnasium, the treatment times were closer to 3-4 months, or took place over a summer break. Certainly having the treatment period over a summer school break would reduce the influence on student improvement that caused by school math classes.

While there are limitations to the statistical results in this study, there are important strengths. This study is based on a much largest sample size than previous Mathnasium Center studies, which improves the quality of the statistical calculations.

When the statistical significance shown by the data is coupled with qualitative feedback from parents that Center attendees demonstrate more enthusiasm towards learning math, and their children's grades improved, the results of this study are very positive.

Appendix A: References

American Educational Research Association (AERA), American Psychological Association (APA), and National Council on Measurement in Education (NCME). (1999). *The Standards for Educational and Psychological Testing*.

Kerlinger, F. M. (1973). Foundations of behavioral research. New York: Holt Rinehart & Winston.

Mathnasium, LLC. (2004). Results of Parent Satisfaction Survey. (Web Site) URL: www.mathnasium.com.

Trochim, W. (2000). The Research Methods Knowledge Base, 2nd Edition. Atomic Dog Publishing, Cincinnati, OH.

Trochim, W. and Land, D. (1982). Designing Designs for Research. The Researcher, 1, 1, 1-6.

Appendix B. Sample of Mathnasium Internal Pretests used in this Study

• Math Checkup #5 •

Show all work – neatly

1) $7,349 + 321 + 6 + 75 =$ _____

2)
$$\begin{array}{r} 4,423 \\ 5,576 \\ 1,917 \\ + \ 8,082 \\ \hline \end{array}$$

3)
$$\begin{array}{r} 3,482 \\ - \quad 724 \\ \hline \end{array}$$

4)
$$\begin{array}{r} 70,000 \\ - \quad 9,123 \\ \hline \end{array}$$

5)
$$\begin{array}{r} 63,905 \\ - \quad 5,348 \\ \hline \end{array}$$

6)
$$\begin{array}{r} 896 \\ \times \quad 87 \\ \hline \end{array}$$

7)
$$\begin{array}{r} 2,753 \\ \times \ 524 \\ \hline \end{array}$$

8)
$$\begin{array}{r} 45,000 \\ \times \ 20,000 \\ \hline \end{array}$$

9) $9 \overline{)7,290}$

10) $16 \overline{)51,232}$

11) $79 \overline{)53,205}$

DATE _____

GRADE _____

NAME _____

Web_Assessment/W_Assmnt_5_v1_v01–1

12) $3.24 + 7.2 = $ _____   13) $3.69 + 7.2 + 3 = $ _____

14) $18.79 - 3.2 = $ _____   15) $8 - 1.75 = $ _____

16)
$$\begin{array}{r} 3.42 \\ \times \quad 1.1 \\ \hline \end{array}$$

17)
$$\begin{array}{r} 0.25 \\ \times \quad 0.25 \\ \hline \end{array}$$

18) $1.2 \overline{)1.56}$ 19) $0.25 \overline{)875}$

Write your answers in simplified form.

20) $\frac{3}{8} + \frac{3}{8} = $ _____   21) $2\frac{3}{8} + \frac{5}{6} = $ _____

22) $7 - 4\frac{3}{8} = $ _____   23) $8\frac{2}{3} - 2\frac{3}{4} = $ _____

24) $\frac{8}{9} \times \frac{3}{4} = $ _____   25) $4\frac{4}{5} \times \frac{1}{2} = $ _____

26) $\frac{8}{9} \div \frac{2}{3} = $ _____   27) $3\frac{9}{10} \div \frac{3}{5} = $ _____

Draw a rectangle below. Label the length $12^1/_2$ feet and the width 2 feet.

28) Find the PERIMETER of the rectangle. _____

29) Find the AREA of the rectangle. _____

30) Write the number in words: 87,654,321

_____

_____

31) Write the number in words: 5.234

_____

_____

32) 25% of 20 = _____   **33)** 8% of 300 = _____

34) 16% of 225 = _____   **35)** 12% of 130 = _____

36) 10% of the apples in a barrel were rotten. The barrel contained a total of 120 apples. How many apples were *not* rotten? _____

A bag contains 5 red M&Ms, 4 green M&Ms, and 3 blue M&Ms.

37) What is the ratio of blue M&Ms to green M&Ms? _____

38) What is the ratio of green M&Ms to red M&Ms? _____

39) What part of the M&Ms are red? _____

Web_Assessment/W_Assmnt_5_v1_v01–3

40) 3,000 pounds of sand is used to fill sandboxes. 1,000 pounds was used to fill the big sandbox, and the rest was used to fill four equal-size sandboxes. How much sand was put in each of the smaller sandboxes?

_____

41) Martha and George take turns baby–sitting. Martha works for 4 hours and George works for 2 hours. They are paid a total of $24.00.

How should they share the money so that each person gets a fair share?

Martha = _____   **George** = _____

42) $7 + {}^-3 =$ _____

43) ${}^-9 + 7 =$ _____

44) ${}^-8 + {}^-7 =$ _____

45) ${}^-1 + 2 + {}^-7 + {}^-2 =$ _____

46) $4 - 7 =$ _____

47) ${}^-3 - {}^-7 =$ _____

48) ${}^-5 +$ _____ $= {}^-2$

49) ${}^-4 -$ _____ $= 9$

50) Round to the nearest *thousand*: 1,237,421:   _____

51) Round to the nearest *hundredth*: 24.3472:   _____

52) Round to the nearest *tenth*: 129.9521:   _____

53) What is the *sum* of 10 and 2?   _____

54) What is the *product* of 10 and 2?   _____

55) What is the *quotient* of 10 and 2?   _____

56) What is the *difference* of 10 and 2?   _____

Define in your own words:

57) DENOMINATOR _____

58) MULTIPLE _____

59) FACTOR _____

What is the next number in the pattern:

60) 0, 1, 3, 6, 10, 15, _____   **61)** 0, 1, 1, 2, 3, 5, 8, 13, _____

List *all* the factors of:

62) 12 _____   **63)** 60 _____

What is the **GCF** (Greatest Common Factor) of:

64) 18 and 24 GCF = _____   **65)** 75 and 125 GCF = _____

What is the **LCM** (Least Common Multiple) of:

66) 6 and 8   LCM = _____   **67)** 10 and 12   LCM = _____

A bag contains 10 red marbles, 8 white marbles, and 6 blue marbles. If one marble is picked from the bag, what is the probability that the marble will be:

68) a blue marble _____?   **69)** *not* a white marble _____?

70) A furlong is one–eighth ($^1/_8$) of a mile. What part of a mile is 6 furlongs? _____

Papa bear ate half of the pie. Mama bear ate half of what was left. Baby bear ate half of what was left.

71) What fractional part of the pie was left for Goldilocks? _____

72) What fractional part of the pie did Mama bear get? _____

73) Name five numbers between $^1/_4$ and $^3/_4$: ____, ____, ____, ____, ____

74) Circle the fraction with the *greatest* value: $^{12}/_{13}$, $^{19}/_{20}$, $^3/_7$, $^{77}/_{99}$

75) Arrange in order from *smallest* to *largest*: 0, 1, $^1/_2$, $^5/_{12}$, $^5/_8$

_____, _____, _____, _____, _____

76) $^3/_4$ of 20 = _____ 77) $^5/_8$ of 24 = _____

78) $^1/_5$ of _____ = 7 79) $^3/_5$ of _____ = 9

80) half of 20 = _____ 81) half of 30 = _____

82) half of 100 = _____ 83) half of 150 = _____

84) half of 7 = _____ 85) half of 21 = _____

86) half of 99 = _____ 87) half of $7^1/_2$ = _____

88) half of _____ = 8 89) half of _____ = 4 $^1/_2$

90) half of _____ = 24$^1/_2$ 91) half of _____ = 5$^3/_4$

Appendix C. Sample Test Alignment to California State Standards

Grade 5, Test PT5A

Item	Strand	Standard
2a	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
2b	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
3a	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
3b	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
—	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
4a	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
4b	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
4c	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
5a	Number Sense	2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
5b	Number Sense	2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
5c	Number Sense	2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
6a	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
6b	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
6c	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
7a	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
7b	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
7c	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
9a	Number Sense	2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
9b	Number Sense	2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
9c	Number Sense	2.2 Demonstrate proficiency with division, including division with positive decimals and long division with multidigit divisors.
10a	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
10b	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
11a	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
11b	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
14a	Measurement and Geometry	1.1 Derive and use the formula for the area of a triangle and of a parallelogram by comparing it with the formula for the area of a rectangle (i.e., two of the same triangles make a parallelogram with twice the area; a parallelogram is compared with a rectangle of the same area by cutting and pasting a right triangle on the parallelogram).
14b	Measurement and Geometry	1.1 Derive and use the formula for the area of a triangle and of a parallelogram by comparing it with the formula for the area of a rectangle (i.e., two of the same triangles make a parallelogram with twice the area; a parallelogram is compared with a rectangle of the same area by cutting and pasting a right triangle on the parallelogram).
15a	Number Sense	1.1 Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.
15b	Number Sense	1.1 Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.
16a	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
16b	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
16c	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.

16d	Number Sense	2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.
18a	Statistics, Data Analysis, and Probability	1.3 Use fractions and percentages to compare data sets of different sizes.
18b	Statistics, Data Analysis, and Probability	1.3 Use fractions and percentages to compare data sets of different sizes.
18c	Statistics, Data Analysis, and Probability	1.3 Use fractions and percentages to compare data sets of different sizes.
21a	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21b	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21c	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21d	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21e	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21f	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21g	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
21h	Number Sense	2.1 Add, subtract, multiply, and divide with decimals; add with negative integers; subtract positive integers from negative integers; and verify the reasonableness of the results.
22a	Number Sense	1.1 Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.
22b	Number Sense	1.1 Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.
22c	Number Sense	1.1 Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.
25a	Mathematical Reasoning	1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
25b	Mathematical Reasoning	1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
26a	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
26b	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
27a	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
27b	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
28a	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
28b	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
29a	Number Sense	2.3 Solve simple problems, including ones arising in concrete situations, involving the addition and subtraction of fractions and mixed numbers (like and unlike denominators of 20 or less), and express answers in the simplest form.
29b	Statistics, Data Analysis, and Probability	1.3 Use fractions and percentages to compare data sets of different sizes.
30	Statistics, Data Analysis, and Probability	1.3 Use fractions and percentages to compare data sets of different sizes.