# Standardizing Assessment Across QL Courses

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# A new core curriculum

- Old: Computation requirement (3-4 credits)
- *Students will be able to solve basic mathematical problems and demonstrate some ability to interpret and present numerical data.*

- Statistics (in any department)
- “Mathematics Everywhere” (math for liberal arts course)
- Calculus

# New core curriculum will take effect next fall

- Quantitative Literacy requirement  (3-4 credits)

- Quantitative literacy (QL) is a habit of mind. It involves using elementary mathematical tools to interpret and manipulate quantitative data arising in a variety of contexts. It is marked by computational fluency, and by competence and comfort in working with numerical data. Those who are quantitatively literate can create arguments supported by data and can communicate those arguments in many ways – using tables, graphs, mathematical expressions, and words.

- A course that satisfies the QL section of the Core Curriculum should have as its main focus the use of mathematics to solve real-world problems. In those courses, using data and appropriate technology, students will collaborate to solve multi-step problems and effectively communicate their reasoning to others.

# How to recognize a QL course?

We believe that a course that satisfies the QL requirement should include many of the following:

- Problem-solving: applying mathematics to real-world problems.
- Working with data.
- Using (and knowing when to use) appropriate technology.
- Looking carefully at quantitative arguments in the media, or in journal articles in another discipline.
- Reasoning: using quantitative skills to defend one's opinion.

# How to recognize a QL course?

- Solving multi-step quantitative problems (as in a class project).
- Active learning and engagement.
- Collaborative learning.
- Communicating (mostly in writing) about quantitative issues in everyday life. May include homework, exams, lab reports, essays.
- Presenting data in useful ways: graphs, charts, tables, equations.
- Multiple forms of assessment.

# Student learning outcomes in a QL course

Students who successfully complete a QL course should be able to

- Demonstrate computational fluency.
- Understand and interpret data presented in a variety of formats, and convert from one format to another.
- Draw conclusions based on numerical data and assess their limitations.
- Evaluate quantitative arguments in a variety of settings.
- Communicate their understanding of the usefulness of mathematics.

# Courses

- Statistics (Mathematics, Economics, Psychology, Sociology)
- Mathematics Everywhere
  - Mathematics of Daily Life (*For All Practical Purposes)*
  - Mathematics of Democracy
  - Mathematics of Games and Sports
- Workshop Calculus I

# Assessing QL courses

- Learning objectives
- Attitudes

- Fall 2013:
  - MATH 111 Mathematics Everywhere
    - Math of Daily Life
    - Math of Games and Sports
  - MATH 112 Applied Statistics

# How do our current QL courses address the desirable attributes of a QL course?

**Quantitative Literacy in Math 111A-The Mathematics of Daily Life**

- **Problem Solving**-The first two topics in Math 111A are Euler Circuits and Hamiltonian circuits, where students determine most efficient routes for mailmen, airlines, etc. In the personal finance unit students determine how much mortgage they can afford and how much they need to save a month to accrue a down payment. These are just two examples, since problem solving is occurring in every unit.
- **Working with Data**-We do a complete unit on one variable and two variable statistics. We develop the skills necessary to analyze the statistic by hand and with Excel. Interpreting graphs, 5 number summaries, stem plots, etc. are emphasized.
- **Using (and Knowing When to Use) Appropriate Technology**-About a third of the course involves using Excel. We do three labs and a project using Excel to manage and analyze personal finances. We use Excel to present and analyze one variable and two variable statistics, as well.

- **Looking Carefully at Quantitative Arguments in the Media, or Journal Articles in Other Disciplines**-This is addressed in homework assignments in our statistics unit.
- **Reasoning**: Using quantitative skills to defend one's opinion-using the web and Excel, students make and defend an argument for their choice of the greatest homerun hitter of all time. As with problem solving, reasoning is a part of every unit.
- **Active Learning and Engagement**-The class format includes very little lecture. Much more time is spent on well-designed worksheets and labs that introduce and develop the subject matter. Students are encouraged to talk to each other as they work through the worksheets and material. At the same time they can question and seek reinforcement from the instructor. Often the class summary is an exit slip demonstrating mastery of the day's topic. The student must answer the problem on the exit slip correctly to exit the room.

- **Collaborative Learning**-See active learning above. Students also do a home buying project with a partner in which, using the web and Excel, they determine how much mortgage they can afford and develop a plan to save for the down payment.
- **Communicating about Quantitative Issues in Everyday Life**-Besides the assignment defending the greatest homerun hitter, students use data to analyze current events such as health care costs.
- **Presenting Data in Useful Ways**: We do a complete unit on one variable and two variable statistics. We develop the skills necessary to analyze the statistic by hand and with Excel. Histograms, scatter plots, stem plots, box and whisker plots, and five number summaries are emphasized.
- **Multiple forms of assessment**: Labs (primarily Excel based, in-class and take home ; projects; two midterms with take home components; and a final exam. The students also do an Excel practical at the end of the course.

# How did students meet the learning objectives?

Examples from three courses:

- Mathematics of Daily Life
- Applied Statistics
- Mathematics of Games and Sports

# Math of Daily Life
# Class project: buying a home

## Main Goal and Purpose

The purpose of this project is to explore a realistic (hence, more complicated) financial situation. You will combine several of the Excel techniques that you have been practicing over the past two weeks to plan the purchase of a house.

## The Project

The project has two parts: an Excel part and a writing part. You will submit an Excel workbook with two worksheets and a Word document. You may work on the project alone or with a partner. Submit one copy of your project per individual or partners.

### Excel Part

Assume you have graduated from college, and you have a real job. You want to save money to buy a house. You will be using the Internet to track down some information to plan your savings. **Make certain that you record the places that you find your information so that you can later cite them properly. Remember: to cite a webpage you should give the URL and the date that you accessed the website.**

Here is the outline of what you will do. When you buy a house, you get a big loan from a bank (the *mortgage*), which you will pay back with monthly payments, usually over a term of 30 years. You are never allowed to borrow the entire amount that the house costs, and so you also have to provide a large sum of money called the *down payment*. In this project, you will figure out how much money you can afford to borrow to buy a house (how large a mortgage you can take out), and you will figure out how to save up the money you will need for the down payment.

# Example student submission

Dear Mom,

Hey, mom. How are you? I am great because I am looking to buy a house with my partner Stephanie. I just received my Teaching Certificate from Hood College and she plans to be a stay at home mommy. The average salary for teachers in Maryland is $63,960 annually. With this income, I can afford a monthly mortgage payment $1066.00, and I determine this by taking twenty percent of my monthly salary. With this mortgage payment we found a beautiful condo in Frederick, Maryland. It is located at 6076 Flagstone Ct, Frederick, MD 21701. The house has three beds, three baths, and is a total of 1,938 square feet. In total the condo will cost $254,900 and worth every penny because of the spacious rooms, fire place, and scenery off our back deck.

To be able to pay for this home we took out a thirty year fixed rate mortgage of $207,023.32. The APR of this loan is 4.64% and our monthly check to the bank will be $1066.00. My plan for saving for our down payment is to save $308.32 every month for ten years. The interest that we would be expected to earn is 5% APR and that is compounded monthly.

Love,

Leah and Stephanie

| | Start Balance | Interest | Payment | End Balance |
|---|---|---|---|---|
| 1 | $207,023.32 | $800.15 | $1,066.00 | $206,757.46 |
| 2 | $206,757.46 | $799.12 | $1,066.00 | $206,490.58 |
| 3 | $206,490.58 | $798.09 | $1,066.00 | $206,222.67 |
| 4 | $206,222.67 | $797.05 | $1,066.00 | $205,953.72 |
| 5 | $205,953.72 | $796.01 | $1,066.00 | $205,683.73 |
| 6 | $205,683.73 | $794.97 | $1,066.00 | $205,412.70 |
| 7 | $205,412.70 | $793.92 | $1,066.00 | $205,140.62 |
| 8 | $205,140.62 | $792.87 | $1,066.00 | $204,867.48 |
| 9 | $204,867.48 | $791.81 | $1,066.00 | $204,593.30 |
| 10 | $204,593.30 | $790.75 | $1,066.00 | $204,318.05 |
| 11 | $204,318.05 | $789.69 | $1,066.00 | $204,041.74 |
| 12 | $204,041.74 | $788.62 | $1,066.00 | $203,764.36 |
| 13 | $203,764.36 | $787.55 | $1,066.00 | $203,485.91 |
| 14 | $203,485.91 | $786.47 | $1,066.00 | $203,206.38 |
| 15 | $203,206.38 | $785.39 | $1,066.00 | $202,925.78 |
| 16 | $202,925.78 | $784.31 | $1,066.00 | $202,644.08 |
| 17 | $202,644.08 | $783.22 | $1,066.00 | $202,361.30 |
| 18 | $202,361.30 | $782.13 | $1,066.00 | $202,077.43 |
| 19 | $202,077.43 | $781.03 | $1,066.00 | $201,792.46 |
| 20 | $201,792.46 | $779.93 | $1,066.00 | $201,506.39 |
| 21 | $201,506.39 | $778.82 | $1,066.00 | $201,219.21 |
| 22 | $201,219.21 | $777.71 | $1,066.00 | $200,930.92 |

| | |
|---|---|
| APR | 4.64% |
| Monthly | 0.003865 |

a) Our annual salary is $63,960.00. Our annual salary multiplied by four is $255,840.00. Our monthly salary is $5,330,00. And 20% of our monthly salary which is our monthly payment is $1,066.00 ( teacherportal.com)

b)Our Condo costs $254,900.00 (zillow.com)

c) Our APR is 4.64 % , which makes our monthly interest .003865 (totalmortgage.com)

d) We can afford to take out a $207,023.32 mortgage.

e) Our down payment is $47,876.68

## Statistics

| | |
|---|---|
| Count | 25 |
| Minimum Value | 6.00 |
| Maximum Value | 20.00 |
| Range | 14.00 |
| Average | 17.44 |
| Median | 18.00 |
| Standard Deviation | 3.48 |
| Variance | 12.09 |

## Status Distribution

| | |
|---|---|
| Null | 0 |
| In Progress | 0 |
| Needs Grading | 0 |
| Exempt | 0 |

## Grade Distribution

| | |
|---|---|
| Greater than 100 | 0 |
| 90 - 100 | 18 |
| 80 - 89 | 2 |
| 70 - 79 | 0 |
| 60 - 69 | 4 |
| 50 - 59 | 0 |
| 40 - 49 | 0 |
| 30 - 39 | 1 |
| 20 - 29 | 0 |
| 10 - 19 | 0 |
| 0 - 9 | 0 |
| Less than 0 | 0 |

## Problem 4: Great Home-Run Hitters

Start a new workbook (Excel file) for this problem.

The web site http://www.baseball-almanac.com/hitting/hihr1.shtml lists the 100 all-time top home-run hitters in Major League Baseball. If you click on a player's name, you get to a page with much more detailed data on that player's career. Check this out: click on a player, and scroll down to find Hitting Stats. The column HR in that table lists home runs by season.

1. Choose 3 players (your favorites? Your least favorite, favorite, and Hank Aaron? The top 3? 3 who are still playing? It's up to you.) Enter their home-run data by season into Excel. You should make a separate worksheet for each player.
2. Make a histogram of the home-run data for each player. As you did with the previous data sets, you should choose your bin size appropriately to display the distribution of the home-run variable.
3. Convince me that one of the three players you chose is the best home run hitter. Since I am a mathematician, a verbal argument will not suffice: you will need to use descriptive statistics. Determine 3 statistics that support your opinion. You could use mean, total count of homeruns, shapes of distributions, outliers, number of years for which data is available, or whatever statistic you find useful. Organize the data for your argument in a fourth worksheet along with a short paragraph convincing me. (A simple way to type text in Excel is to insert a Text Box, using the "Text Box" button in the Text group on the Insert tab.)

| | Ryan Zimmerman | Barry Bonds | Rick Wilkins |
|---|---|---|---|
| Mean | 19.89 | 34.64 | 5.4 |
| Total HR's | 179 | 762 | 81 |
| Median | 24 | 34 | 6 |

Out of these three baseball players, Barry Bonds is the best Home Run hitter, followed by Ryan Zimmermen and then Rick Wilkins. I can tell this by each of their averages of home runs hits per season, their total amount of home runs hit during their careers, and their median.

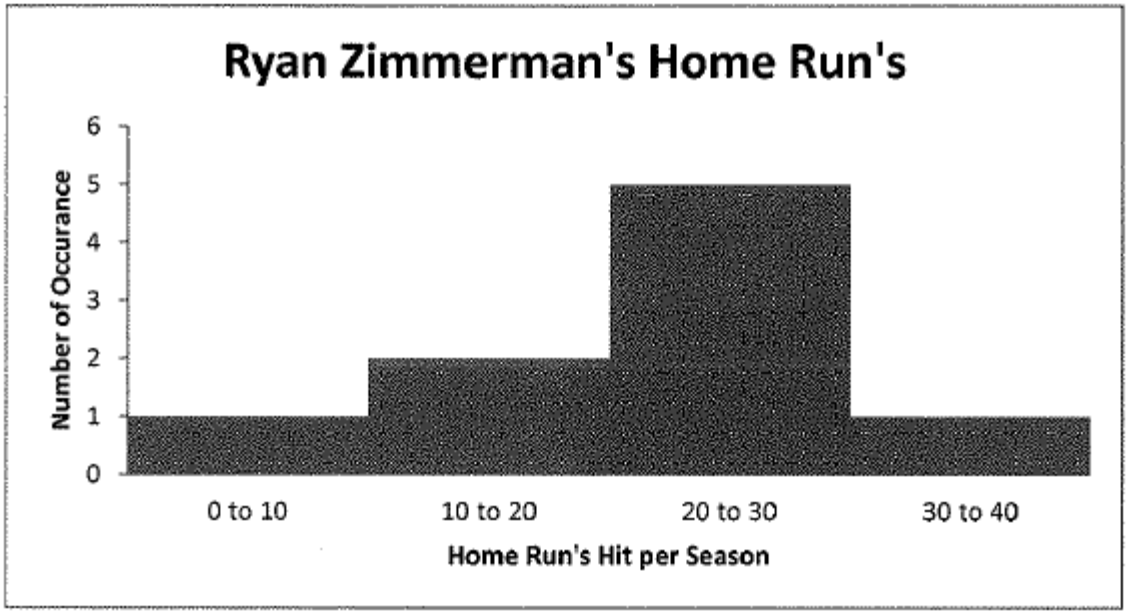
Mean: Barry Bonds leads with an average of 34.64 home runs per season, Ryan Zimmermen is next with 19.89, and Rick Wilkins' is only 5.4. There is no argument here since the distance between each average is large.

Total: Barry Bonds has had the most home runs, with a total of 762. Ryan Zimmermen hit 179, while Rick Wilkins hit 81. Barry Bonds is beating the other two by around 600, while Ryan Zimmermen still leads Rick Wilkins at around 100.

Median: Because Barry Bonds has an outliar, that definitely had an influence on his mean and total home runs. The median is not as influenced by it though. However, Barry Bonds still has the largest median of 34. The other two continue after with 24 and then 6.

All three of these statistics hold the same results. Barry Bonds came in first, then Ryan Zimmermen, followed by Rick Wilkins; so it is clear that that is the order of the best to worst home run hitter.

| | | | |
|---|---|---|---|
| 0 | | | |
| 20 | 0 to 10 | 1 | |
| 24 | 10 to 20 | 2 | |
| 14 | 20 to 30 | 5 | |
| 33 | 30 to 40 | 1 | |
| 25 | | | |
| 12 | Mean | 19.88889 | |
| 25 | Total | 179 | |
| 26 | Median | 24 | |



# Applied Statistics: Final project

- Form hypothesis
- Collect data
- Analyze
- Report findings – orally and in writing

# Examples

- Compare the yearly temperature means with the crime rate in New York City (using published data)
- Relationship between the day of the week and the number of EMS and fire calls (student was a volunteer at a VFD)
- Cost analysis of several local grocery stores and “supercenters”

# Math of Games and Sports: NFL Passer Rating Lab

| NFL Passer Ratings | | | | | | Names: | | | |
|---|---|---|---|---|---|---|---|---|---|
| Completions: | 4123 | | | | | | | | |
| Attempts: | 7250 | a= | 1.343448276 | mm(a)= | 1.343448276 | | | Quarterback's | 79.86206897 |
| Total Yards: | 51475 | b= | 1.025 | mm(b)= | 1.025 | | | Rating | 80 |
| Touchdowns: | 300 | c= | 0.827586207 | mm(c)= | 0.827586207 | | | | |
| Interceptions: | 226 | d= | 1.595689655 | mm(d)= | 1.595689655 | | | | |
| | | | | | | | | | |
| Tom Brady | | | | | | | | | |
| Completions: | 3891 | a= | 1.681000654 | mm(a)= | 1.681000654 | | | Quarterback's | 96.3851646 |
| Attempts: | 6116 | b= | 1.122956181 | mm(b)= | 1.122956181 | | | Rating | 96 |
| Total Yards: | 45820 | c= | 1.115107914 | mm(c)= | 1.115107914 | | | | |
| Touchdowns: | 341 | d= | 1.864045128 | mm(d)= | 1.864045128 | | | | |
| Interceptions: | 125 | | | | | | | | |
| | | | | | | | | | |
| Steve Young | | | | | | | | | |
| Completions: | 2667 | a= | 1.714027477 | mm(a)= | 1.714027477 | | | Quarterback's | 96.80897003 |
| Attempts: | 4149 | b= | 1.245902627 | mm(b)= | 1.245902627 | | | Rating | 97 |
| Total Yards: | 33124 | c= | 1.118341769 | mm(c)= | 1.118341769 | | | | |
| Touchdowns: | 232 | d= | 1.730266329 | mm(d)= | 1.730266329 | | | | |
| Interceptions: | 107 | | | | | | | | |

# NFL Passer Rating: recognizing a problem

## NFL Passer Ratings

**Names:**

**Elway**

| | | | | | |
|---|---|---|---|---|---|
| Completions: | 4123 | | | | |
| Attempts: | 7250 | a= | 1.343448276 | mm(a)= | 1.343448276 |
| Total Yards: | 51475 | b= | 1.025 | mm(b)= | 1.025 |
| Touchdowns: | 300 | c= | 0.827586207 | mm(c)= | 0.827586207 |
| Interceptions: | 226 | d= | 1.595689655 | mm(d)= | 1.595689655 |

Max(Min(2,5),4)=4

**Manning**

| | | | | | |
|---|---|---|---|---|---|
| Completions: | 117 | a= | 2.25 | mm(a)= | 2.25 |
| Attempts: | 156 | b= | 1.605769231 | mm(b)= | 1.605769231 |
| Total Yards: | 1470 | c= | 2.051282051 | mm(c)= | 2.051282051 |
| Touchdowns: | 16 | d= | 2.375 | mm(d)= | 2.375 |
| Interceptions: | 0 | | | | |

**Rivers**

| | | | | | |
|---|---|---|---|---|---|
| Completions: | 105 | a= | 2.197183099 | mm(a)= | 2.197183099 |
| Attempts: | 142 | b= | 1.360915493 | mm(b)= | 1.360915493 |
| Total Yards: | 1199 | c= | 1.549295775 | mm(c)= | 1.549295775 |
| Touchdowns: | 11 | d= | 2.022887324 | mm(d)= | 2.022887324 |
| Interceptions: | 2 | | | | |

I chose Manning and Rivers becuase they have the highest ratings in the data I found for the 2013 season. I think that their data will be similar to eachother but different then Elway's because his is based on his career, not just a season.

source:
http://espn.go.com/nfl/statistics/player/_/stat/passing/sort/quarterbackRating

| | |
|---|---|
| Quarterback's | |
| Rating | 138.034188 |

| | |
|---|---|
| Quarterback's | |
| Rating | 24316.66667 |

118.838

...ay out of bounds!
...e cell right below:

completion: a forward pass that is sucessfully caught
attempts: # of times the pass is tried
total yards: # of yards completed by the player
touchdows: # of touchdowns made
interceptions: # of time the passes were intercepted

Accoring to my data, Rivers would "win" because he has a higher quarterback's rating. This does not seem like a fair assesment because Rivers has a lower amont of completes, arrempts, total yards and touchdowns then Manning does. i noticed that in the data for all the parameters Rivers scores are lower, so it does not make sence that he has a higher rating. It doesn't- it's far enough off that you should be suspicious.

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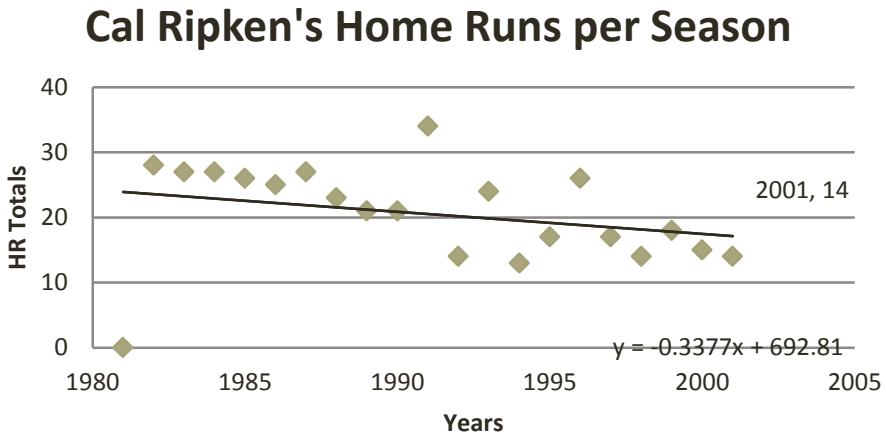
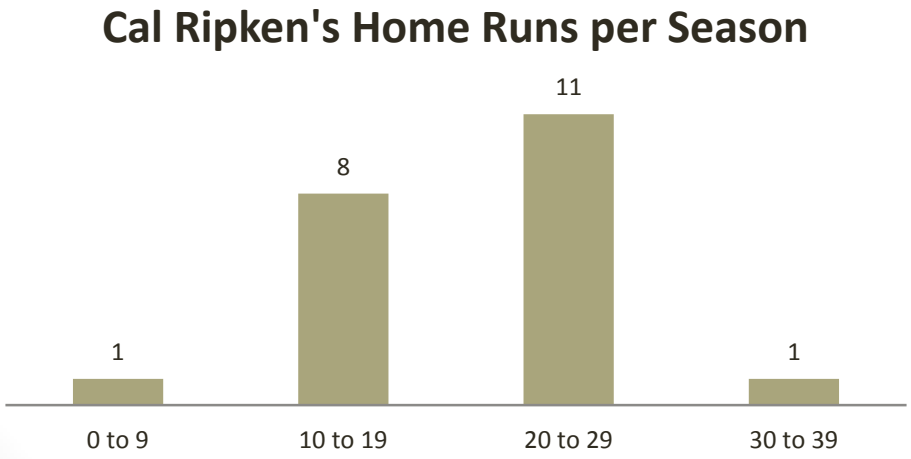
# Data in different formats



# What is slope, anyway?

b. The chart in figure 4 gives a nice aggregate view of the data, but what important piece of information is presented in figure 3 that is impossible to get from figure 4?

The important piece of information which is omitted from Figure 4 is the years in which he hit those homeruns. Figure 3 shows his homerun totals over the course of his careers.

c. Figure 3 has a linear model superimposed on the data, along with a formula (y= etc.) Which part of the formula represents the slope of the linear model, and what does that number tell you about the data? The m part of the formula represents the slope. It tells us that on average every season, Cal Ripken's home run totals drops by about 0.3377 home runs.

# What is slope, anyway?

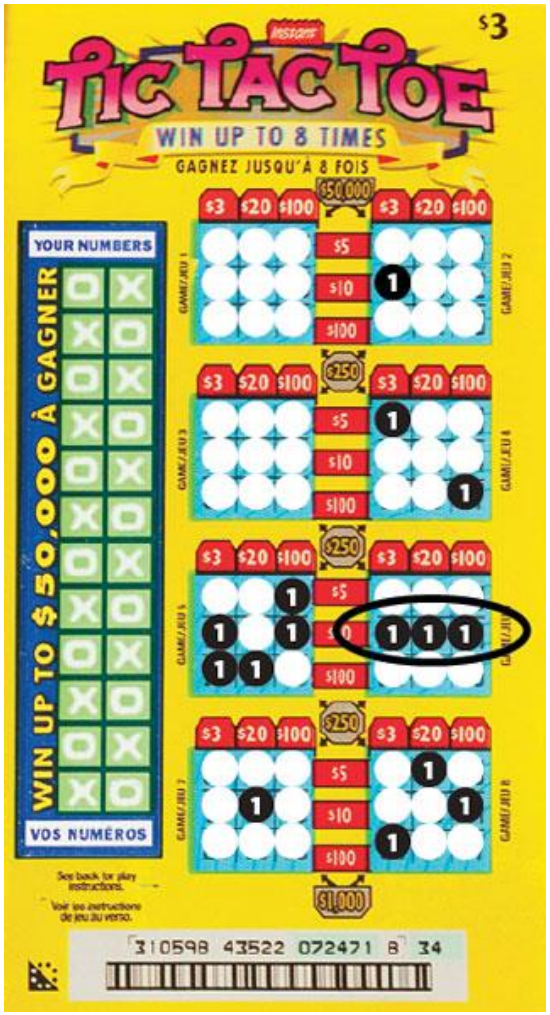
b. The chart in figure 4 gives a nice aggregate view of the data, but what important piece of information is presented in figure 3 that is impossible to get from figure 4?

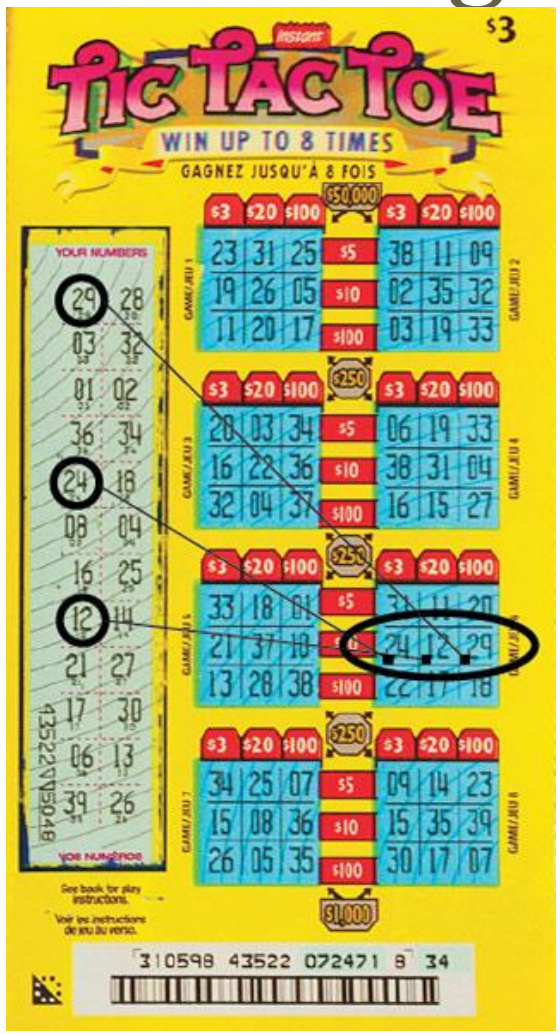
the line of regression (linear model) slope line!

c. Figure 3 has a linear model superimposed on the data, along with a formula (y= etc.) Which part of the formula represents the slope of the linear model, and what does that number tell you about the data?

$y = mx + b$ m represents the slope and this number tells you how the data changes as time goes on.

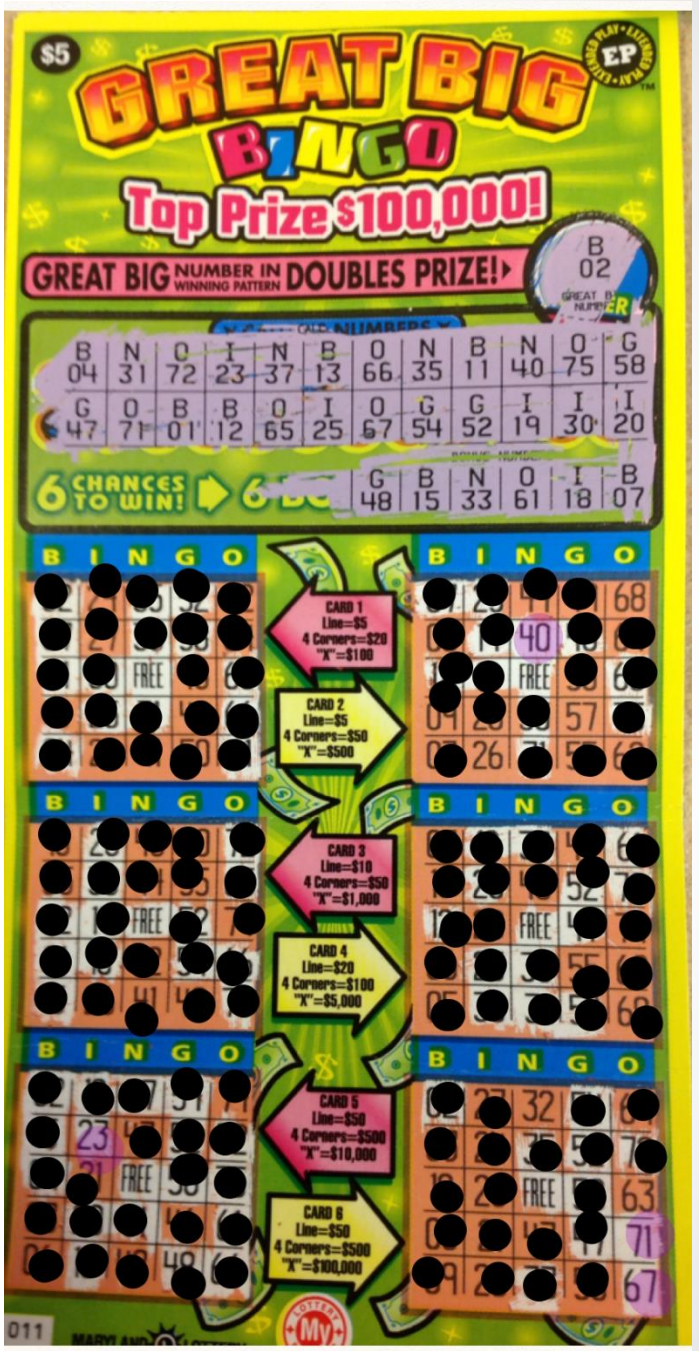
# “Cracking the Scratch Lottery Code” from Wired magazine



# Alas, no big money for us this year!

We did carefully analyze a much simpler scratch ticket using Excel

# Analyzing our own scratch tickets

| prizes | total prizes | prob. of ind. payout | payout | summands | | |
|---|---|---|---|---|---|---|
| 2000 | 25 | 5.89424E-06 | 1999 | 0.011782583 | | |
| 1000 | 36 | 8.4877E-06 | 999 | 0.008479216 | | |
| 500 | 57 | 1.34389E-05 | 499 | 0.006705993 | | |
| 100 | 584 | 0.000137689 | 99 | 0.013631252 | | |
| 50 | 1591 | 0.000375109 | 49 | 0.018380358 | | |
| 30 | 2877 | 0.000678309 | 29 | 0.01967096 | | |
| 15 | 5648 | 0.001331626 | 14 | 0.018642769 | | |
| 10 | 14354 | 0.003384236 | 9 | 0.030458124 | | |
| 5 | 98797 | 0.023293323 | 4 | 0.093173293 | | |
| 2 | 289287 | 0.068205063 | 1 | 0.068205063 | | |
| 1 | 390045 | 0.09196073 | 0 | 0 | | |
| | 803301 | | | 0.28912961 | -0.81061 | |
| | | | | expected value | -0.52148 | |
| | | | | | | |
| | | | | | | |

# Conditional Probability in Blackjack

a. Conditional probability: what is the probability that the dealer has blackjack, given that a 10-point card is showing?

P(10) 4/51

b. Conditional probability: what is the probability that the dealer has blackjack, given that an ace is showing?

16/51

c. Conditional probability: what is the probability that the dealer has blackjack, given that some other card is showing?

P(bj) = 20/51 0

# Another blackjack response

3. The first possibility is that the dealer has blackjack. This is only possible if one card is an ace and the other card is worth 10 points: a 10, jack, queen, or king. Only one of the dealer's cards is currently visible to the table.
    a. Conditional probability: what is the probability that the dealer has blackjack, given that a 10-point card is showing?

$P(21/10)\ \frac{4}{51}$ .

    b. Conditional probability: what is the probability that the dealer has blackjack, given that an ace is showing?

$P(21/10)\ \frac{16}{51}$ .

    c. Conditional probability: what is the probability that the dealer has blackjack, given that some other card is showing?

$P(21/10)\ \frac{0}{51}$ .

# Who is faster?

Scientists run a series of computer simulations comparing Florence Griffith-Joyner from 1988 and Carmelita Jeter's present-day performance in the 100 meter sprint. After many simulations, they find Griffith-Joyner's record of 10.49 to have a 1% margin of error and Jeter's personal best time of 10.64 has a 0.4% margin of error.

a. Give both runners' estimated times using interval notation.

Joyner:

$10.49 - (10.49)(.01), 10.49 + (10.49)(.01)$

$[10.3851, 10.5949]$

$.004 \times 10.64$

too wide!

Jeter: $10.64 - (10.64)(.4) = [6.384, 14.896]$

b. What can we conclude from this simulation data? Is one runner definitely faster than the other?

We can not conclude who is faster because the data overlaps. Jeter's interval is much broader than Griffith-Joyner's.

# Students' attitudes towards mathematics

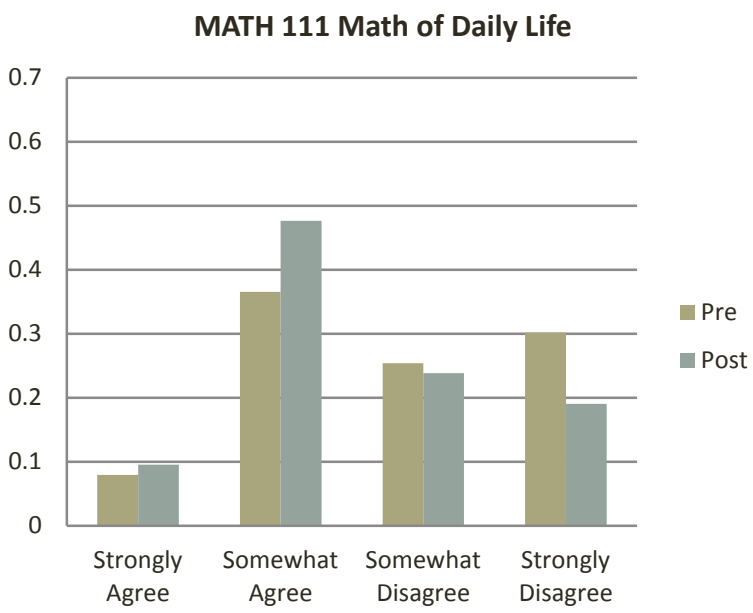
- Attitudinal survey administered to all students in MATH 111 and MATH 112 in Fall 2013.
- Once in September, once in December.
- Items from existing attitudinal instruments, including
  - Fennema & Sherman
  - Dartmouth Mathematics Attitude Survey
- Students responded to 16 statements:

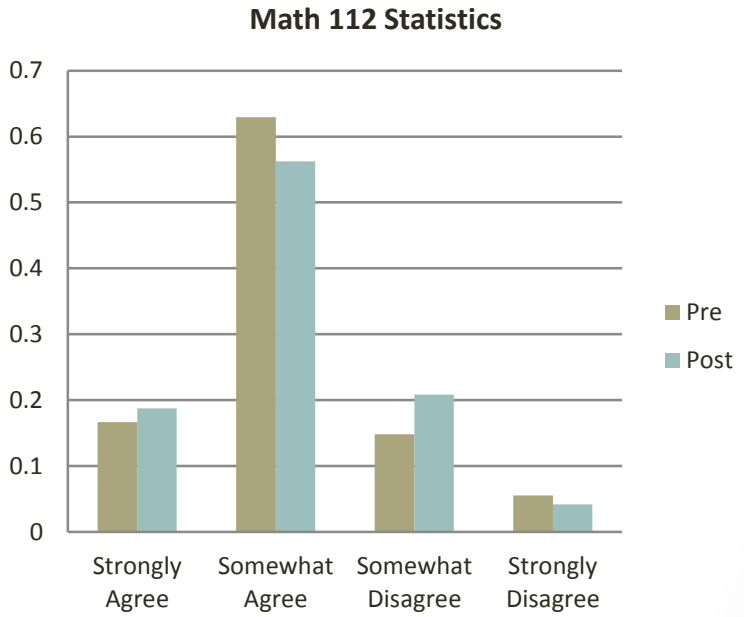
  e.g., "Mathematics is very interesting to me, and I enjoy math courses."

  Strongly agree/Somewhat agree/Somewhat disagree/Strongly disagree

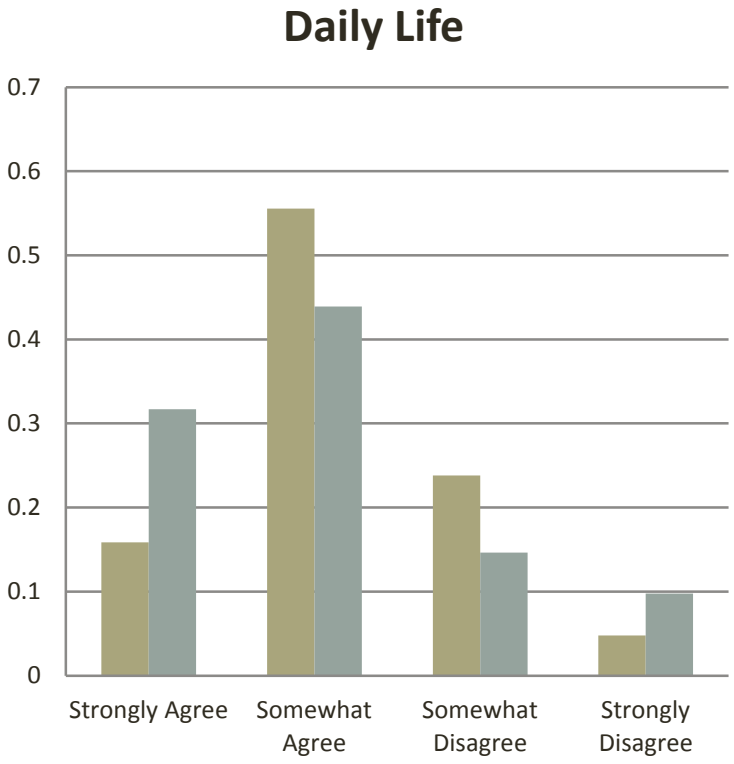
- Some examples…

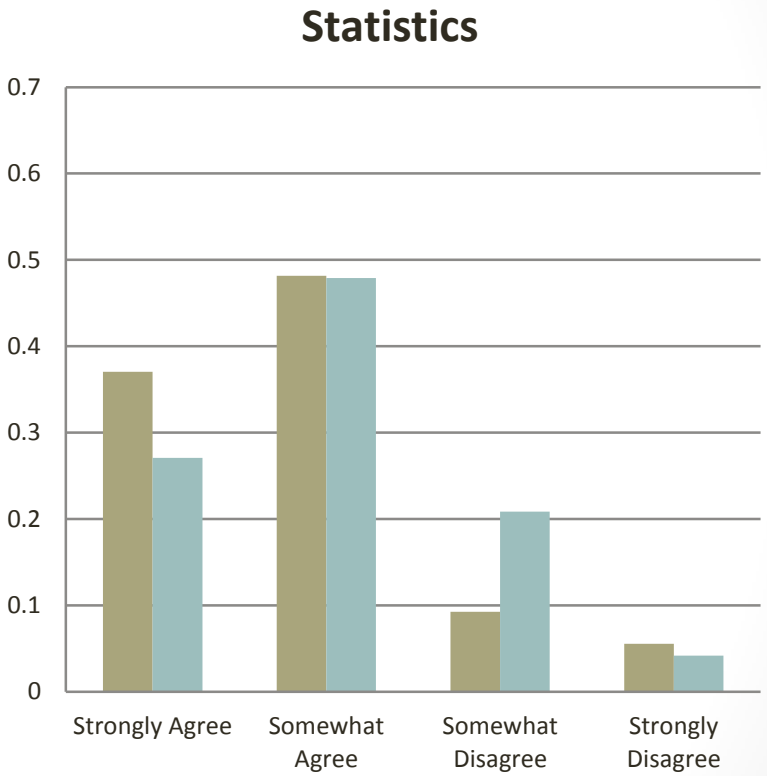
# I like exploring problems using real data and computers.



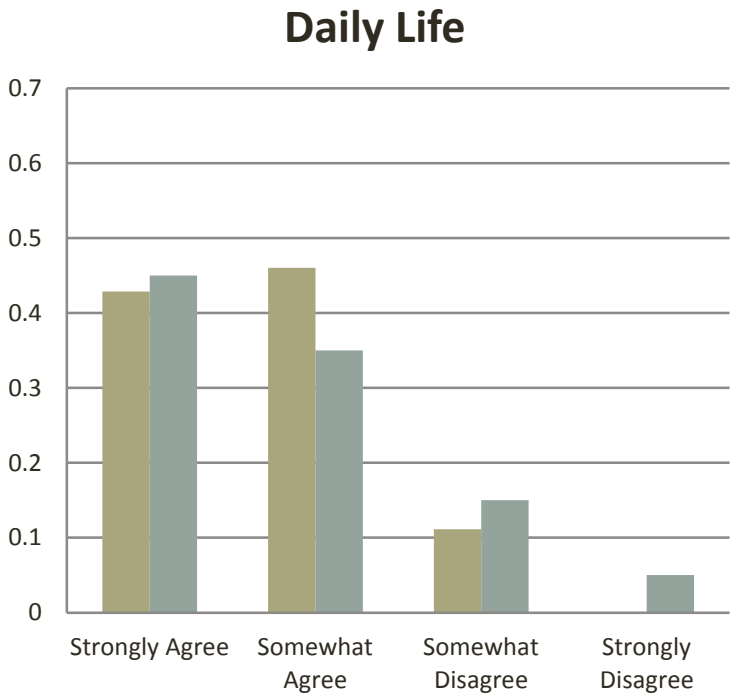



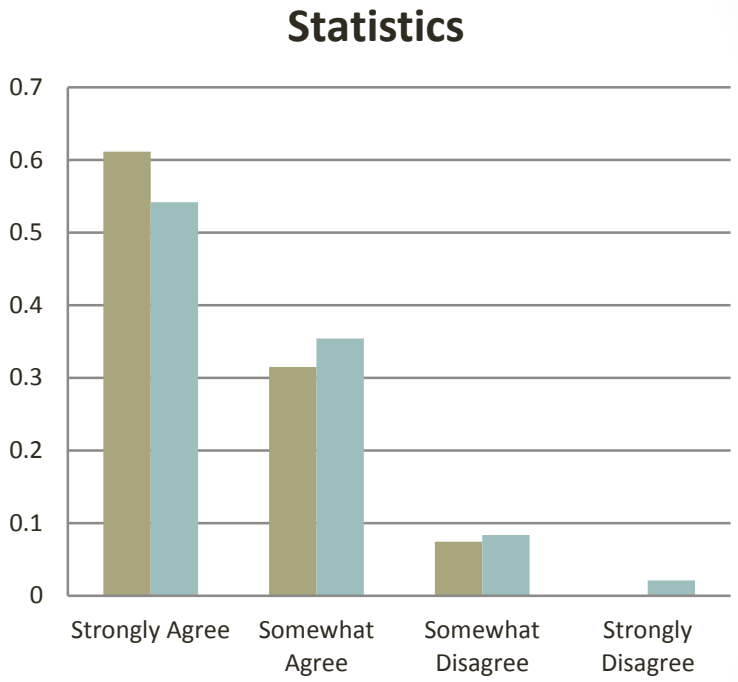
# I am comfortable applying math to real world situations.



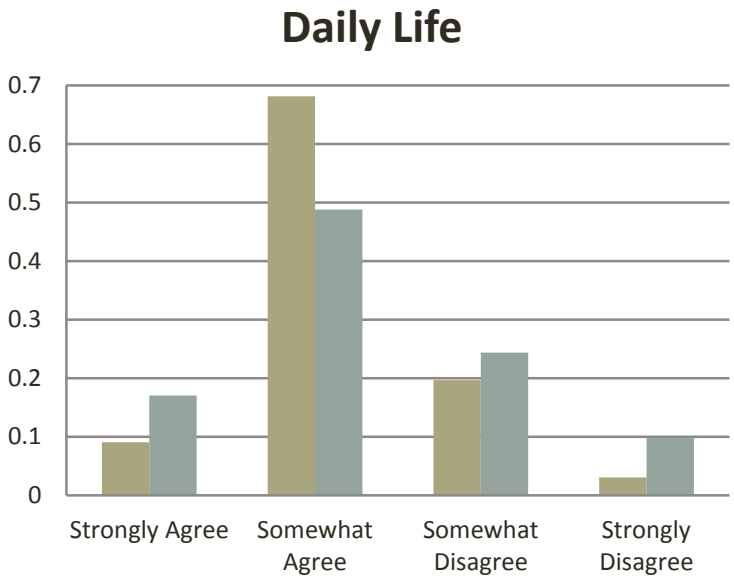



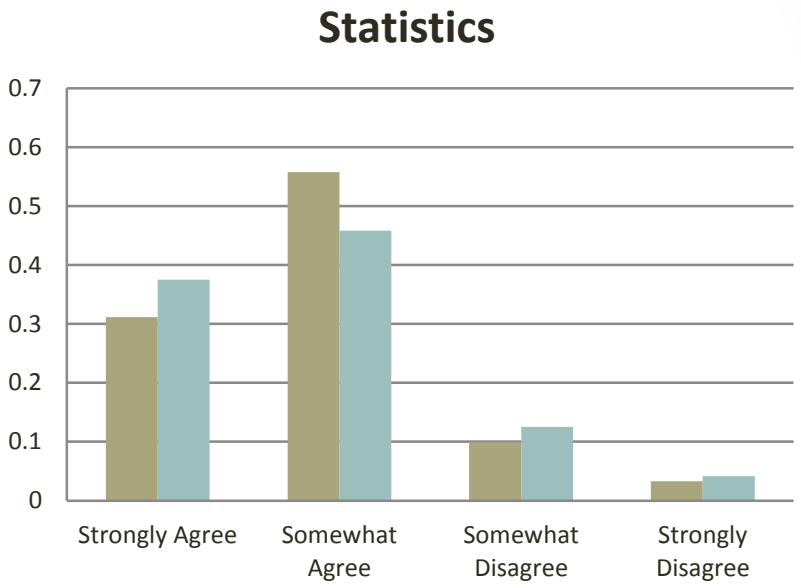
# I believe that mathematics is useful in the real world.



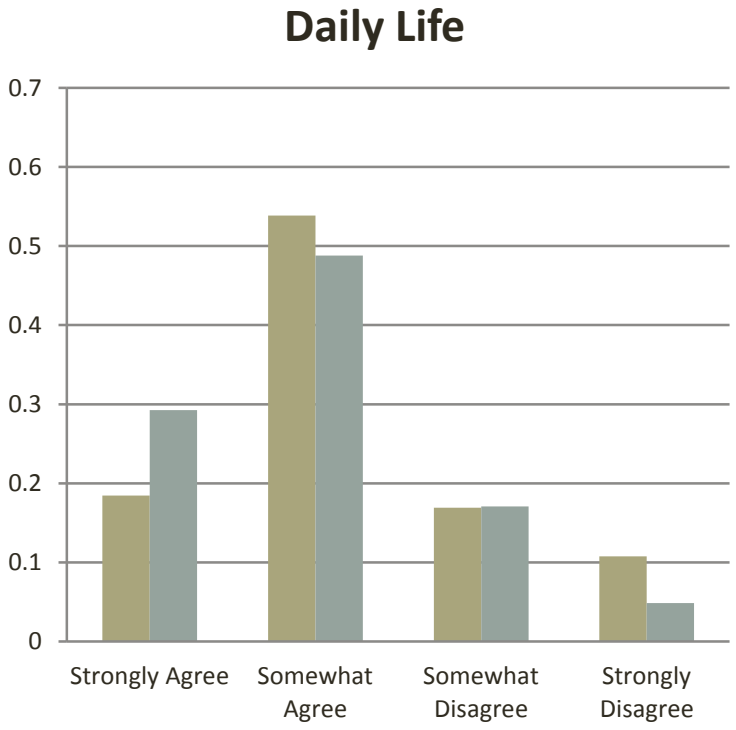



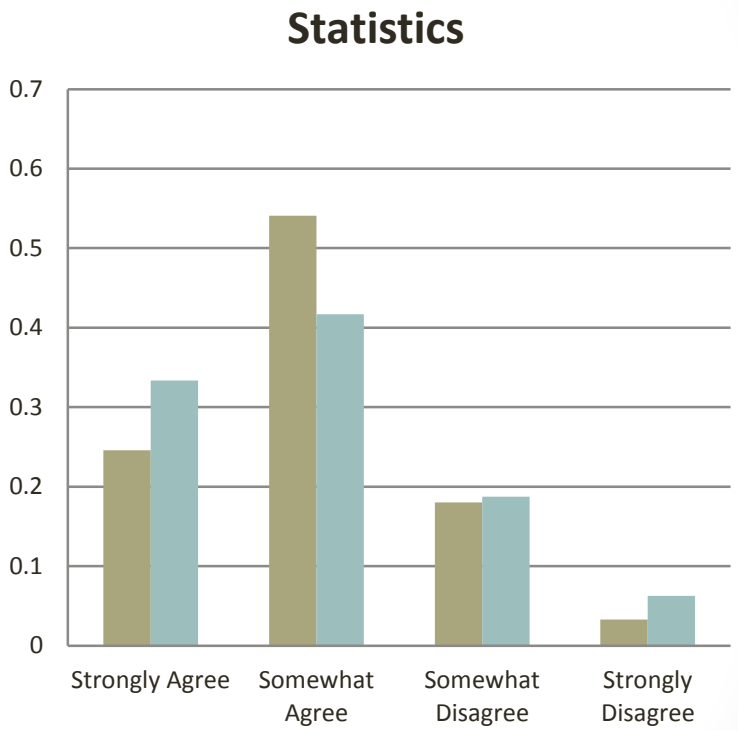
# Technology can make math easier to understand.



# I feel confident in my ability to complete math problems.



# Conclusions

- We are doing a good job of creating assignments that address the learning objectives.
- For the most part, students are meeting those objectives.
- Especially for the attitudes survey, perhaps we should use a different sort of assessment.
- Instructors did not address attitudes explicitly in their classes.
- We need to do a better job of articulating to instructors what evidence to collect.
- Adjunct instructors cannot be expected to put in a lot of time on assessment; we need a clear, streamlined process.
- We will re-examine our learning objectives; perhaps we need to address the use of technology explicitly.

# References, thanks

- National Numeracy Network
- MAA SIGMAA QL
- Fennema-Sherman attitudes survey
- Dartmouth math attitudes survey
- Numerous papers, books, reports about QL