Mathmagical Science: The Development and Validation of a Quantitative Literacy Assessment for Introductory Astronomy Courses

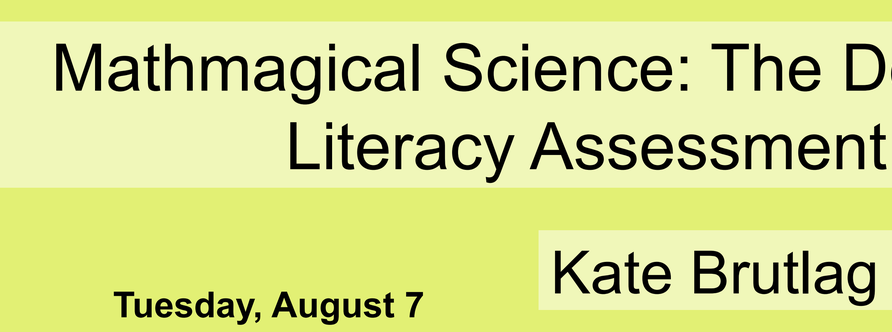
Kate Brutlag Follette and Don McCarthy

University of Arizona
kfollette@as.arizona.edu

Tuesday, August 7
10-11am in Salon H
Panel Discussion
"Does Society Need Numbers? Does Science Education?

Tuesday, August 7
11:15am-12:15pm in Salon H
One Hour Workshop
"ReNumerate: A Wrokshop to Restore Essential Numerical Skills and Thinking via Astronomy Education"

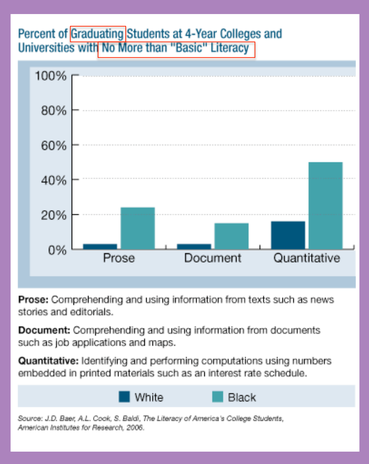
Motivation



And yet…

Table 1. Common mathematical misconceptions encountered frequently in our classrooms.

Operation	Common Incorrect Answer
1 ÷ 5	0.5
0.5=	5%
How many seconds in an hour?	60sec/min + 60min/hr = 120sec
10^{-2}=	20
4.3×10^{0}=	4.3000000

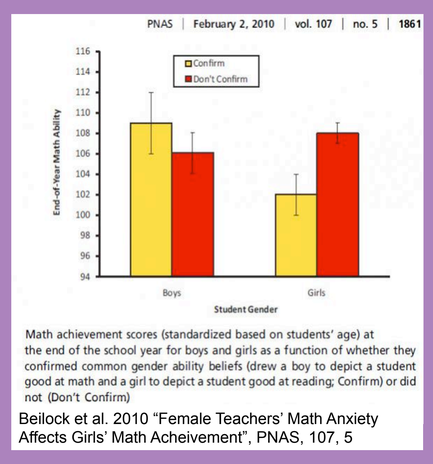


Prose: Comprehending and using information from texts such as news stories and editorials.

Document: Comprehending and using information from documents such as job applications and maps.

Quantitative: Identifying and performing computations using numbers embedded in printed materials such as an interest rate schedule.

Source: J.D. Baer, A.L. Cook, S. Baldi, The Literacy of America's College Students, American Institutes for Research, 2006.



Math achievement scores (standardized based on students' age) at the end of the school year for boys and girls as a function of whether they confirmed common gender ability beliefs (drew a boy to depict a student good at math and a girl to depict a student good at reading; Confirm) or did not (Don't Confirm)

Beilock et al. 2010 "Female Teachers' Math Anxiety Affects Girls' Math Acheivement", PNAS, 107, 5

<u>National Assessment of Adult Literacy (2003) Conclusions</u>

1. **More than 45%** of American adults fell into the lowest two proficiency categories
2. Quantitative proficiency rates declined with age, suggesting that the **numerical proficiency of the US population is declining with time.**
3. Individuals with the highest numerical proficiencies reported **weekly wages 2-3 times highe**r and were **more likely to be employed.**
4. **Minorities, women and the disabled** were more likely to perform in the lowest two levels.

<u>Additional Conclusions from Studies in the Literature</u>

1. Women are more susceptible to math anxiety (Betz 1978)
2. Minorities are more likely to leave college with deficits in numeracy (Raudenbush and Kasim, 2009, Ogbu 1990)
3. Students with learning difficulties are particularly likely to struggle with applied mathematics (Chan and Dally 2001, Rousselle and Noel 2007).

CONCLUSION = Innumeracy is a serious problem in modern society that especially affects traditionally underserved populations

Why is this our job?

"I have always heard a lot about science and math being related, but I have never actually used them together. I have finished an entire year of algebra, but there has never been any science in it. The same holds true in my science class. Frankly, I have never seen any connection between the two of them."

Based on AIP survey: "introductory astronomy enrollments have remained in the 180,000-190,000 range since 2004" (Nicholson and Mulvey, 2010)

+ community colleges, where "an estimated 100,000 students take Astronomy 101 in departments not covered by the AIP survey" (Fraknoi 2001).

Bureau of Labor Statistics: 2.2 million people were enrolled in college in the US in Fall, 2010.

>10% of college students eventually pass through the door of an "Astronomy 101" course in college.

What Do YOU Think?

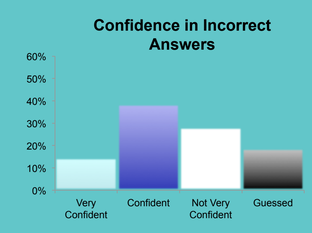
Which numerical skills are the most important to Astronomy?
Which are the most important in dailhy life?

Please complete our 5 minute survey!

Instrument Development

The Key Question:

Can we make positive changes in students' numerical abilities and attitudes through one semester of introductory astronomy for non-majors?



Actual Score ~10% lower than Predicted Score

Fall, 2011

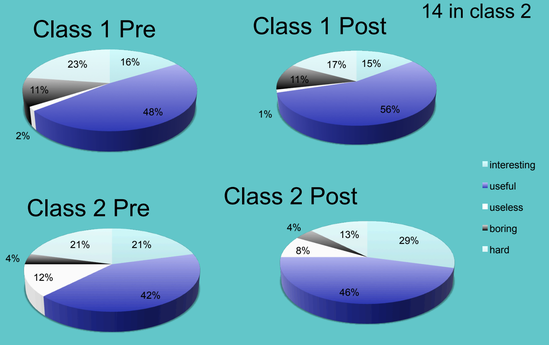
2 classes
1 large (188 students)
1 small (26 students)

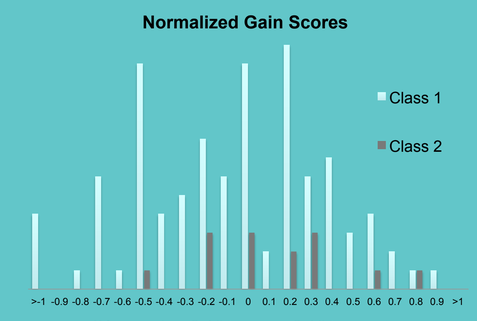
Inclusion Criteria:
Completed both
18+ years
Spent ≥10min on both

Leaves ~55%:
102 in class 1
14 in class 2

"the most interesting thing that I have learned in this class, by far, is how small we are compared to the universe. I think that everybody knows there is a lot of space out there, but UNTIL YOU SIT DOWN AND DO SOME MATH ABOUT IT you can't get an idea of how insignificant we are"
-Astro 101 Student #1

"I most enjoyed the use of math in this class. I knew science is based on math, but it really set in after this class"
-Astro 101 Student #2





Class 1 : 64% pre, 64% post
Class 2: 68% pre, 73% post

Spring, 2012

- 6 classes
  - 4 small (25-35)
  - 1 large (100)
  - 1 very large (800+)
- 1000+ students
- Large research university + community college

Results TBD

How you can help

Please contact us if you would be willing to administer the survey to your class or would like to consult on survey development/verification

For More Information

Visit our website: katefollette.com/QL

- Links to More Information
- Access to our Instrument
- Quantitative Think-Pair-Share Question Database
- Quantitative Intro Astronomy Labs
- Skill Development Worksheets

Takeaways

- Many Americans leave college with significant lingering deficits in numerical skills.
  - -especially women, minorities and the learning disabled
- Cross-curricular application of numerical skills is likely the only way to convince students of their usefulness.
  - *"Math is only useful to pass a test in math class."* (anonymous Honor student)
- Introductory science classes for non-majors may be the last opportunity for many students to experience applied mathematics in context.
- Because of its broad appeal and large enrollment numbers, Introductory Astronomy is an important place to emphasize numerical skills.
- YOU may be your students' last chance to appreciate the role of arithmetic in science and the importance of quantitative thinking in their roles as consumers, voters, citizens, parents and <u>future educators</u>!
- **JOIN US** to help understand and solve this problem.