



Carnegie Foundation
for the Advancement of Teaching

Unlocking the Mathematical Gate: Using Our Collective Findings for Greatest Impact

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The Problem

60-70%

Students assigned to developmental math course.

80%

Percent of these students that never get past this gate.

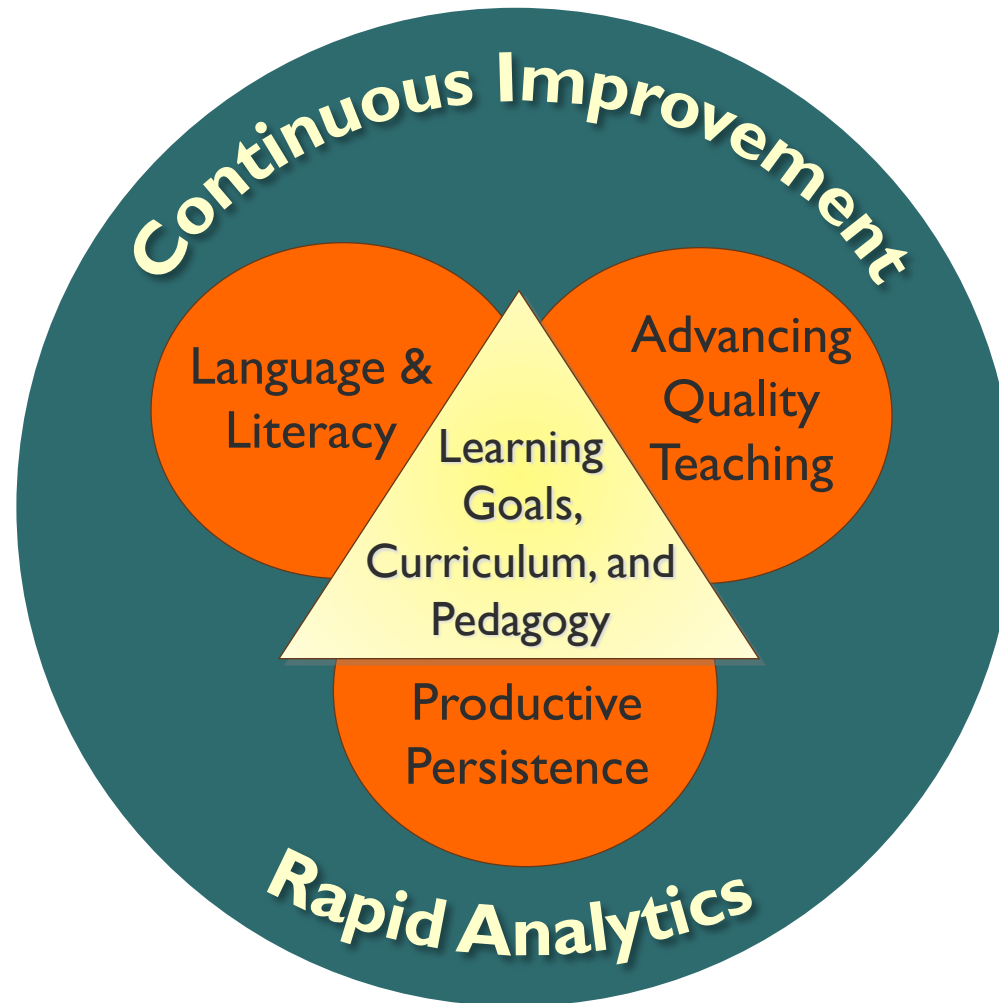
**500,000
students**

in every cohort will never complete college math requirement.

If we continue to do what we have always done, we will continue to get what we have always gotten.



The Improvement Drivers for Success



HOW

Increase the percentage of Developmental Math students achieving college math credit within one year of continuous enrollment

Institutional Structures & Leadership

Instructional System

Productive Persistence

Language and Literacy

Advancing Quality Teaching

HOW Networked Improvement Communities



Networked Improvement Communities (NICs)

Power of networks

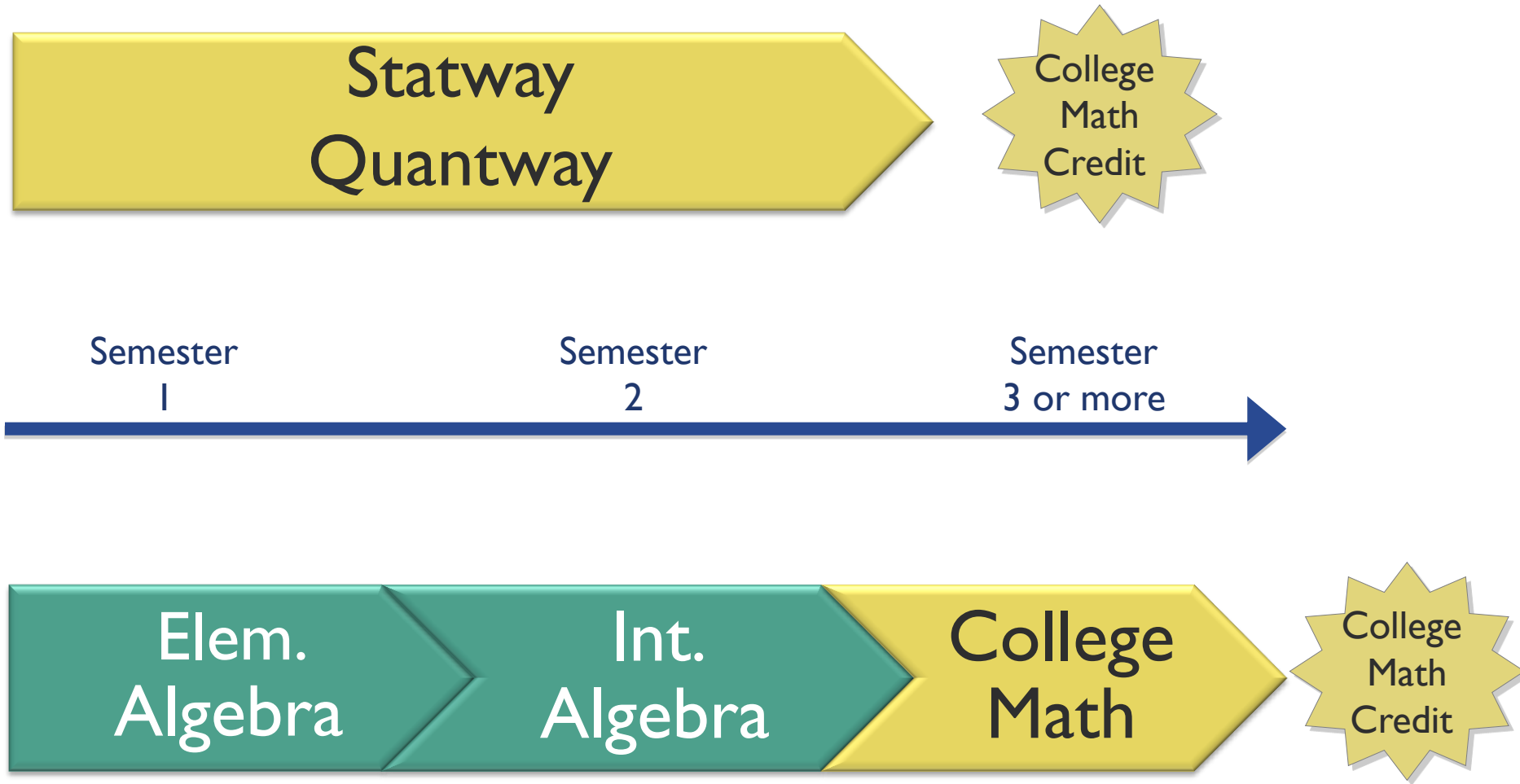
- Distributed learning
- Wisdom of crowds

“You can’t
improve at scale
what you cannot
measure”

Improvement methodologies

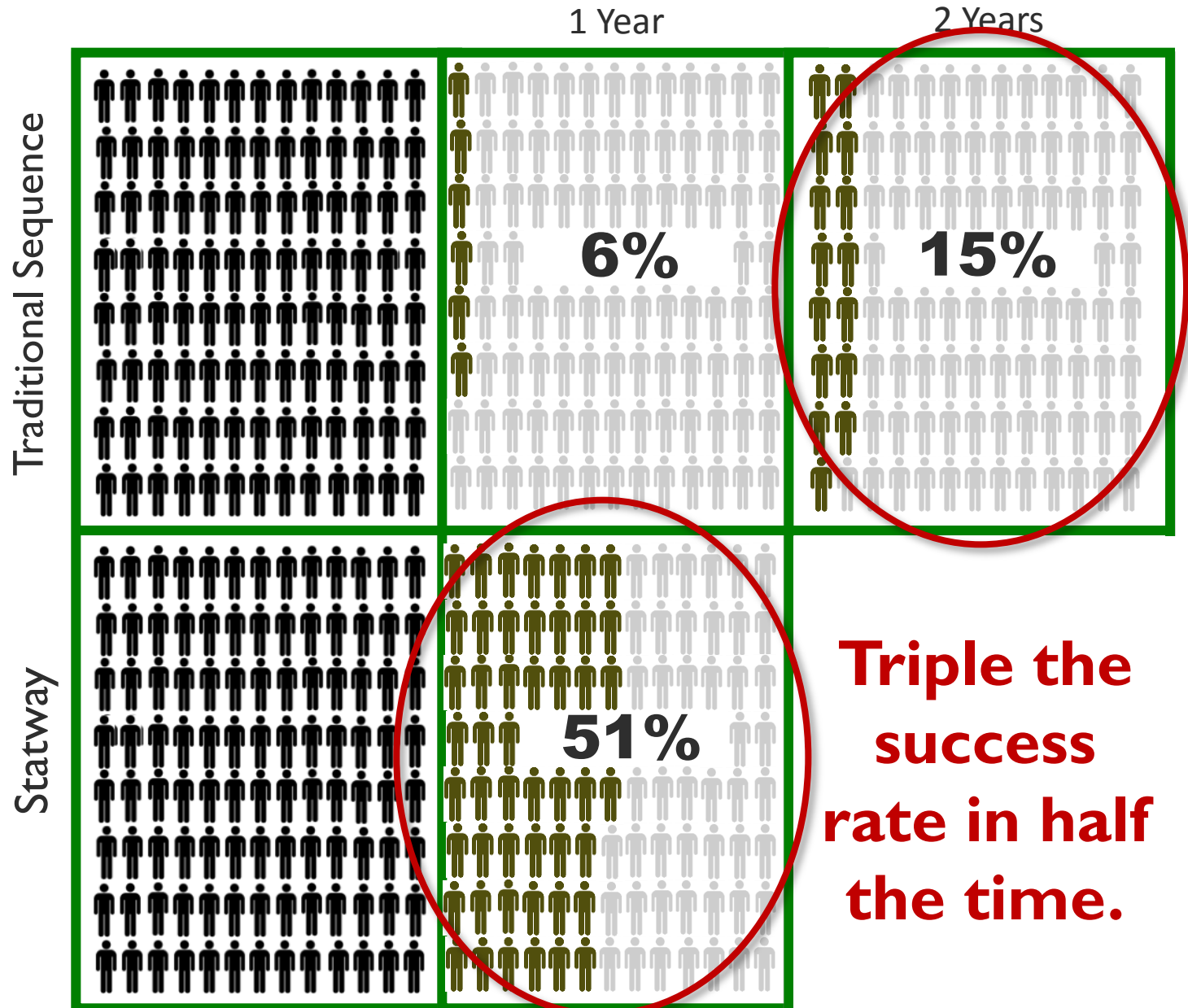
- (1) What are we trying to accomplish?
- (2) What changes are likely to result in improvement?
- (3) How will we know a change is an improvement?

A Solution: Coherent, Intensive Learning Pathways



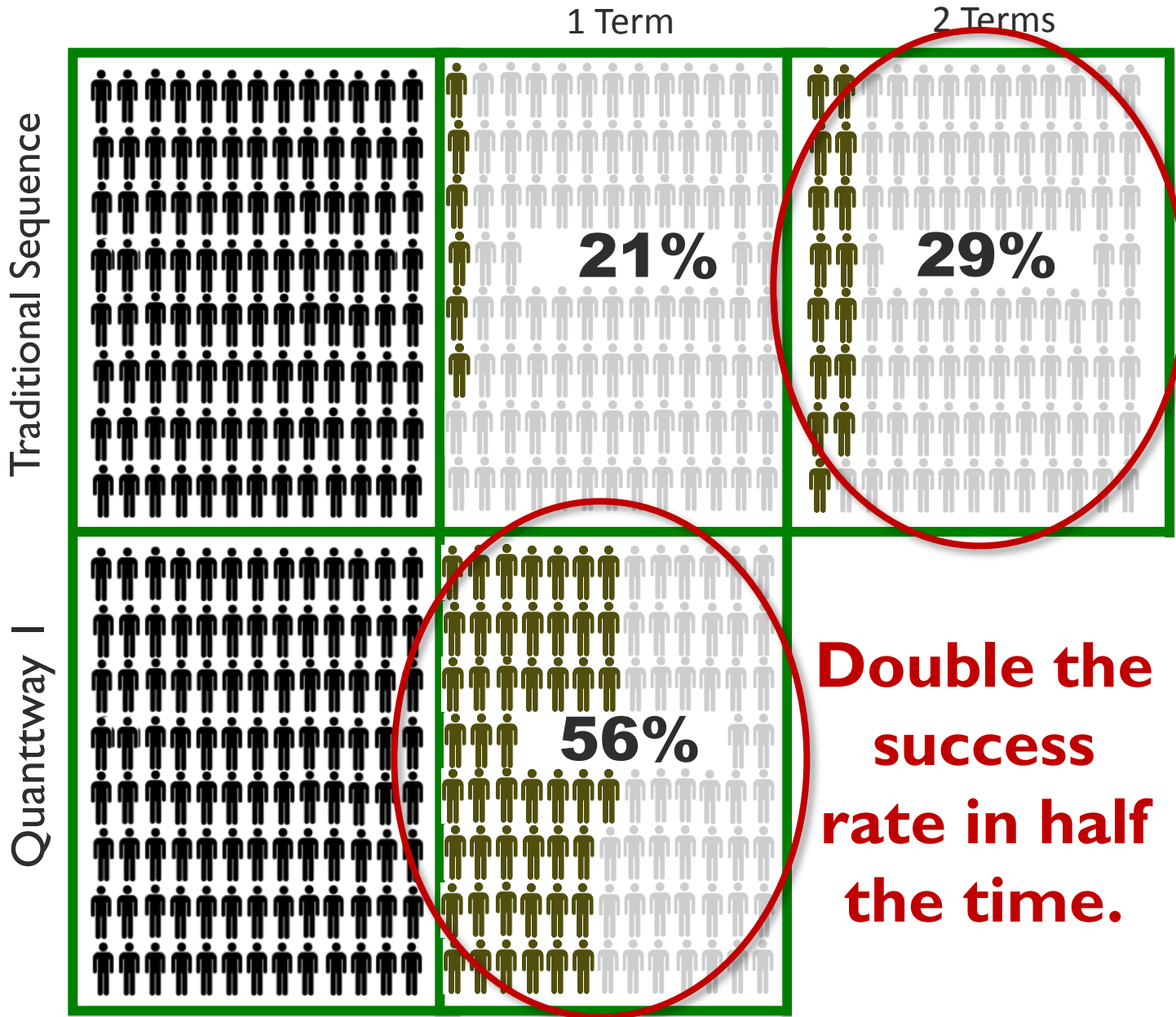
What Colleges Traditionally Have Done

Statway: Time to Complete a College Level Math Course

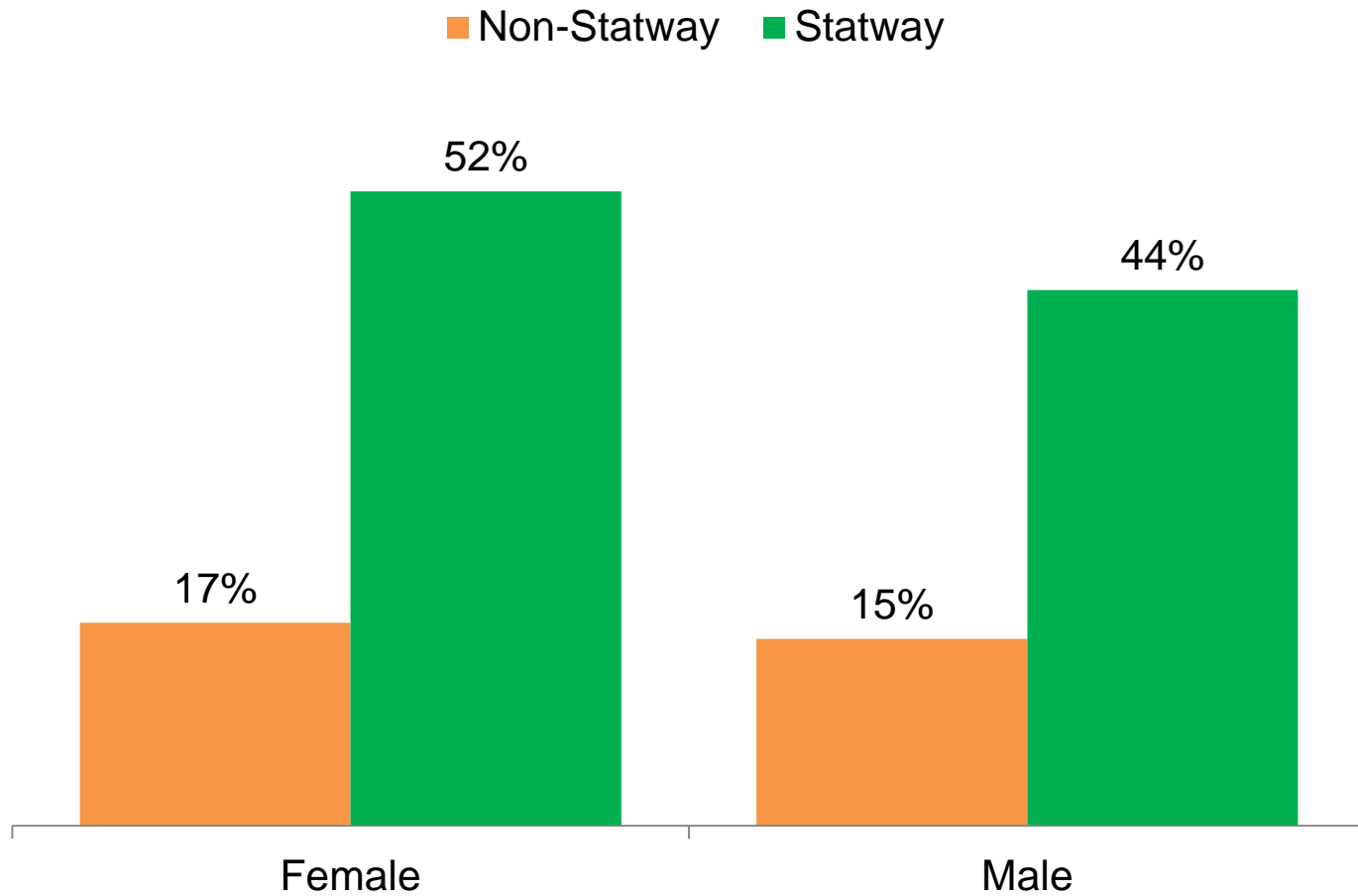


Triple the success rate in half the time.

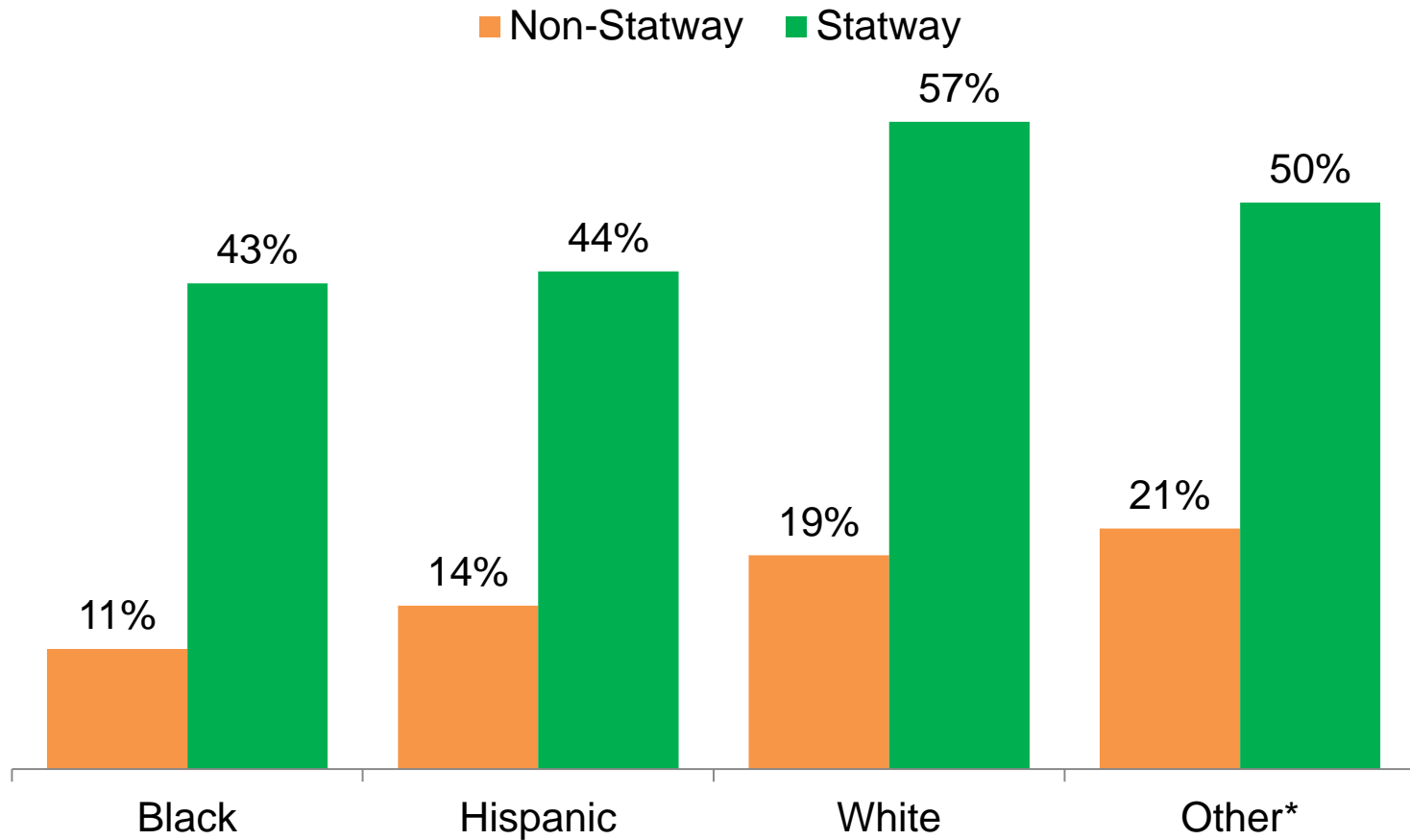
Quantway: Time to Complete Developmental Sequence



Success Rate – Gender

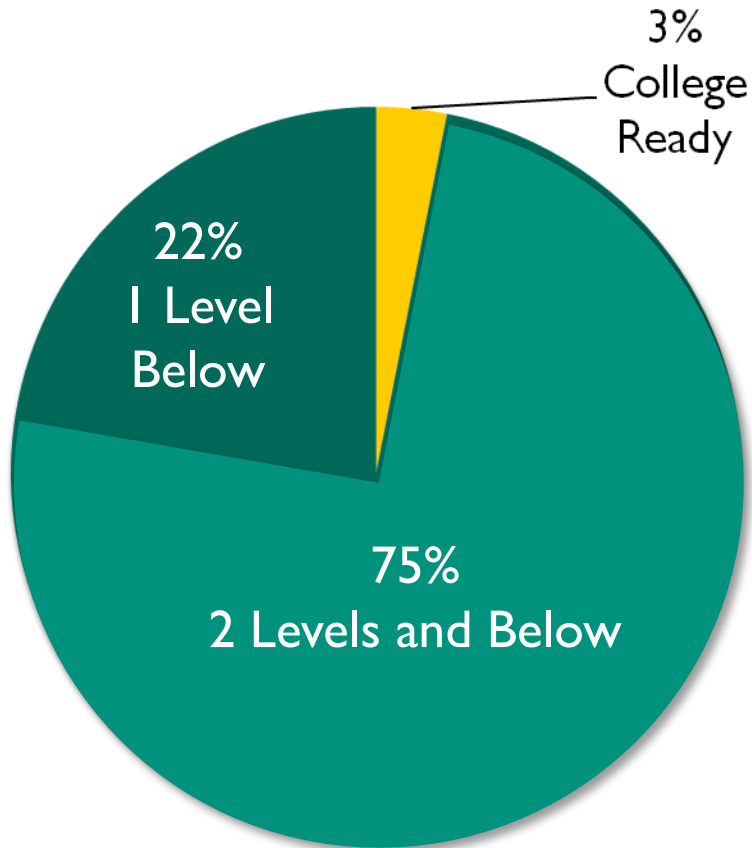


Success Rate – Gender and Race/Ethnicity

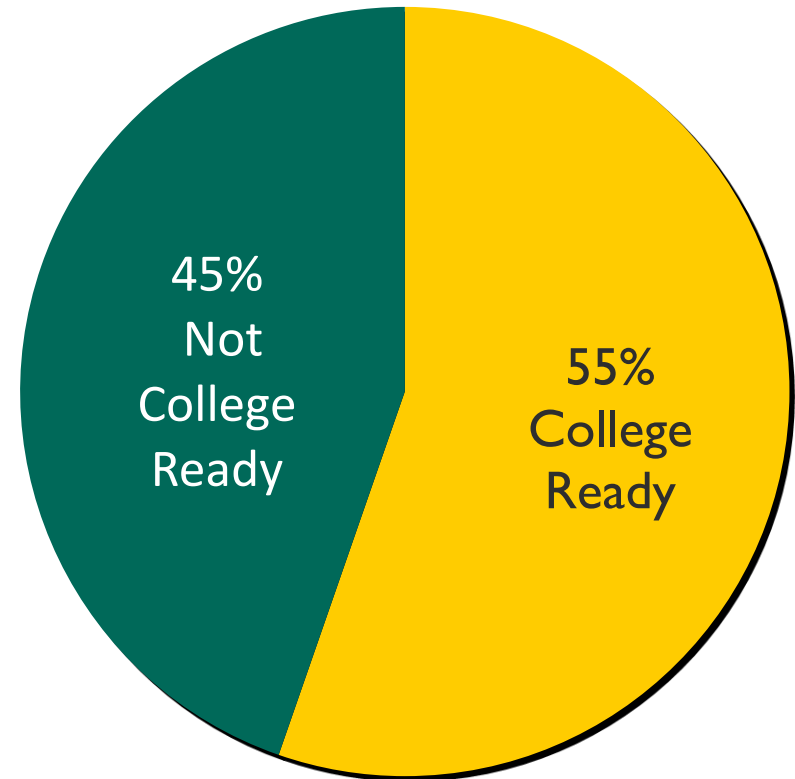


Who Are Pathways Students?

College Readiness: Math

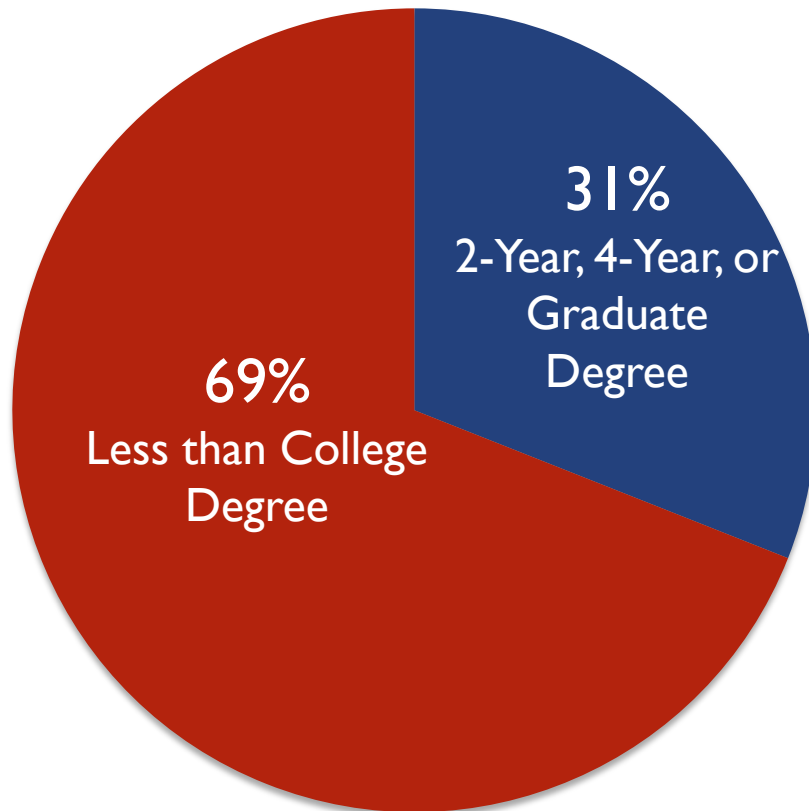


College Readiness: Reading

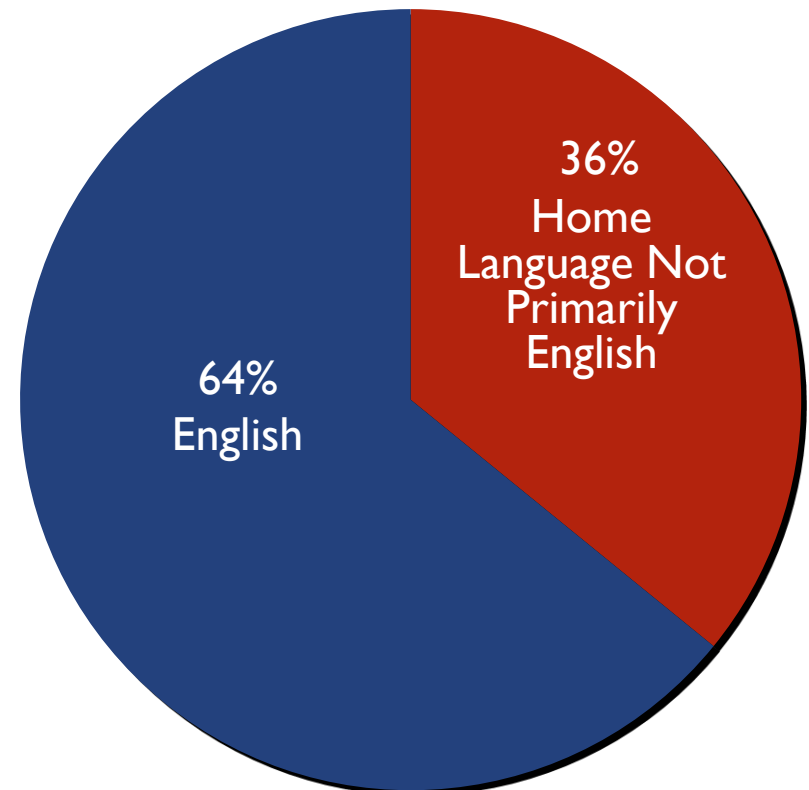


Who Are Pathways Students?

Maternal Education



Home Language



Productive Persistence At Risk Indicator

Key indicator variables:*

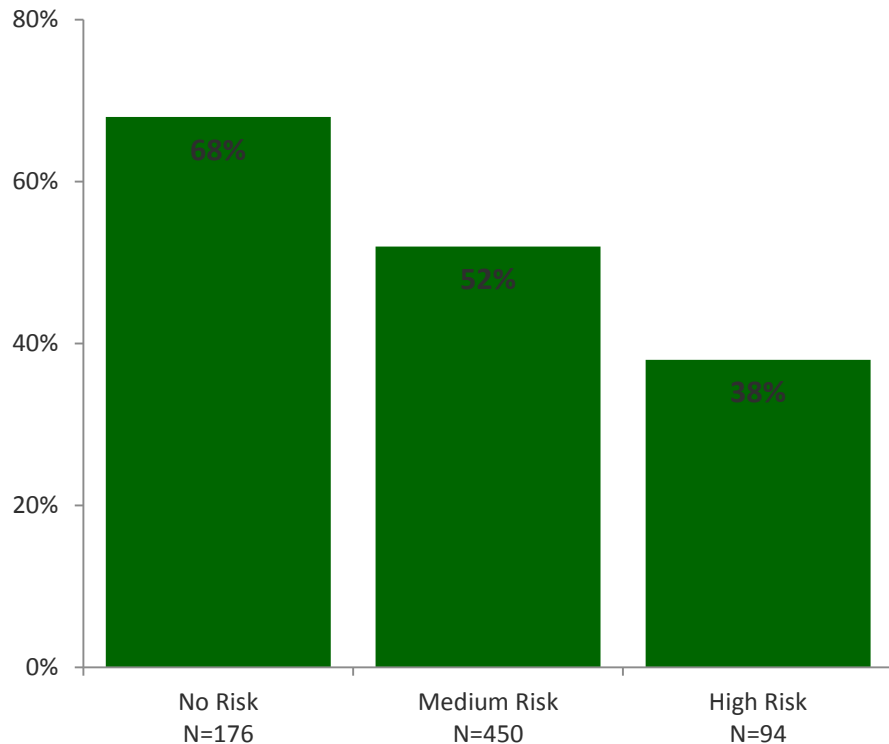
1. Math/ statistics anxiety
2. Fixed mindset
3. Belonging uncertainty
4. Stereotype threat
5. Grit

* Each scored (0/1 for presence of risk)

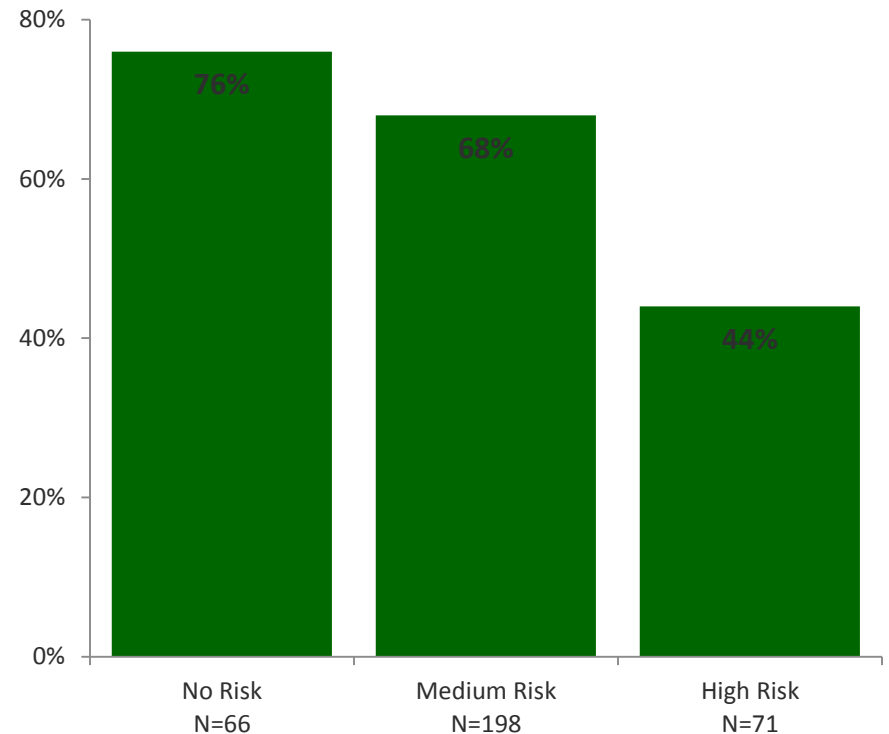
Risk Level	Number of Risk Factors
No risk	0
Medium risk	1 or 2
High risk	3, 4 or 5

Productive Persistence At Risk Indicator

Percentage Passing Common Assessment Statway

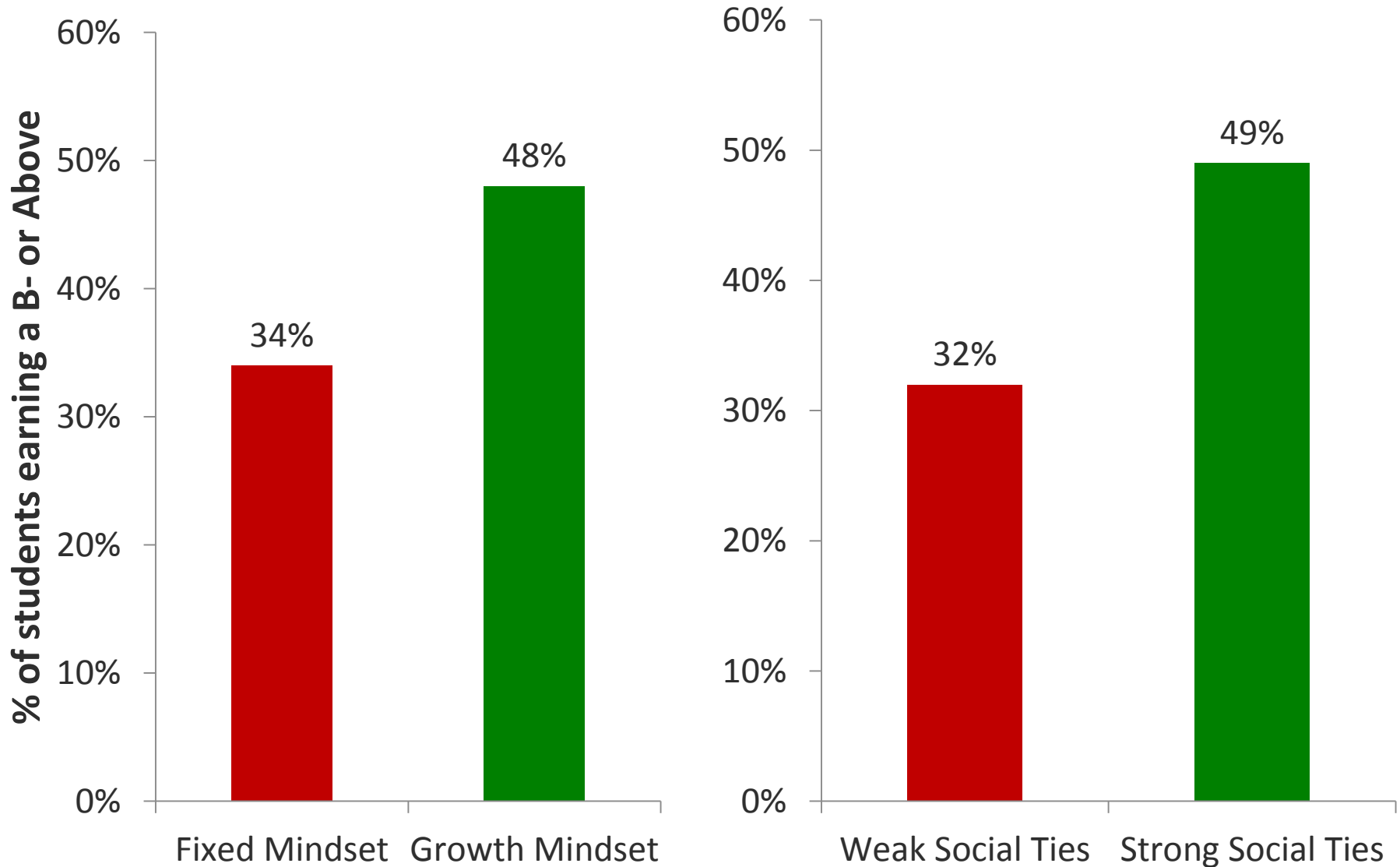


Percentage Passing Common Assessment Quantway



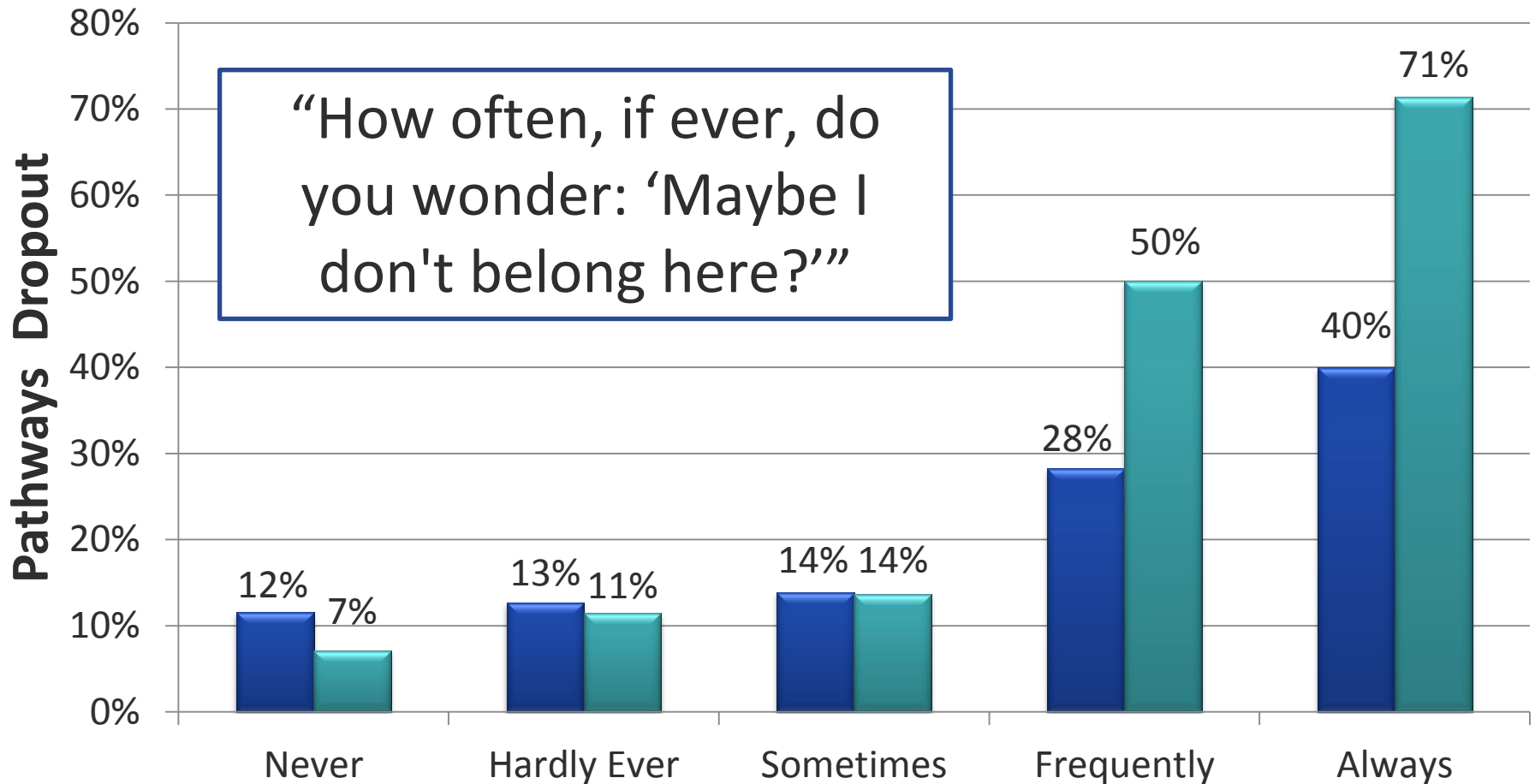
•Passing the first term common assessment defined as earning a 60% or above

Mindsets and Social Ties (Both Pathways)



Connections to Stereotype Threat

■ All students ■ Black students



“How often, if ever, do you wonder: ‘Maybe I don't belong here?’”

N = 714 math students

Discussion Question

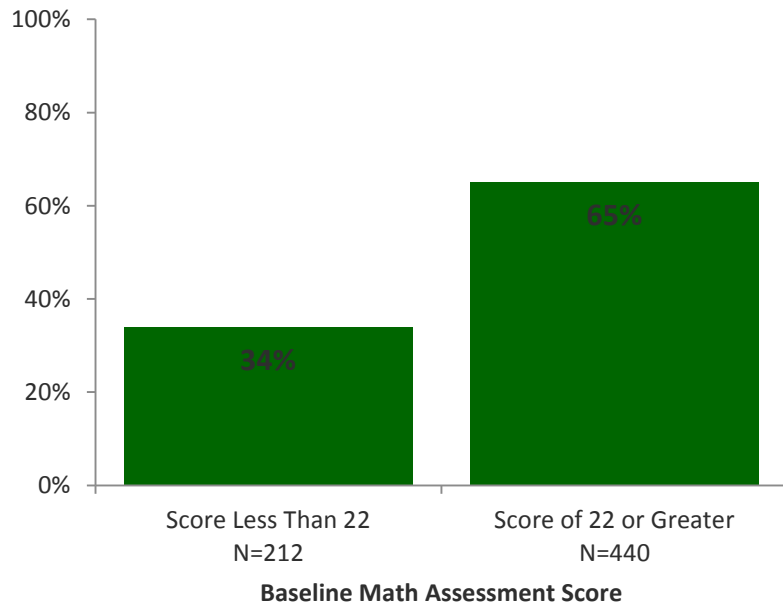
- Suppose you are designing a mathematics course that seeks to address psychological barriers that inhibit meaningful mathematical engagement. What *strategies* or *interventions* would you incorporate into the course?

Productive Persistence

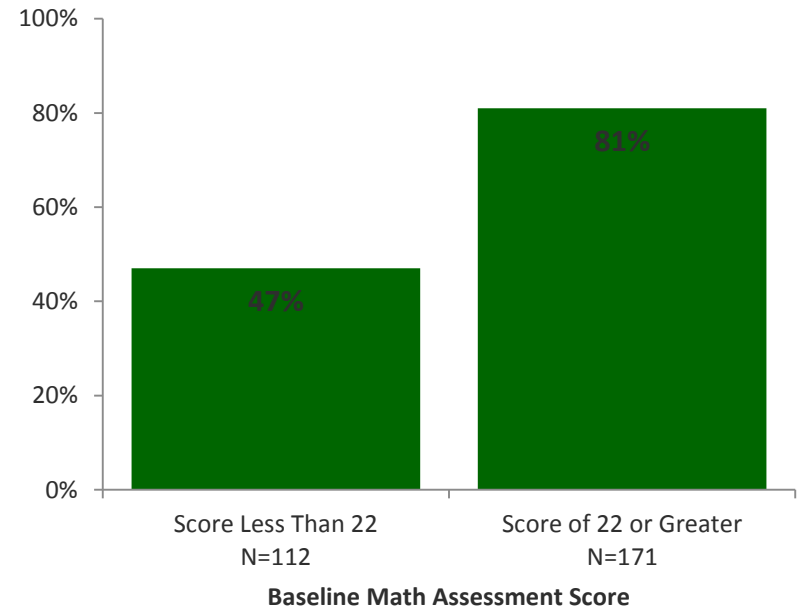
- **Aim:** Students develop *tenacity* and *strategies* to persist despite challenges
 - Students develop the skills, habits, and know-how to succeed in college setting
 - Students feel socially tied to peers, college, and the course
 - Students believe the course has value
 - Students believe they are capable of learning math
 - Faculty & college support students skills and mindsets

Baseline Math Knowledge

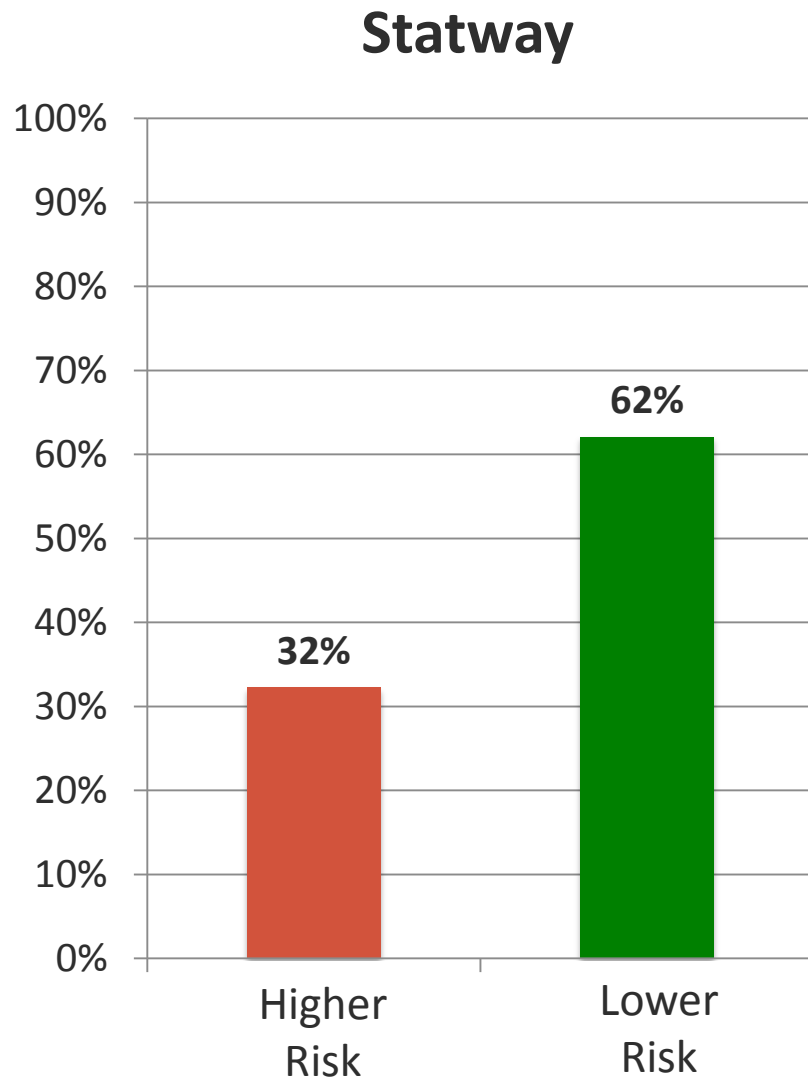
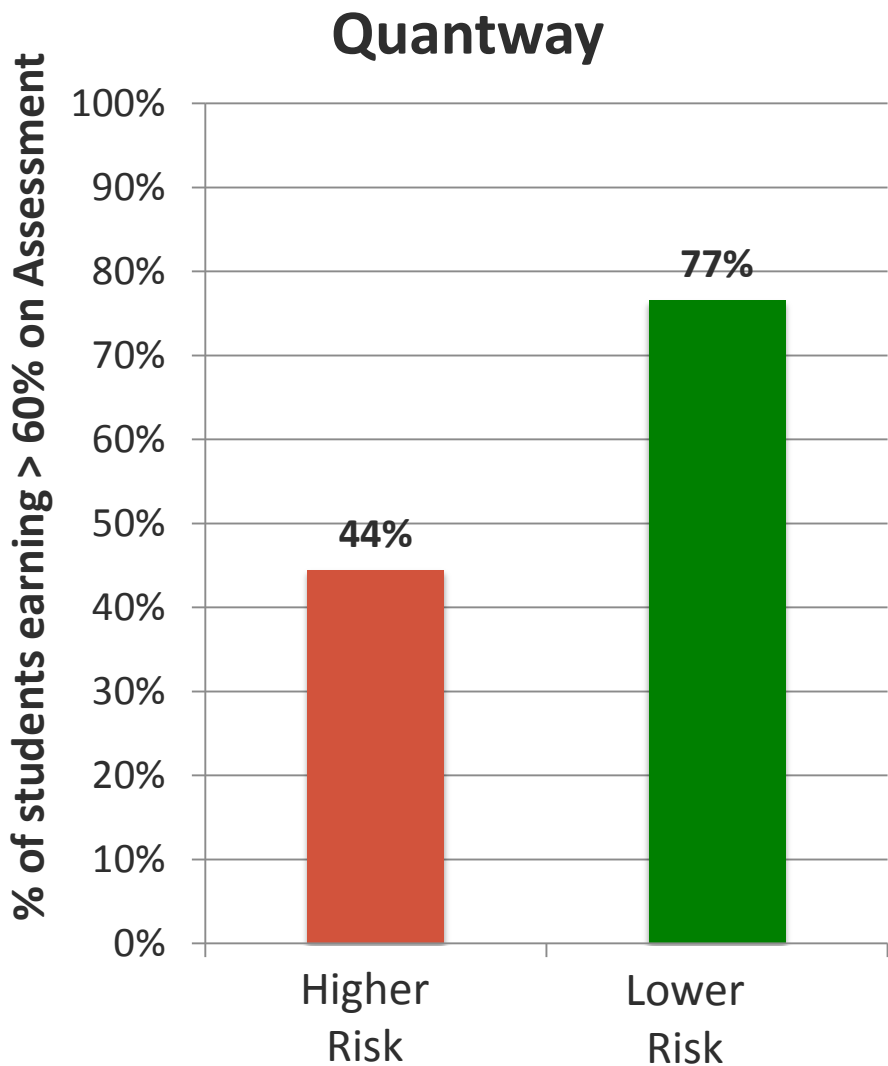
Passing Statway Common Assessment



Passing Quantway Common Assessment



- Maximum baseline math assessment score is 42
- Passing the first term common assessment defined as earning a 60% or above



Math Conceptual Background

WHERE WE ARE NOW, 2013-14



Student Voices

<http://vimeo.com/59423729>

The Roadmap to Success

- Student will *struggle* with important mathematics
- Make *explicit connections* to mathematical concepts
- Use *deliberate practice* by applying concepts and procedures in order to solve problems

Curriculum

- Online component
- Instructor & student in-class lessons
- Homework
- Online faculty resource site
- Assessments

Quantway™

Summative Assessment



CFAT SW Spring 2012

Quantway™ Instructor's Notes
Lesson 3.1: The Cost of Driving, Part 1
Theme: Personal Finance

Checkpoint Module 7

Question 1

Statway™ Module 2 ASSESSMENT ITEMS version 2.0

Prerequisite Assumptions

Before beginning this lesson, students should:

- be able to multiply two fractions
- be able to divide two fractions
- understand that a fraction's numerator and denominator represent a ratio
- be familiar with basic unit conversions.

Specific Objectives

Students will understand that:

- the units found in a solution that is, factors are positive and negative
- units provide meaning to a calculation

Students will be able to:

- write a rate as a fraction
- use a unit factor to simplify a calculation
- use dimensional analysis to convert units

Explicit Connections

- Canceling units is based on the concept of canceling out common factors in a fraction.

Quantway™
Lesson Theme
Making Connections
(1) Why
(i) /
(ii) /
(iii) /
(iv) /
(v) /
(2) Desc
spec
Develo
(3) The
/
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Part I: Multiple-Choice Items

Remember to UNBOLD the answer before you copy and paste it to any assessment. In most cases, the broad course outcome is followed by finer grained measurable outcomes in blue.

2.1.10 Given a univariate data set, select an appropriate graphical display for summarizing the data based on the type of data and the purpose of the analysis.

1. Josephine is a baseball fan who likes to keep track of statistics for the local high school baseball team. One of the statistics she recorded is Batting Average. A player's batting average is the proportion of hits obtained by the player based on the number of times at bat as shown in the table below.

Player	Proportion of hits	Player	Proportion of hits	Player	Proportion of hits
BH	0.305	SU	0.270	BC	0.301
HA	0.229	DH	0.136	AA	0.143
JS	0.281	TO	0.218	HK	0.341
TC	0.097	RL	0.267	RS	0.261
MM	0.167	JB	0.270	CR	0.115
GV	0.333	WG	0.054	MD	0.125
RC	0.085	MH	0.108		

Using this data, we want to create a graphical display that allows Josephine to describe the shape, center, and spread of the proportion of hits. Choose the graph that will help Josephine give the best description of center, shape, and spread.

1. If you have 30 students in your math class and 1/6 of them were out sick with the flu on the same class day, there are numerous ways to calculate how many students were left in class that day. Which of the following choices is **not** a correct method?

- a. $30 - \frac{1}{6} \times 30$
- b. $(30 + 6) \times 5$
- c. $5 \times 30 + 6$
- d. $\frac{5}{6} \times 30$

A taxi company has just opened in your city. The owners must decide how much they will charge a customer for a ride. This charge is called a fare. They decide to calculate fares using the following formula: $F = 2.50 + 2.00m + 1.50p$ where F is the total fare, m is the number of miles traveled and p is the number of passengers over the first person. For example, if there are three passengers riding in the taxi, p would equal 2. Solve for the number of miles, m .

$$\begin{aligned}
 F &= 2.50 + 2.00m + 1.50p \\
 2.00m &= F - 2.50 - 1.50p \\
 m &= \frac{F - 2.50 - 1.50p}{2.00} \\
 m &= \frac{F - p}{2.00} \\
 m &= F - 2.50 - 1.50p \div 2.00 \\
 m &= F - 1.25 - 1.5p \\
 m &= F - \frac{2.50 - 1.50p}{2.00}
 \end{aligned}$$

Student Review

- 1.1-9 Student Review Word - 7/15/12
- 1.1-9 Student Review PDF - 7/15/12

Assessment

- 1.1-9 Assessment v1.5 Word - 8/3/12
- 1.1-9 Assessment v1.5 PDF - 8/3/12

Module 2

Module 3



Statway Learning Outcomes

- AMA, AMATYC, CAUSE, MAA, ASA

- Students will understand the data analysis process and the well-designed **statistical studies**
- Students will demonstrate the use of **distributional thinking** to reason about data in order to describe trends and patterns, judge a fit of a model to distribution, and describe similarities and differences in comparing distributions.
- Students will demonstrate an ability to use appropriate statistical evidence to **reason** about population characteristics and experimental treatment effects.
- **Mathematics** – numeracy, proportional reasoning, algebraic reasoning, functions

Comparative Concepts

Statistical Computation

Calculate the standard deviation of the following ten numbers:

\$3.58

\$5.12

\$10.25

\$31.18

\$6.75

....

Statway™ Evaluation

A college statistics class conducted a survey of how students spend their money. They asked 25 students to estimate how much money they typically spend each week on fast food. They determined that the mean amount spent on fast food is \$31.52 with a standard deviation of \$21.60. Later they realized that a value entered as \$3 should have been \$30. They recalculate the mean and standard deviation. The mean is now \$32.60. Which of the following is true about the standard deviation?

1. The standard deviation will increase, because we have increased the value of a data point.
2. The standard deviation will stay the same, because the standard deviation is not affected by a change in a single measurement.
3. The standard deviation will decrease, because this change moved a data point closer to the mean.

Productive Struggle

Can a person's birthday determine his or her personality traits, like being kind or jealous?

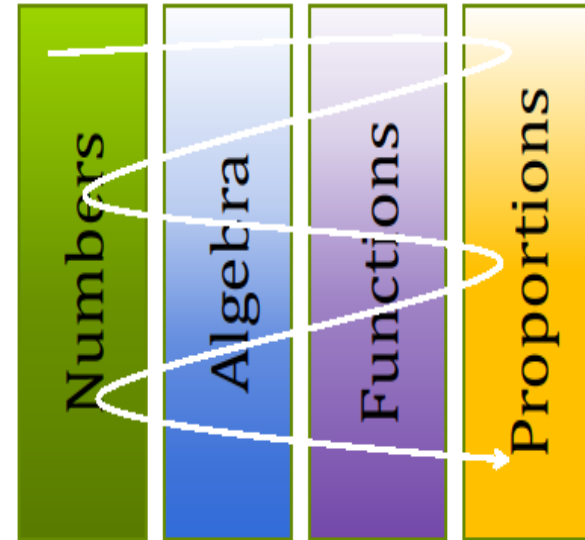
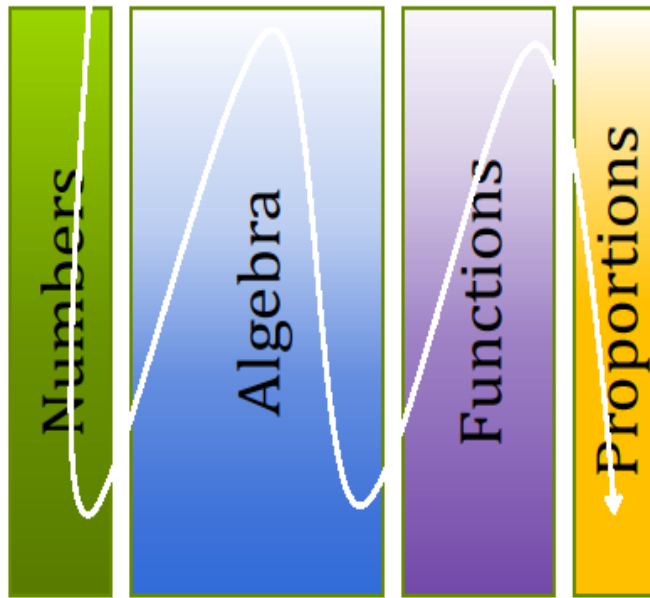
Dates of Zodiac Sign	Choice 1		Choice 2		Choice 3	
	Strengths	Weaknesses	Strengths	Weaknesses	Strengths	Weaknesses
3/21 to 4/20	Adventurous Energetic Pioneering Courageous Enthusiastic Confident Dynamic Quick-witted	Selfish Quick-tempered Impulsive Impatient Foolhardy Daredevil	Adaptable Versatile Communicative Witty Intellectual Eloquent Youthful Lively	Nervous Tense Superficial Inconsistent Cunning Inquisitive	Optimistic Freedom-loving Jovial Good-humored Honest Straightforward Intellectual Philosophical	Blindly optimistic Careless Irresponsible Superficial Tactless Restless
4/21 to 5/21	Modest Shy Meticulous Reliable Practical Diligent Intelligent Analytical	Fussy A worrier Overcritical Harsh Perfectionist Conservative	Patient Reliable Warmhearted Loving Persistent Determined Placid Security-loving	Jealous Possessive Resentful Inflexible Self-indulgent Greedy	Adventurous Energetic Pioneering Courageous Enthusiastic Confident Dynamic Quick-witted	Selfish Quick-tempered Impulsive Impatient Foolhardy Daredevil

Quantway Learning Outcomes

- NNN, AMATYC, SIGMAA-QL, MAA

- Multiple Literacies
- Numerical Skills
- Proportional Reasoning
- Mathematical Modeling
- Statistical Thinking

Traditional vs. Quantway Approach



Undercurrent of geometry, statistics,
student success, mathematical success

Comparative Concepts

Algebraic Evaluation

Evaluate:

$3x - 5$ when $x=4$

Quantway™ Evaluation

The formula for the braking distance of a car is

$$d = \frac{V_0^2}{2g(f + G)}$$

1. Let $f = 0.8$ and $G = 0.05$. Write a simplified form of the formula using these values for the two variables.
2. How can you verify your predictions about the relationship between velocity and braking distance?

Comparative Concepts

Traditional

Find the equation of the line passing through the points

$$(2,-4) \quad \text{and} \quad (-3,7).$$

Write the equation in slope-intercept form.

Quantway

You want to have your own phone and need to decide which option costs less. Note that the descriptions of these options are examples of verbal representations of the mathematical relationships.

- **Per-Minute Pricing:** There is a monthly fee of \$15.99 plus \$0.13 per minute.
- **Unlimited Plan:** The plan costs \$39.99 per month. The phone is free and unlimited minutes of talk time are included, but a two-year contract is required.

Find linear models to help you decide.

Leveling the Playing Field

- Given the right opportunities and supports, prompts and encouragements developmental math students can perform as well as other students

Discussion Question

- In order for reform efforts like the Pathways to scale, a large number of faculty must be prepared to teach a new curriculum using new and unique pedagogical models. How can schools and colleges incentivize and support professional development for faculty?

Improvement Priorities

Institutional Structures

Scaling Impact Subnetwork

Bridge to Pre-Calculus

Instructional System

Targeted Math Supports Subnetwork

Productive Persistence

Mindsets and Social Ties Subnetwork

Language and Literacy

Advancing Teaching

Increase the percentage of Developmental Math students achieving college math credit within one year of continuous enrollment

Scaling Within Colleges

SW and QW are the default pathway. At least 25% of a college's dev math students enroll in the Pathways.

Program articulates internally and externally

Advisors informed, motivated and empowered

Leaders create sustained, aligned commitment throughout organization

Adjunct faculty are prepared to teach the Pathways

The Carnegie Network-College partnership

Contact: pathways@carnegiefoundation.org

NETWORK provides:

- Advancing Quality Teaching professional development
- All instructional materials and assessments
- Analytics on student performance
- Engagement in a Networked Improvement Community

COLLEGE involvement:

- College team of faculty, IR, counselor, dean
- Winter Orientation and National Forum
- Co-development of materials
- Conference calls/webinars
- Data Sharing



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