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

“Getting Under the Hood”
Increase the percentage of Developmental Math students achieving college math credit within one year of continuous enrollment.
HOW Networked Improvement Communities
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

Statway
Quantway

College Math Credit

Semester 1
Semester 2
Semester 3 or more

Elem. Algebra
Int. Algebra
College Math

College Math Credit

What Colleges Traditionally Have Done
Statway: Time to Complete a College Level Math Course

1 Year

Traditional Sequence

6%

Statway

51%

2 Years

15%

Triple the success rate in half the time.
Quantway: Time to Complete Developmental Sequence

- **1 Term**
  - Traditional Sequence: 21%
  - Quantway: 56%

- **2 Terms**
  - Traditional Sequence: 29%
  - Quantway: 29%

Double the success rate in half the time.
Success Rate – Gender

- **Female**
  - Non-Statway: 17%
  - Statway: 52%

- **Male**
  - Non-Statway: 15%
  - Statway: 44%
Success Rate – Gender and Race/Ethnicity

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Non-Statway</th>
<th>Statway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>11%</td>
<td>43%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>14%</td>
<td>44%</td>
</tr>
<tr>
<td>White</td>
<td>19%</td>
<td>57%</td>
</tr>
<tr>
<td>Other*</td>
<td>21%</td>
<td>50%</td>
</tr>
</tbody>
</table>
Who Are Pathways Students?

**College Readiness: Math**
- 75% 2 Levels and Below
- 22% 1 Level Below
- 3% College Ready

**College Readiness: Reading**
- 55% College Ready
- 45% Not College Ready

- 55% College Ready
- 45% Not College Ready
Who Are Pathways Students?

Maternal Education

- 69% Less than College Degree
- 31% 2-Year, 4-Year, or Graduate Degree

Home Language

- 36% Home Language Not Primarily English
- 64% English
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)

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Number of Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>No risk</td>
<td>0</td>
</tr>
<tr>
<td>Medium risk</td>
<td>1 or 2</td>
</tr>
<tr>
<td>High risk</td>
<td>3, 4 or 5</td>
</tr>
</tbody>
</table>
Productive Persistence At Risk Indicator

Percentage Passing Common Assessment Statway

No Risk N=176: 68%
Medium Risk N=450: 32%
High Risk N=94: 38%

Percentage Passing Common Assessment Quantway

No Risk N=66: 76%
Medium Risk N=198: 68%
High Risk N=71: 44%

• Passing the first term common assessment defined as earning a 60% or above
Mindsets and Social Ties (Both Pathways)

- % of students earning a B- or Above:
  - Fixed Mindset: 34%
  - Growth Mindset: 48%
  - Weak Social Ties: 32%
  - Strong Social Ties: 49%
“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

• Maximum baseline math assessment score is 42
• Passing the first term common assessment defined as earning a 60% or above
**Math Conceptual Knowledge**

- **Quantway**
  - Higher Risk: 44%
  - Lower Risk: 77%

- **Statway**
  - Higher Risk: 32%
  - Lower Risk: 62%
WHERE WE ARE NOW, 2013-14

44 Community Colleges
5 State Colleges & Universities
14 States

22 colleges and universities in 14 states
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

Quantw™ Module 2 ASSESSMENT ITEMS version 2.0

Part 1: Multiple-Choice Items

**Statway** Module 2

**Lesson 2.1:** The Cost of Driving: Part 2

**Theme:** Personal Finance

**Main Math Task:**

<table>
<thead>
<tr>
<th>Dimensional Analysis</th>
<th>Cost</th>
</tr>
</thead>
</table>

**Prerequisite Assumptions**

- Students will understand that
- Units are found in a table
- Units provide meaning

**New Objectives**

- Students will be able to:
  - Write a rate as a fraction
  - Use unit rates to solve
  - Use dimensional analysis

**Explicit Connections**

- Converting units is based on the denominator and denominator that changes concept (i.e., change the value of a number while retaining the same measure). Students will operate on and understand:

**Question 1**

**Checkpoint Module 7**

**Question 1**

**Part 1: 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 finer grain measureable 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.

<table>
<thead>
<tr>
<th>Player</th>
<th>Proportion of hits</th>
<th>Player</th>
<th>Proportion of hits</th>
<th>Player</th>
<th>Proportion of hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH</td>
<td>0.305</td>
<td>SU</td>
<td>0.270</td>
<td>BC</td>
<td>0.301</td>
</tr>
<tr>
<td>HA</td>
<td>0.229</td>
<td>DH</td>
<td>0.136</td>
<td>AA</td>
<td>0.143</td>
</tr>
<tr>
<td>JS</td>
<td>0.281</td>
<td>TO</td>
<td>0.218</td>
<td>HK</td>
<td>0.341</td>
</tr>
<tr>
<td>TC</td>
<td>0.097</td>
<td>RL</td>
<td>0.267</td>
<td>RS</td>
<td>0.261</td>
</tr>
<tr>
<td>MM</td>
<td>0.167</td>
<td>JB</td>
<td>0.270</td>
<td>CR</td>
<td>0.115</td>
</tr>
<tr>
<td>GV</td>
<td>0.333</td>
<td>WG</td>
<td>0.054</td>
<td>MD</td>
<td>0.125</td>
</tr>
<tr>
<td>RC</td>
<td>0.085</td>
<td>NH</td>
<td>0.108</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
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?

<table>
<thead>
<tr>
<th>Dates of Zodiac Sign</th>
<th>Choice 1</th>
<th>Choice 2</th>
<th>Choice 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strengths</td>
<td>Weaknesses</td>
<td>Strengths</td>
</tr>
<tr>
<td>3/21 to 4/20</td>
<td>Adventurous</td>
<td>Energetic</td>
<td>Pioneering</td>
</tr>
<tr>
<td></td>
<td>Selfish</td>
<td>Quick-tempered</td>
<td>Impulsive</td>
</tr>
<tr>
<td>4/21 to 5/21</td>
<td>Modest</td>
<td>Shy</td>
<td>Meticulous</td>
</tr>
<tr>
<td></td>
<td>Fussy</td>
<td>A worrier</td>
<td>Overcritical</td>
</tr>
</tbody>
</table>

|                       | Patient | Reliable | Warmhearted | Loving | Persistent | Determined | Placid | Security-loving |
|                       | Jealous | Possessive | Resentful | Loving | 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
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

\((2, -4)\) and \((-3, 7)\).

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