Radically Transforming Mathematics Learning Experiences: Lessons from the Carnegie Math Pathways

Karon Klipple, Executive Director, Carnegie Math Pathways
John Kellermeier, Statway Faculty Mentor and Retired Tacoma Community College Math Faculty
Carnegie Foundation for the Advancement of Teaching

3CSN Equity Institute
November 18, 2016
How can we radically transform our students’ outcomes in (developmental) mathematics?

Completion
Persistence
Quality of learning
Identities as learners

For ALL Students
1. How can we design course structures for the realities of our students’ lives in order to give them the best chance for success?

2. How can we best support powerful mathematics learning and students' persistence and engagement?

3. How can student success outcomes be sustained and improved?
The Problem

60-70% of community college students need at least one developmental math course before enrolling in college-credit courses.

80% of those students never get out of the developmental math pathway.

500,000 students in every cohort will never complete the math requirement.

We cannot continue to use the same approach and expect different results.
Change Math from Gatekeeper to Gateway

Accelerated, cohort-based Pathway

Ambitious, relevant, problem-centered curriculum

Student-focused, collaborative pedagogy

Productive Persistence interventions/practices

Language and Literacy supports

Comprehensive and sustained professional learning opportunities

Network engagement and improvement
Statway and Quantway

In classrooms since 2011

Now in over 58 institutions across the country

More than 20,000 students served
Time to Complete College Level Math Course

Statway vs. Traditional Sequence

Nationally, only 15% of students successfully complete the traditional sequence by the end of two years, while 49% of Statway students successfully complete the course in one year.\(^1\)
Triple Success in Half the Time

Statway

Success Rate (C or higher)

- 2011-12: 48%
- 2012-13: 52%
- 2013-14: 49%
- 2014-15: 46%
- 2015-16*: 49%

Matched comparison:
- 2011-12: 16%
- 2012-13: 14%
- 2013-14: 18%
- 2014-15: 16%
- 2015-16*: 16%

Enrollment:
- 2011-12: 0
- 2012-13: 1000
- 2013-14: 2000
- 2014-15: 3000
- 2015-16*: 4000

* includes summer enrollment
Triple Success in Half the Time

One college struggling to implement all elements removed from the analysis
Advancing Equity - Major Gains Across All Subgroups
Time to Complete Developmental Math Requirement

Quantway 1 vs. Traditional Developmental Sequence

Nationally, only 29% of students successfully complete the traditional sequence by the end of two terms, while 56% of Quantway students successfully complete the course in one term.¹

Success in 1 Term

Traditional Mathematics Sequence

Success in 2 Terms

Quantway

21%  29%

Success in 1 Term

Nearly double the success in half the time.
Twice the Success in Half the Time

Quantway

Success Rate (Pass or C or higher)

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantway 1 - 1 Term</th>
<th>Matched comparison - Academic year</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-12</td>
<td>58%</td>
<td>36%</td>
<td>500</td>
</tr>
<tr>
<td>2012-13</td>
<td>57%</td>
<td>34%</td>
<td>1000</td>
</tr>
<tr>
<td>2013-14</td>
<td>58%</td>
<td>41%</td>
<td>1500</td>
</tr>
<tr>
<td>2014-15</td>
<td>64%</td>
<td>38%</td>
<td>2000</td>
</tr>
<tr>
<td>2015-16*</td>
<td>64%</td>
<td>37%</td>
<td>2500</td>
</tr>
</tbody>
</table>
Advancing Equity - Major Gains Across All Subgroups

![Bar chart showing success rates for different subgroups](chart.png)
1. How can we design course structures for the realities of our students’ lives in order to give them the best chance for success?

Shorten the sequence and reduce transition points

*Acceleration*
A Solution: Coherent, Intensive, Learning Pathways

Statway

Quantway 1 → Quantway 2 or college level QR course → Bridge to STEM

Traditional Mathematics Sequence

Semester 1: Elementary Algebra
Semester 2: Intermediate Algebra
Semester 3: College Math
Statway Outperforms Comparison Group at Every College

Graph showing student success rates for Statway and comparison group. The x-axis represents the comparison student success rate, and the y-axis represents the Statway student success rate. The graph includes data points for 1 Semester, 1 Quarter, and 2 Quarters, with a line indicating parity.
1. How can we design course structures for the realities of our students’ lives in order to give them the best chance for success?

- Shorten the sequence and reduce transition points
  - *Acceleration*

- Keep students together
  - *Cohort model*
Cohort model matters...

The graph shows the success rate and enrollment over different years.

- **2011-2012**: Statway - 1 Year: 43%, Enrollment: 56
- **2012-2013**: Statway - 1 Year: 42%, Enrollment: 50
- **2013-2014**: Statway - 1 Year: 28%, Enrollment: 280
- **2014-2015**: Statway - 1 Year: 30%, Enrollment: 495

Success Rate (C or Better) is measured on the left y-axis, and Enrollment is measured on the right y-axis.
An Innovation with Men of Color

The Men of Distinction program at Tacoma Community College is a cohort based student success program for young men of color ages 18-24 that has been in existence since 2010.

During the Winter 2016 term, 16 men from the Men of Distinction program enrolled in a combined Statway I and Statway II class. There was a total of 27 students.

During the term there was continual coordination between the Statway instructor and the program coordinator for the Men of Distinction program.
2. How can we best support powerful mathematics learning and students' persistence and engagement?

Make curriculum productively challenging and relevant to students' lives
### Comparable Concepts

#### Statistical Computation

Calculate the standard deviation of the following ten numbers:

- $3.58$
- $5.12$
- $10.25$
- $31.18$
- $6.75$
- ...

#### Statway Problem Situation

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.
Comparable Concepts

Linear Equations

Find the equation of the line passing through the points

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

Write the equation in slope-intercept form.

Quantway Problem Situation

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.
It’s practical! I’m sorry, but in math you’re like, “When am I ever going to want to… I mean what do I do with this stuff? But this stuff (Statway) is everyday life.

If you are afraid of higher math, this will help you see how it really does apply.
The Hidden Curriculum

● All assessment and teaching items have an overt curriculum and a hidden curriculum

● The overt curriculum is the goal of the item

● The hidden curriculum is the context of the item
Intentional Use of The Hidden Curriculum

- Increase awareness and cultural competence
- Address issues of equity and diversity
Sex and Gender

Members of an advocacy organization for transgender rights were asked what sex they were assigned at birth (female or male) and how they identify their gender presentation now (woman, man or other). The results are summarized in the table below.

<table>
<thead>
<tr>
<th>Sex Assigned at Birth</th>
<th>Gender Presentation</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Woman</td>
<td>Man</td>
<td>Other</td>
<td>Total</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>62</td>
<td>9</td>
<td>81</td>
</tr>
<tr>
<td>Male</td>
<td>75</td>
<td>13</td>
<td>11</td>
<td>99</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>75</td>
<td>20</td>
<td>180</td>
</tr>
</tbody>
</table>

What percent of those who were assigned female at birth now present as other than man or woman?
Poverty Rates of Elderly Americans

Data from 2001 gives the poverty rates of elderly Americans (65 years and older) broken down by race (U.S. Census Bureau, 2002). The poverty rate is the percent of people in a group who have income below the poverty line.

What percent of poor elderly Americans are white?

<table>
<thead>
<tr>
<th>Race</th>
<th>Poverty rate</th>
<th>Percent of total elderly population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>21.9%</td>
<td>8.4%</td>
</tr>
<tr>
<td>White</td>
<td>8.1%</td>
<td>82.8%</td>
</tr>
<tr>
<td>Other</td>
<td>17.7%</td>
<td>8.7%</td>
</tr>
</tbody>
</table>
2. How can we best support powerful mathematics learning and students' persistence and engagement?

Make curriculum productively challenging and relevant to students' lives

Employ instruction that promotes development of flexible expertise and engages students actively and collaboratively
What Do We Want Our Students to Learn?

• *Flexible vs. routine* expertise (Hatano & Inagaki)

• What is flexible expertise?
  – Procedural fluency
  – Conceptual understanding
  – Disposition to think/make sense of mathematics
  – Ability to nimbly bring knowledge to bear across a wide array of new situations
Research Indicates Three Critical Learning Opportunities

To achieve flexible expertise, students need recurring and sustained opportunities for:

- *Productive struggle* – with important mathematics
- *Explicit connections* – between concepts, procedures, problems, situations
- *Deliberate practice* – increasing variation and complexity over time
The Problem Cycle Routine

- Designed to support productive struggle
- Collaborative learning is critical component
- Makes student thinking/reasoning visible
- Builds key mathematical ideas from student thinking
- Leaves students with key takeaways from problem
My experience has been positive. You know, I struggled with it..., but I think that’s just a main part of it. You’re supposed to jump in and figure it out!

I enjoy coming to class. I want to think through the problems, not just get the answer.

Having a small group allows you to have more contact with the people around you - not necessarily having to raise your hand or be on the spot in front of the whole class. Your questions can get answered a little quicker, you can come to an understanding with your peers quicker. I think it’s great.
2. How can we best support powerful mathematics learning and students' persistence and engagement?

Make curriculum productively challenging and relevant to students' lives

Employ instruction that promotes development of flexible expertise and engages students actively and collaboratively

Integrate productive persistence into math curriculum and pedagogy
Productive Persistence

Aim:
Students continue to put forth effort during challenges and when they do so they use effective strategies.

- Students believe they are capable of learning math.
- Students feel socially tied to peers, faculty, and the course.
- Students believe the course has value.
- Students have skills, habits and know-how to succeed in college setting.
- Faculty and college support students’ skills and mindsets.
Do students’ mindsets matter?

- Based on survey with developmental math students.
- Categorized students as “at risk” or not in terms of the four drivers during week 1.
Can we change students’ mindsets in the first 4 weeks of class?

<table>
<thead>
<tr>
<th></th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest in Math</td>
<td>0.34</td>
</tr>
<tr>
<td>Confidence</td>
<td>0.21</td>
</tr>
<tr>
<td>Relevance of math in course</td>
<td>0.48</td>
</tr>
<tr>
<td>Belief that math intelligence is fixed</td>
<td>-0.65</td>
</tr>
<tr>
<td>Math Anxiety</td>
<td>-0.47</td>
</tr>
<tr>
<td>Stereotype Threat</td>
<td>-0.22</td>
</tr>
</tbody>
</table>
Because I have had such a turn around in the way I feel as someone who is competent at doing math, it has started to translate into the other things that I do in my life. I feel like I am growing a new capacity.

I couldn’t imagine taking another stats class. The people in this class are more like a family than a classroom… Not only will you leave with a higher education, you will leave with friends.
An Innovation with Men of Color
The Classroom
An Innovation with Men of Color
The Impact, Winter 2016

● 8/16 (50%) MoD completed Statway II.

● 4/6 (67%) MoD completed Statway II the next quarter.

● 12/16 (75%) MoD completed within two terms.
More Impact

Average number of quarters to complete college level mathematics

- 2009: 8
- 2010: 8
- 2011: 8
- 2012: 8
- 2013: 7
- 2014: 6
- 2015: 5
- 2016: 4

Carnegie Foundation for the Advancement of Teaching
3. How can student success outcomes be sustained and improved?

Provide sustained, meaningful opportunities for learning from and about practice
Effective faculty professional development for instructional improvement

- Sustained
- Flexible and responsive
- Designed for collaboration
- Grounded in real teaching
- Job-embedded
- Theory related to practice
3. How can student success outcomes be sustained and improved?

Provide sustained, meaningful opportunities for learning from and about practice

Ongoing collaboration to accelerate and spread learning (across the network)
Pathways Networked Improvement Community

Continuous Improvement
Institutional Readiness & Support
Advancing Quality Teaching
Online Network Environment
Common Data Infrastructure

Learning Opportunities
- Productive Struggle
- Explicit Connections
- Deliberate Practice

Statway/Quantway Curricula
Pathways Pedagogy

Productive Persistence
Language & Literacy Supports
Faculty Network Engagement

Ongoing collaboration to accelerate and spread learning and improvement
Radical transformation requires will for collective action seeing the system mobilizing across the system to take action across the system
SAVE THE DATE

2017 Pathways Winter Institute

January 26-28, 2017 | Carnegie Foundation, 51 Vista Lane, Stanford CA 94305

We welcome interested faculty and administrator teams to come to the Winter Institute to:

• Gain a deeper understanding of the Pathways and what it means to be part of a Networked Improvement Community (NIC).

• Develop an action plan to successfully launch and implement the Pathways at your institution.

• Engage with Pathways students and experienced network faculty and administrator to learn about the impact this program is having nationally.

For more information, email: Pathways@carnegiefoundation.org
pathways.carnegiehub.org

Click “Become an Explorer” to learn more!

pathways@carnegiefoundation.org

Carnegie’s work on Quantway and Statway is supported by The William and Flora Hewlett Foundation, the Bill & Melinda Gates Foundation, the Lumina Foundation, The Kresge Foundation, the Carnegie Corporation of New York, the Great Lakes Higher Education Corporation, and the National Science Foundation's grant DUE-1322844.