

From:

The Math Door

—opening doors to mathematical learning—

An Introduction to Math-Mapper 6-8 as a Means for Mathematics Improvement

Jere Confrey, Joseph D. Moore Distinguished Professor of Mathematics Education
Charlene Marchese, Math Supervisor PreK-8, Freehold Township Schools
Alan Maloney, The Math Door Research Scientist

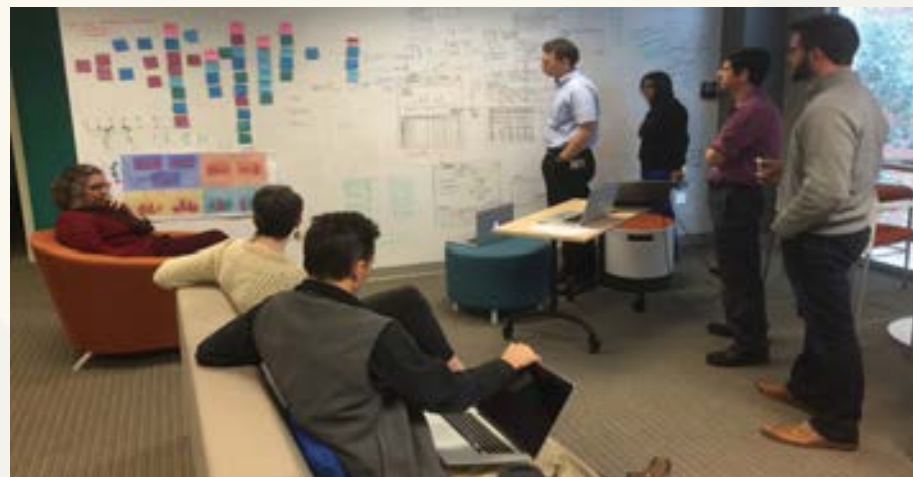


MATH-MAPPER 6-8

Contributors to this presentation--

NC State University (SUDDS group):
Jere Confrey
Garron Gianopulos
Yungjae Kim
Basia Coulter
Meetal Shah
Will McGowan

Freehold Township Schools:
Charlene Marchese
The Math Door:
Alan Maloney



MATH-MAPPER 6-8

Math-Mapper Development Partners and Collaborators--

Freehold Schools, New Jersey, Schools:

Dr. Ross Kasun, Superintendent

Dr. Pam Haimer, Assistant Superintendent, Curriculum and Instruction

Dr. Charlene Marchese, Supervisor of Mathematics Pre K-8

The Math Teachers of Barkalow and Eisenhower Middle School

Harnett County Schools, North Carolina:

Dr. Stan Williams, Superintendent

Brian Graham, Principal of Highland Middle School

The Math Teachers of Highland Middle School



MATH-MAPPER 6-8

The Math Door:

- A Pack-Start (NC State University) Startup, founded Spring 2016
- Winner of New Schools Venture Fund *Ignite Math* Program, 2016
- Semi-finalist for the Intel Accelerator, Summer 2016

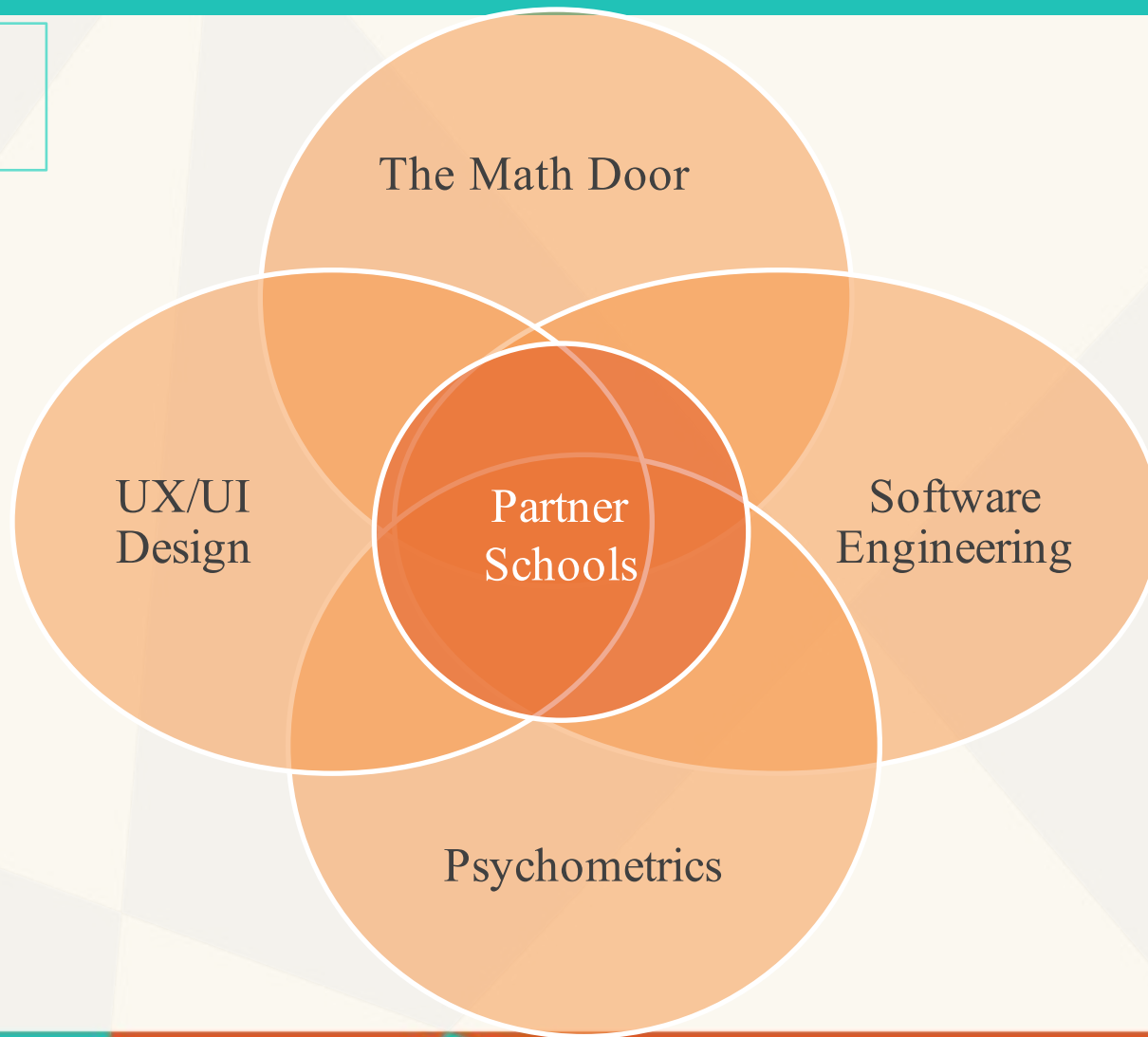
Math-Mapper 6-8:

- Built with prior and ongoing support from National Science Foundation and the Bill and Melinda Gates Foundation
- Intellectual property licensed from NCSU



MATH-MAPPER 6-8

How We Work: A Cross-Field Approach



THE
MATH
DOOR

MATH-MAPPER 6-8

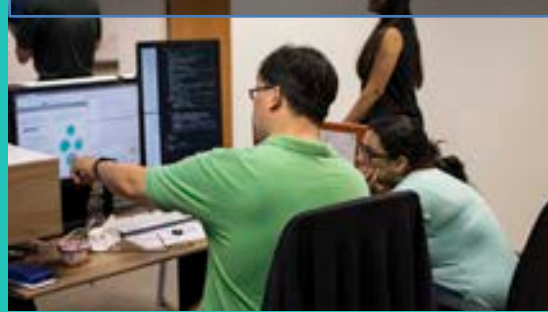
How We Work: SUDDS Research Group

We leverage ground-breaking work
by the Scaling Up Digital Design Studies research team
on Learning Trajectories and Assessment

Research-based



Rapid Prototyping



Partnerships with and of Teachers and Students



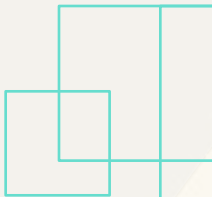

Agile Development



Design Research



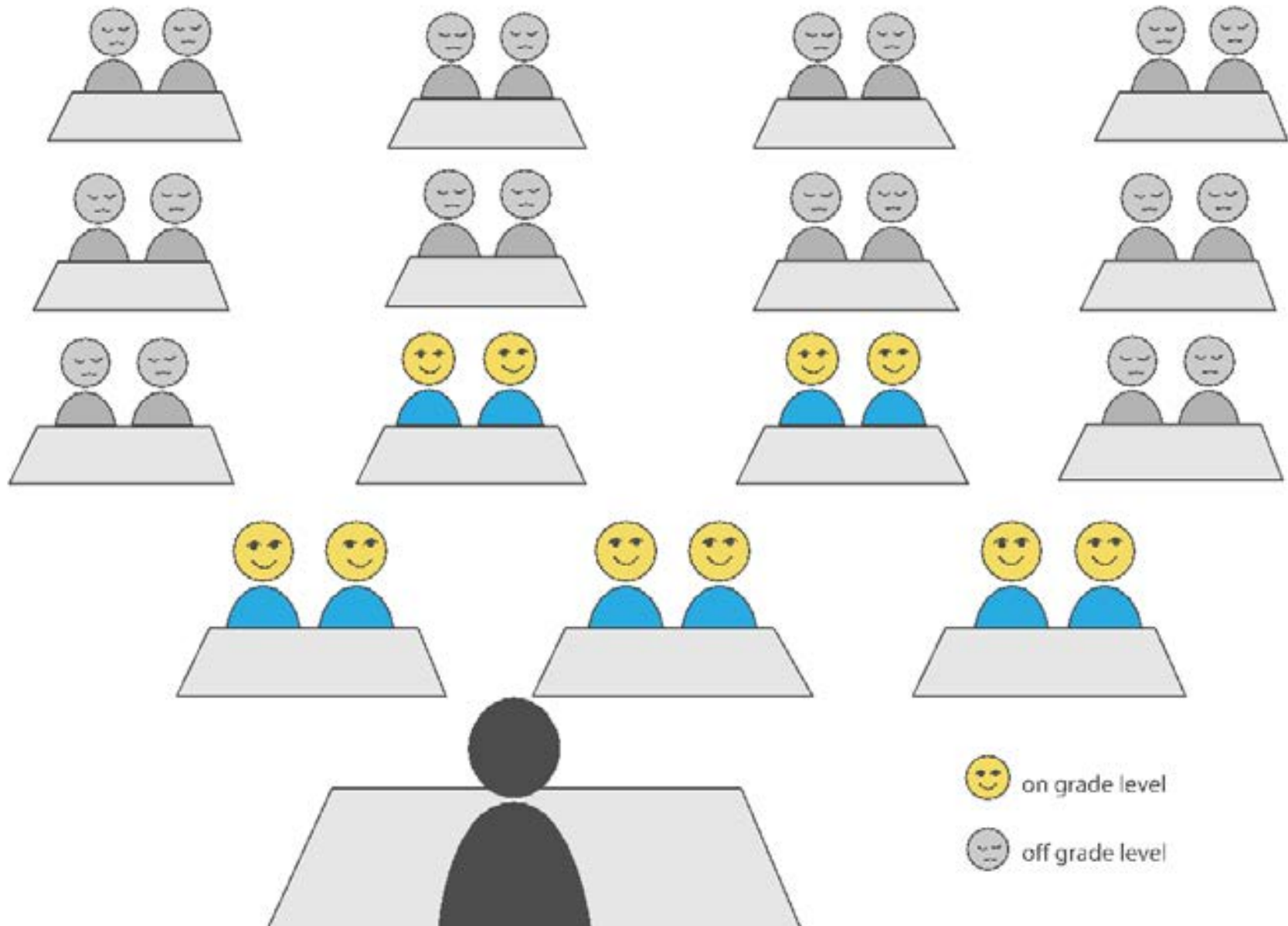
Overview of Presentation

- 
- Challenges and Dilemmas: A New Approach
 - Components of a Digital Learning System (DLS)
 - Demonstration: Math-Mapper 6-8 DLS
 - What we have learned from our Partnerships
 - Opportunities for Future Partnerships
- 

Grand Challenge

- To design a way to meet the needs of all students **without** devolving into excessive individualization
- This is the proper meaning of personalization

“So here we are” —



"So here we are" — Dilemmas

- How do we *all* know what we are supposed to learn—and succeed?
- What is the proper role for standards?
- How can open-ed materials support coherent learning?
- Can we practice *assessment for learning*?
- How can data support wise and timely instructional decisions?
- How can we leverage a more active role for students?

What if...

- ...a coherent, internally consistent navigation of the mathematical concepts for deeper understanding?
- ...students accomplished the CCSS expectations?
- ...open resources aligned with concepts, and helped students deepen their mathematical reasoning?
- ...diagnostic assessments for formative use and personalizing learning, and they matched way we navigated the concepts?
- ...the teachers *and* the students were partners in this learning?
- ...everyone in the classroom progressively developed more sophisticated mathematical understanding and reasoning?

Math-Mapper 6-8:

A Digital Learning System
for Navigating, Exploring, and Assessing
Middle Grades Mathematics

Informs teachers and students:

- *what* the students need to learn,
- *where* to learn it, and
- *how well* they understand it.

- Challenges and Dilemmas: A New Approach
- Components of a Digital Learning System (DLS)
- Demonstration: Math-Mapper 6-8 DLS
- What we have learned from our Partnerships
- Opportunities for Future Partnerships

Math-Mapper 6-8

An innovative digital learning system, where students and teachers can...

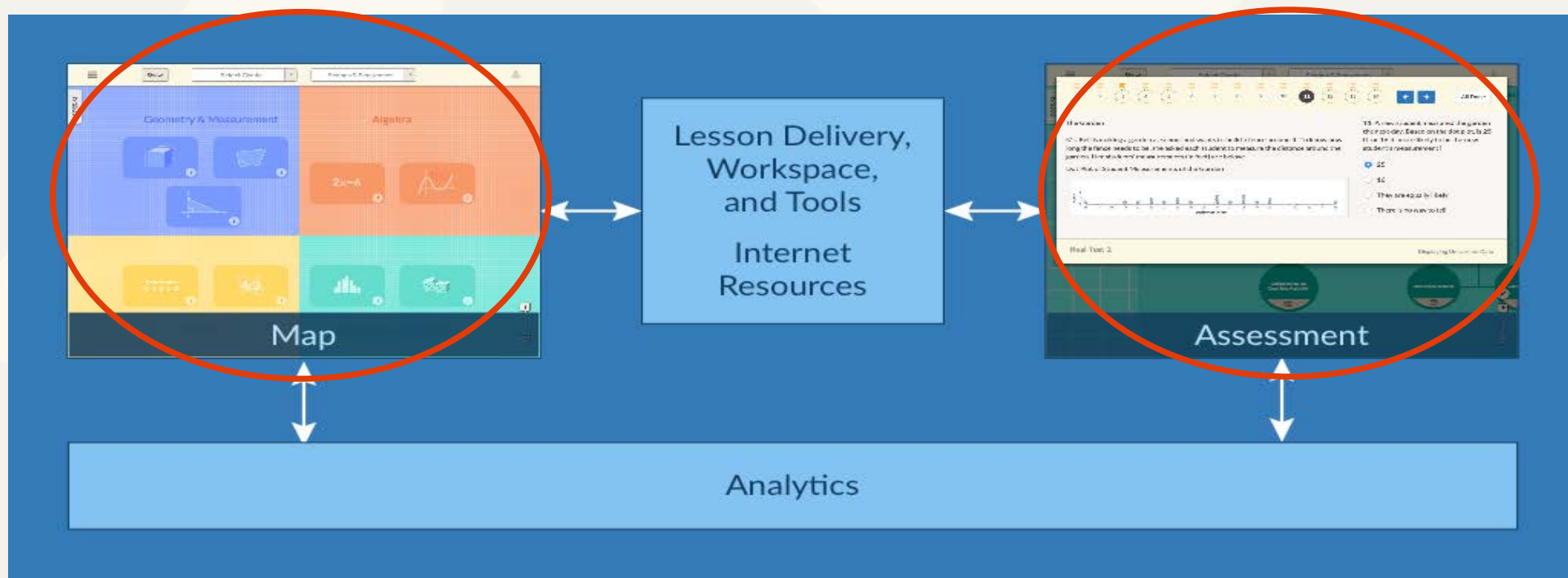
- Navigate the content of middle school mathematics, organized around an underlying framework of big ideas and research-based learning trajectories
- Select and sequence aligned open source curricular resources
- Assess, in real time, students' progress, identifying needs and next steps
- (Compatible with a variety of curriculae, chosen by schools and teachers)

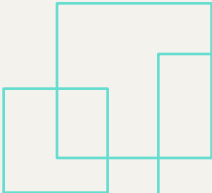

Math-Mapper 6-8, a Digital Learning System (DLS)

1. A Learning Map

2. Curated Links to
Open Resources

3. Diagnostic Assessments--
administered, scored and
reported in real time



- 
- Challenges and Dilemmas. A New Approach
 - Components of a Digital Learning System (DLS)
 - Demonstration: Math-Mapper 6-8 DLS
 - What we have learned from our partnerships
 - Opportunities for Future Partnerships
- 

Demonstration



Show

Select Grade

Scopes & Sequences



CCSS-M

Geometry and Measurement



i



i



i

Algebra

$$2x=6$$

i



i



i

4:3

i

Number



i



i

Statistics and Probability



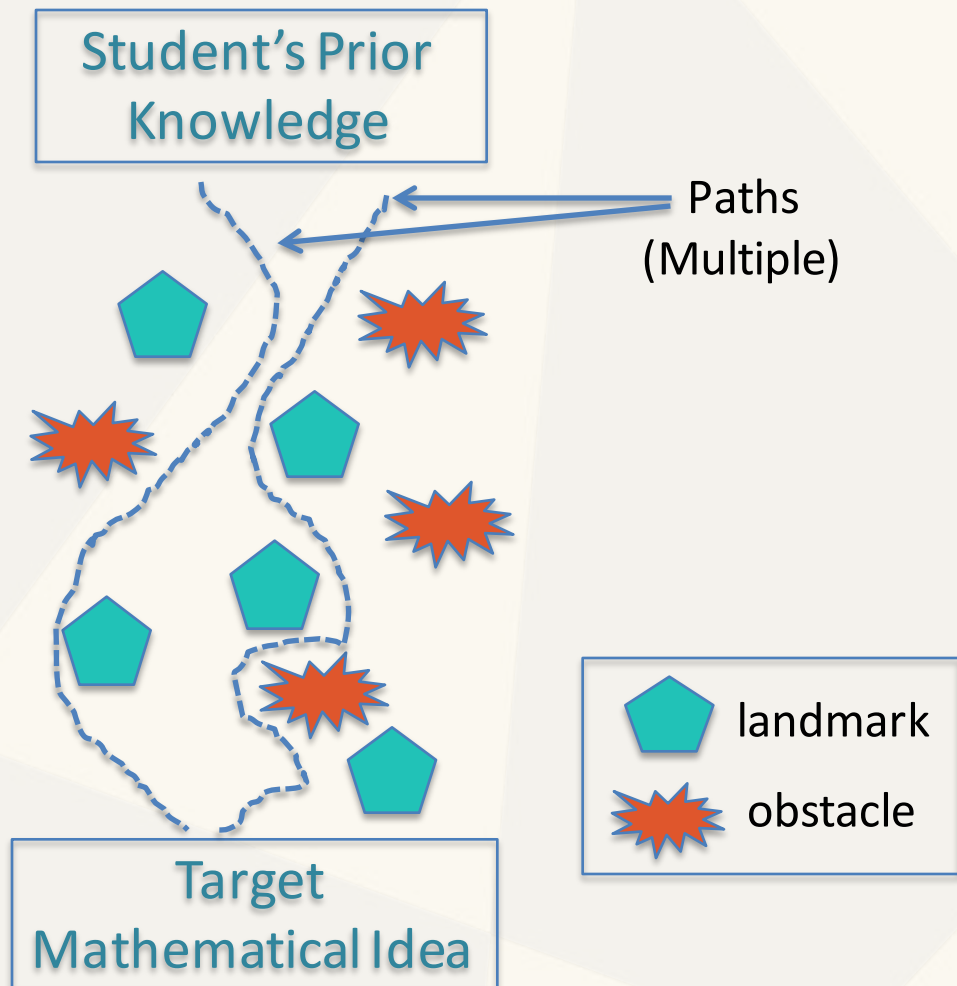
The Underlying Learning Framework

Starting with a Learning Map...

A Learning Map is a navigational system that helps teachers and students to visual the content to be learned structured hierarchically based on research on student thinking.



The Underlying Learning Framework



A **learning trajectory (LT)** connects students' prior knowledge to a target concept.

LTs are comprised of *proficiency levels*, which describe the likely landmarks and **obstacles** students may encounter as they proceed from naïve to sophisticated understandings.

Middle School Mathematics in Nine Big Ideas

Geometry and Measurement



Measure, compose, and scale perimeter, area, and volume



Compose, characterize, and transform lines, angles, and polygons



Represent and explore Pythagorean Theorem and polygons using coordinate points



Position, compare, and operate on one dimensional quantities

4:3

Compare quantities to operate and compose with ratio, rate, and percent

Algebra

$$2x=6$$

Algebraically relate, express, modify, and evaluate unknown quantities



Represent and use relations and functions of two variables

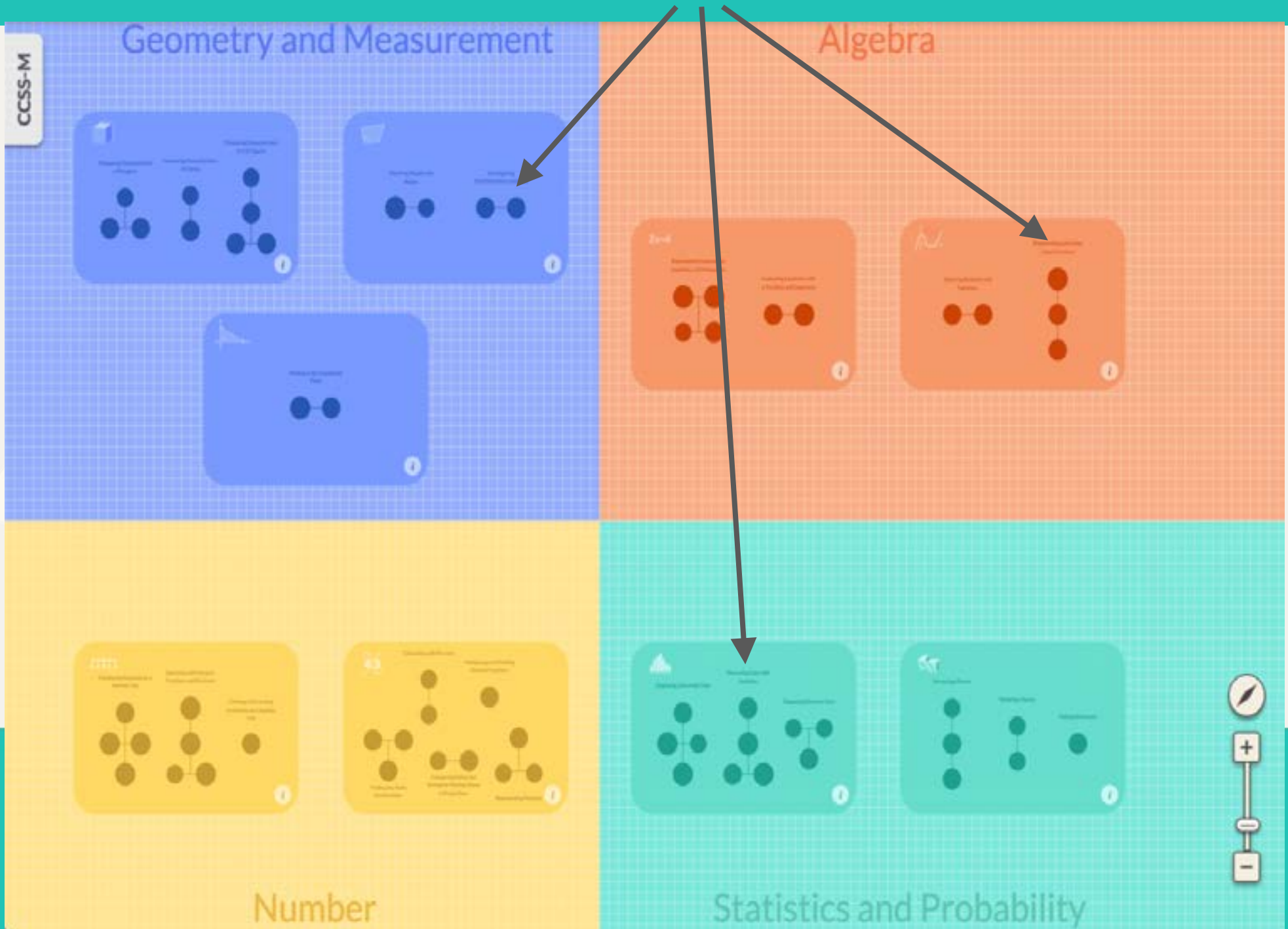


Display data and use statistics to measure center and variation in distribution



Use probability to measure chance and model chance events to make informal inferences

The Related Learning Clusters within the big ideas

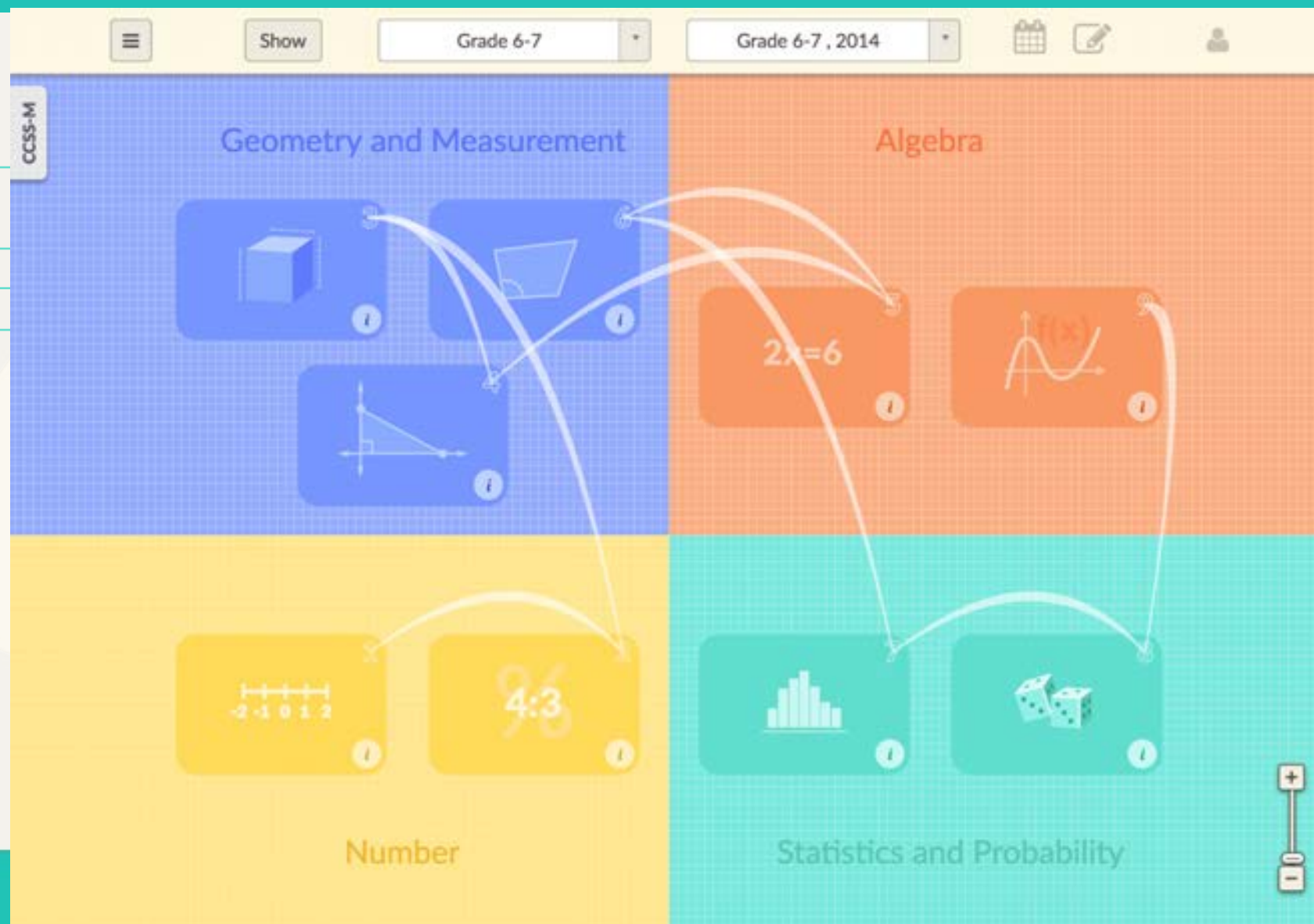


Apply Grade-specific Filters

The screenshot displays the MATH-MAPPER 6-8 interface. At the top, there is a navigation bar with a 'Show' button, a dropdown menu currently set to 'Grade 7' (which is circled in red), and another dropdown menu set to 'None'. Below the navigation bar, the interface is divided into four colored quadrants representing different math domains: 'Geometry and Measurement' (blue), 'Algebra' (orange), 'Number' (yellow), and 'Statistics and Probability' (teal). Each quadrant contains several small, colorful icons representing different mathematical concepts or standards. On the left side, there is a vertical sidebar with a 'CCSS-M' label. On the right side, there is a vertical toolbar with icons for zooming in (+), zooming out (-), and a search icon (magnifying glass).

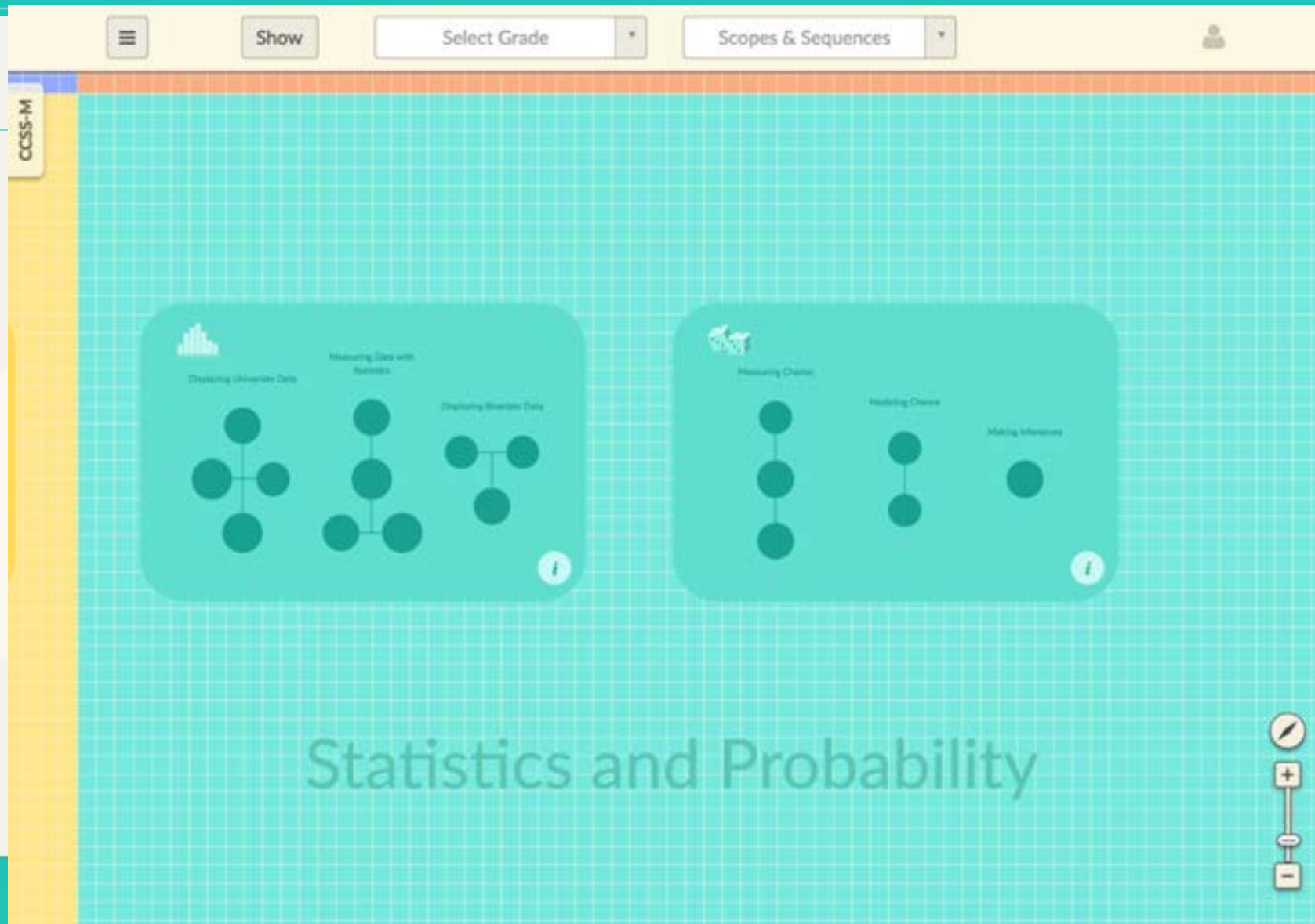
MATH-MAPPER 6-8

Apply Scopes and Sequences to Support Personalization



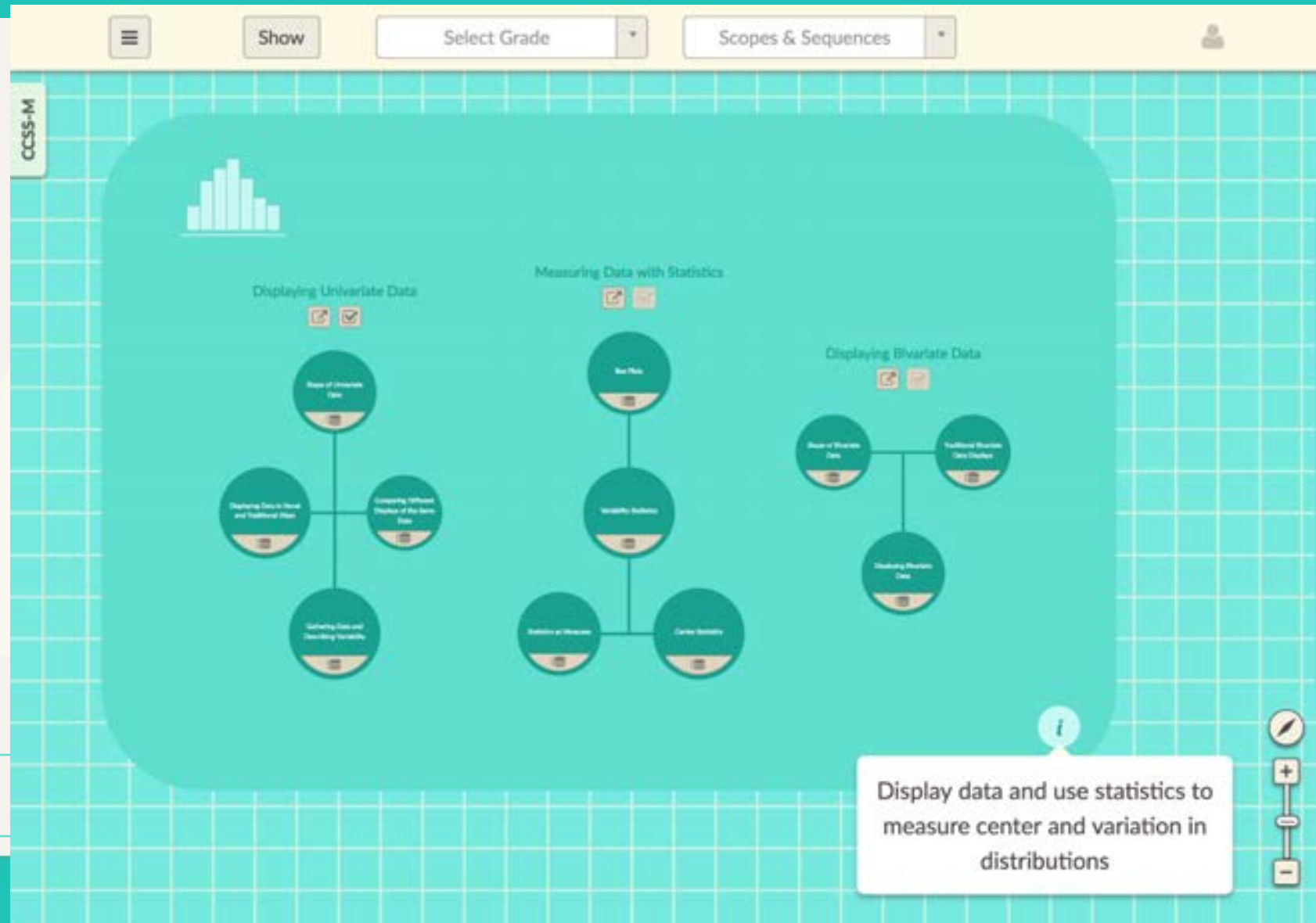
MATH-MAPPER 6-8

Zoom into a Field



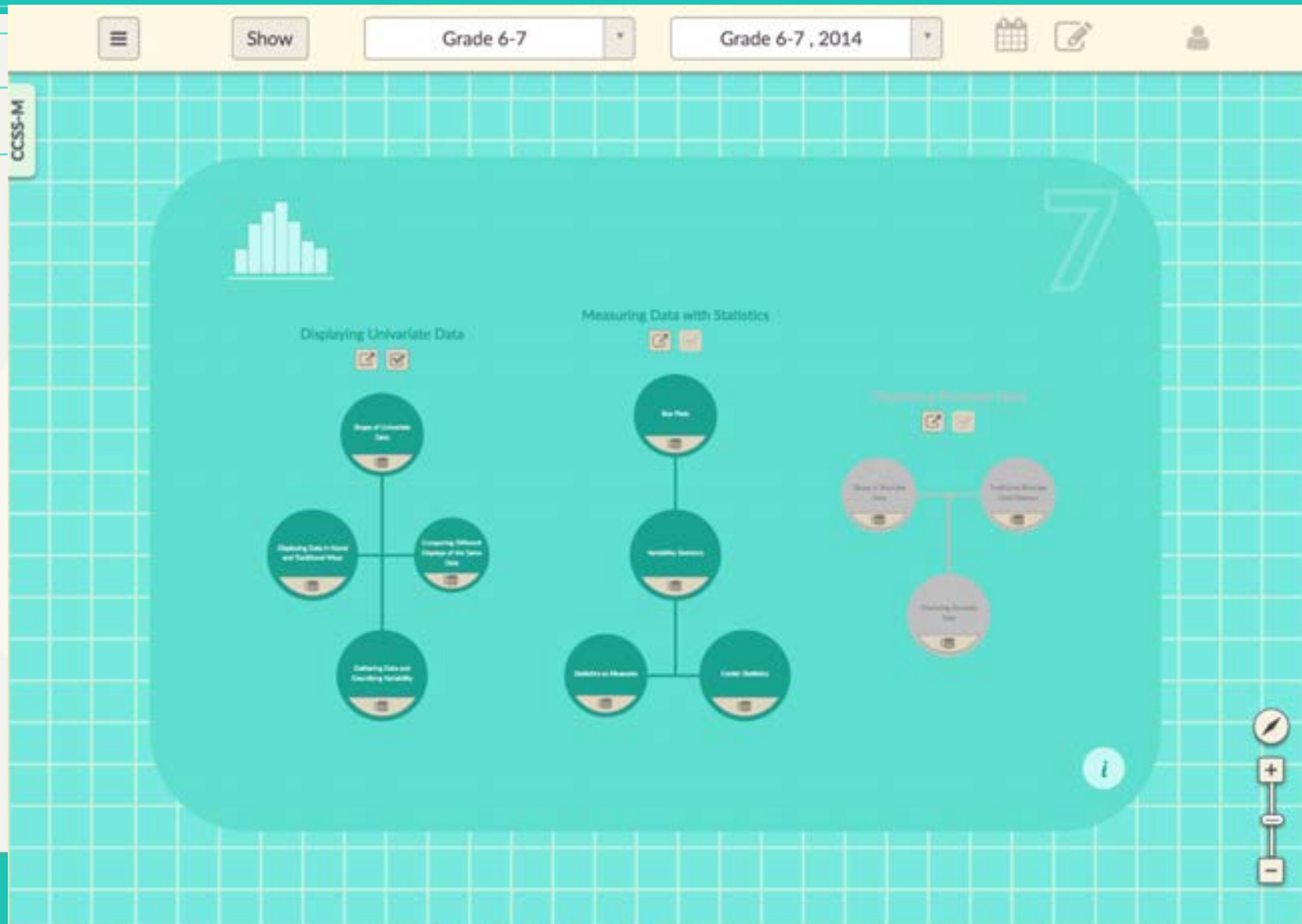
MATH-MAPPER 6-8

Zoom Into a Region: A Big Idea Broken into Clusters



MATH-MAPPER 6-8

Filter Down to a Grade Range

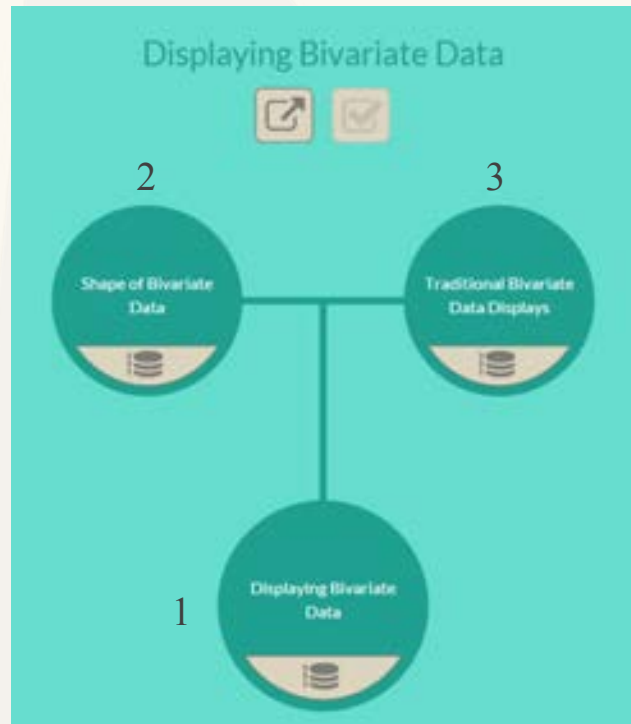


MATH-MAPPER 6-8

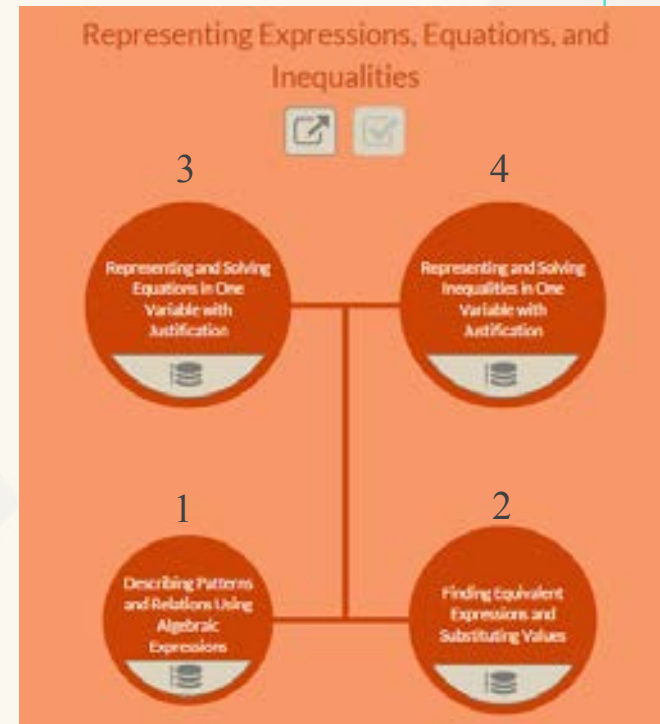
The Shapes of Clusters Inform Possible Sequences



1 then 2 then 3
(linear path)

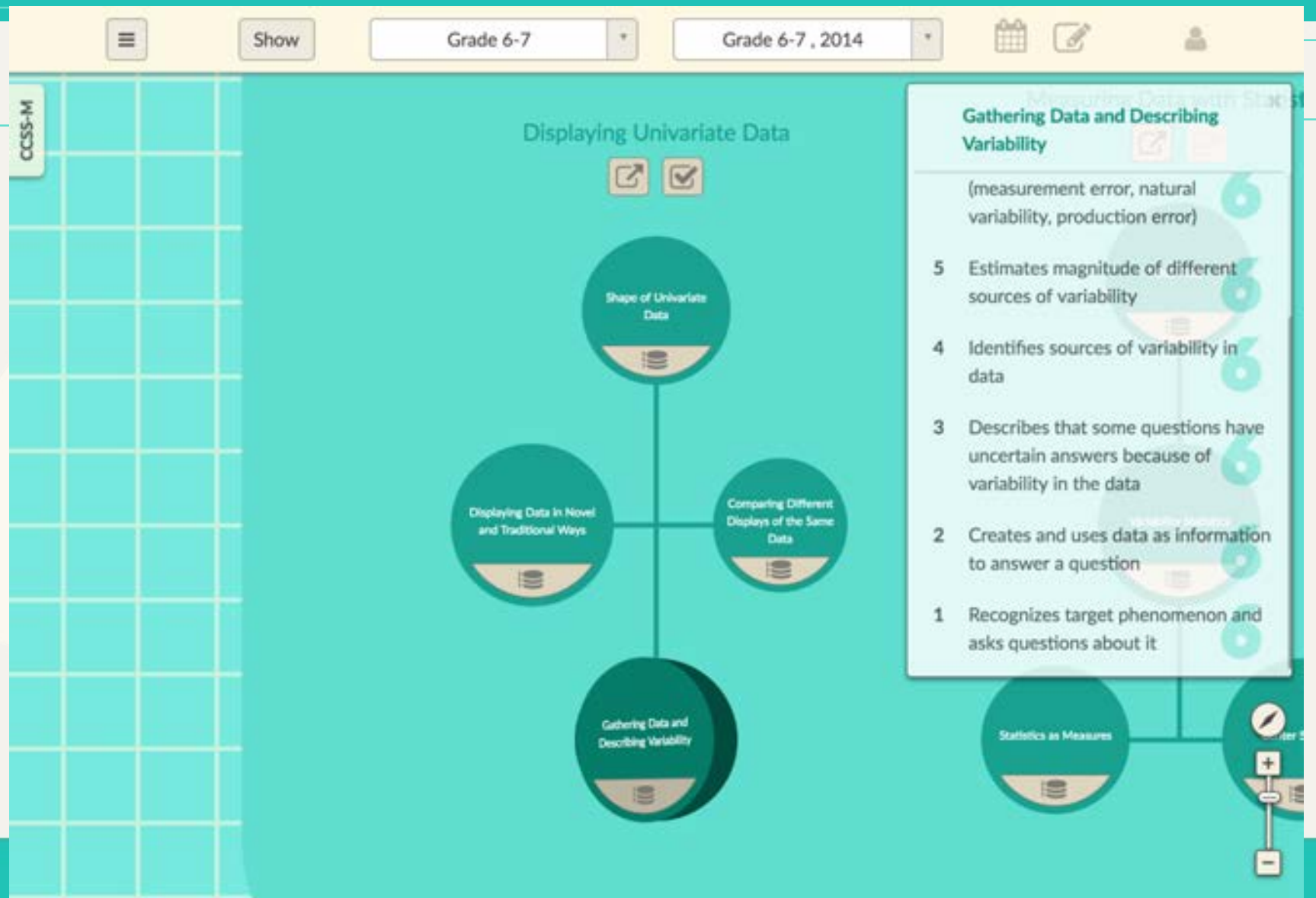


1 then (2,3) or (3,2)
(Divergent)



(1, 2) or (2, 1) then (3, 4) or (4, 3)
(Convergent then Divergent)

Open a Construct to Reveal its Learning Trajectory



MATH-MAPPER 6-8

Find the Common Core Standards linked to the LT

The screenshot displays the MATH-MAPPER 6-8 interface. At the top, the navigation bar includes a 'Show' button, a dropdown for 'Grade 6-7', and another dropdown for 'Grade 6-7, 2014'. On the left, a sidebar titled 'CCSS-M' contains a search bar with the text 'Displaying Data in Novel and Traditional W.' and a list of standards. The central area features a concept map titled 'Displaying Univariate Data' with four interconnected nodes: 'Shape of Univariate Data', 'Comparing Different Displays of the Same Data', 'Gathering Data and Describing Variability', and 'Displaying Data in Novel and Traditional Ways'. On the right, a detailed view of the 'Displaying Data in Novel and Traditional Ways' node is shown, listing six steps: 1. Displays data without reference to investigation, 2. Shows basic familiarity with bar graphs, pie charts, and dot plots, 3. Identifies or creates titles, labels, or keys, 4. Orders data from least to greatest without distinguishing scale from data, 5. Stacks individual values or within groups, intervals, or bins, and 6. Scales using equal intervals.

CCSS-M

Tap on a construct in the map or search the standards

Displaying Data in Novel and Traditional W.

6.NS.C.7.B Write, interpret, and explain statements of order for rational numbers in real-world contexts.

6.SP.B.4 Display univariate data, including dot plots, histograms, and box plots.

6.SP.B.5.A Summarize data sets by reporting the number of observations.

6.SP.B.5.B Describe how an attribute for a data set was measured and its units.

6.SP.B.5.C Summarize data sets by finding measures of center and variability; describe overall pattern and deviations from the pattern in relation to the context.

6.SP.B.5.D Summarize data sets by relating shape, measures of center and variability, and the context.

Displaying Univariate Data

Shape of Univariate Data

Comparing Different Displays of the Same Data

Gathering Data and Describing Variability

Displaying Data in Novel and Traditional Ways

Displaying Data in Novel and Traditional Ways

- 1 Displays data without reference to investigation
- 2 Shows basic familiarity with bar graphs, pie charts, and dot plots
- 3 Identifies or creates titles, labels, or keys
- 4 Orders data from least to greatest without distinguishing scale from data
- 5 Stacks individual values or within groups, intervals, or bins
- 6 Scales using equal intervals

MATH-MAPPER 6-8

Find the Common Core Standards in the Big Ideas

The screenshot displays the MATH-MAPPER 6-8 interface, which is organized into four quadrants representing the four big ideas of mathematics: Number (yellow), Algebra (orange), Statistics and Probability (teal), and Measurement (blue). At the top, there is a navigation bar with a 'Show' button, a 'Select Grade' dropdown menu, and a 'Scopes & Sequences' dropdown menu. On the left side, a vertical sidebar lists the Common Core Standards (CCSS-M). A tooltip box is open over the standard '8.SPA.1 Construct scatterplots and interpret types of association.' in the Statistics and Probability quadrant. A black arrow points from this tooltip to a specific icon within the 'Statistics and Probability' quadrant, which is circled in red. The interface also features various icons for navigation and search, including a magnifying glass and a plus sign.

CCSS-M

8.SPA.1 Construct scatterplots and interpret types of association.

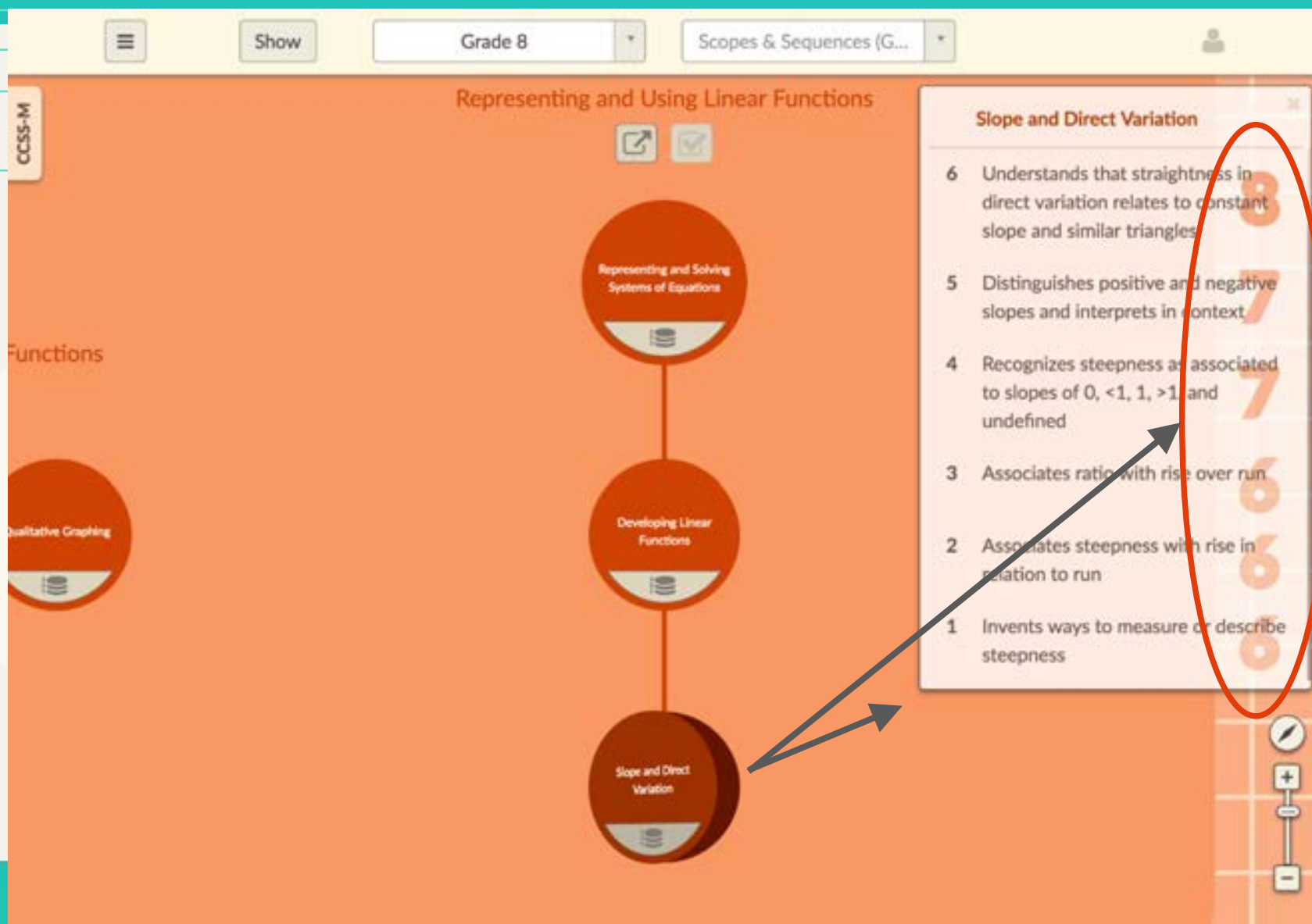
Algebra

Number

Statistics and Probability

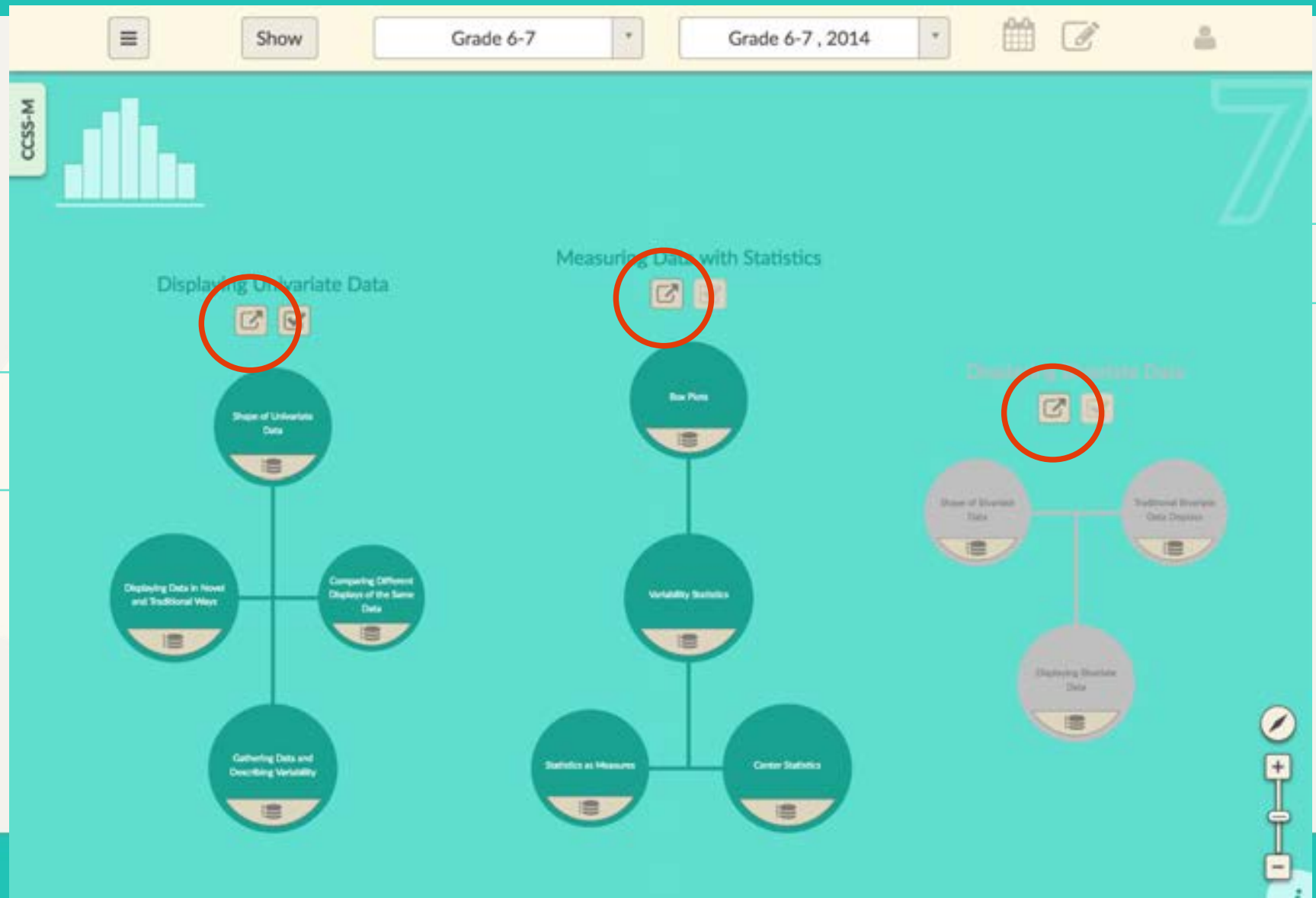
MATH-MAPPER 6-8

Move Below or Above Grade



MATH-MAPPER 6-8

Find the Links to Resources



MATH-MAPPER 6-8

Aligned Curated External Resources

The screenshot displays the Math-Mapper 6-8 interface. On the left, a sidebar titled 'Filter Links by Construct' lists four categories, each with a checkbox: 'Gathering Data and Describing Variability', 'Displaying Data in Novel and Traditional Ways', 'Comparing Different Displays of the Same Data', and 'Shape of Univariate Data'. The 'Displaying Data in Novel and Traditional Ways' checkbox is selected. The main panel, titled 'Links to External Resources', lists seven curated links, each with an external link icon: 'Picturing the World', 'Which is better ... original movies or their sequels?', 'Pixar versus DreamWorks', 'Season 12, American Idol', 'House Prices', 'Chainsaw Data Game', 'Inventing Displays', and 'Do We Know Anything?'. The background shows a network diagram of data science concepts, including 'Displaying Data in Novel and Traditional Ways', 'Statistics as Measures', and 'Center Statistics'. A 'CCSS-M' label is visible in the top left corner of the interface.

MATH-MAPPER 6-8

Browse the Resourcery of External Open/Free Resources

The screenshot displays the Resourcery website interface. At the top, there is a search bar labeled "Search for resource" and a "Curated Resource" dropdown menu. Below the search bar, a "Filter by:" section shows a count of "(156)" resources. A sidebar on the left lists various filter categories with plus icons: Map Location, Grades, Learning Experience and Instruction, Activity Type, Accessibility, Support and Enrichment, Student:Device, Cost, Hardware, and Instructional Supports. The main content area shows three resource cards, each with a "Assorted" label and a "More" link. The first card, "Counting Cogs", features a pattern of interconnected circles and describes a problem for children to think about factors and multiples. The second card, "Number Visuals", features the "youcube at Stanford Univer" logo and describes an activity by Stephen Von Worley. The third card, "Ticket Booth", features a graphic of a ticket booth sign with prices and describes a task to compare unit rates. Each card also includes a "Source" line at the bottom.

Curated Resource

Search for resource

Filter by: (156)

Map Location

Grades

Learning Experience and Instruction

Activity Type

Accessibility

Support and Enrichment

Student:Device

Cost

Hardware

Instructional Supports

All | Free | Paid

Add New Resource

Assorted

Counting Cogs

This problem requires children to think about factors and multiples and, in particular, common factors, but it is not necessary for them to have met this term prior to having a go [...] [More](#)

Source : YouCubed

Assorted

Number Visuals

This activity, created by Stephen Von Worley, invites students to investigate a really interesting representation of numbers that fascinates children and adults alike. The [...] [More](#)

Source : Jo Boaler, YouCubed, Stanford University

Image

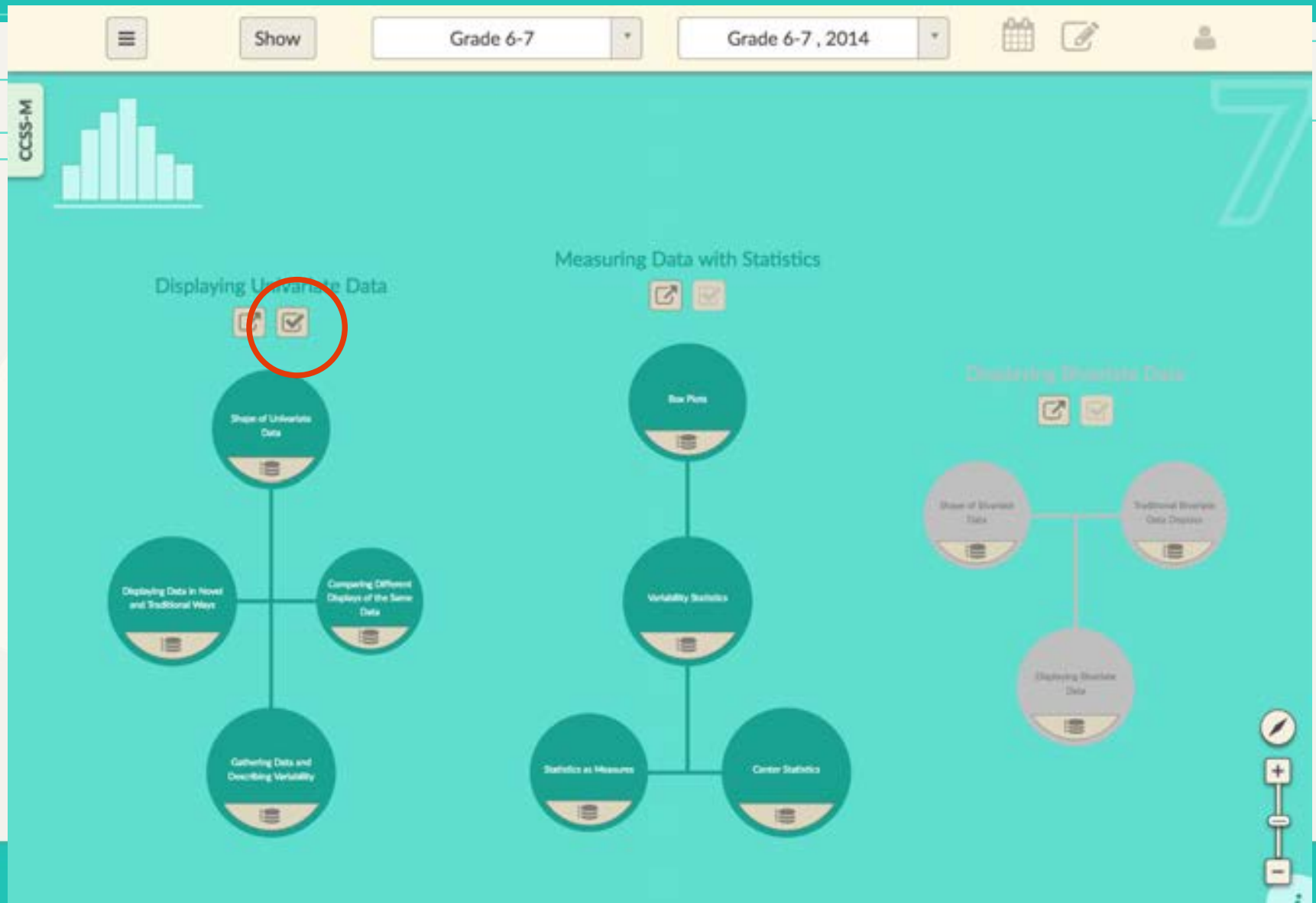
Ticket Booth

The goal of this task is to compare unit rates in a real world context. This task was based upon an image shown here as taken from Robert Kaplinsky's blog. This task was written as [...] [More](#)

Source : Illustrative Math

MATH-MAPPER 6-8

Link to Assessments



MATH-MAPPER 6-8

Take an Assessment

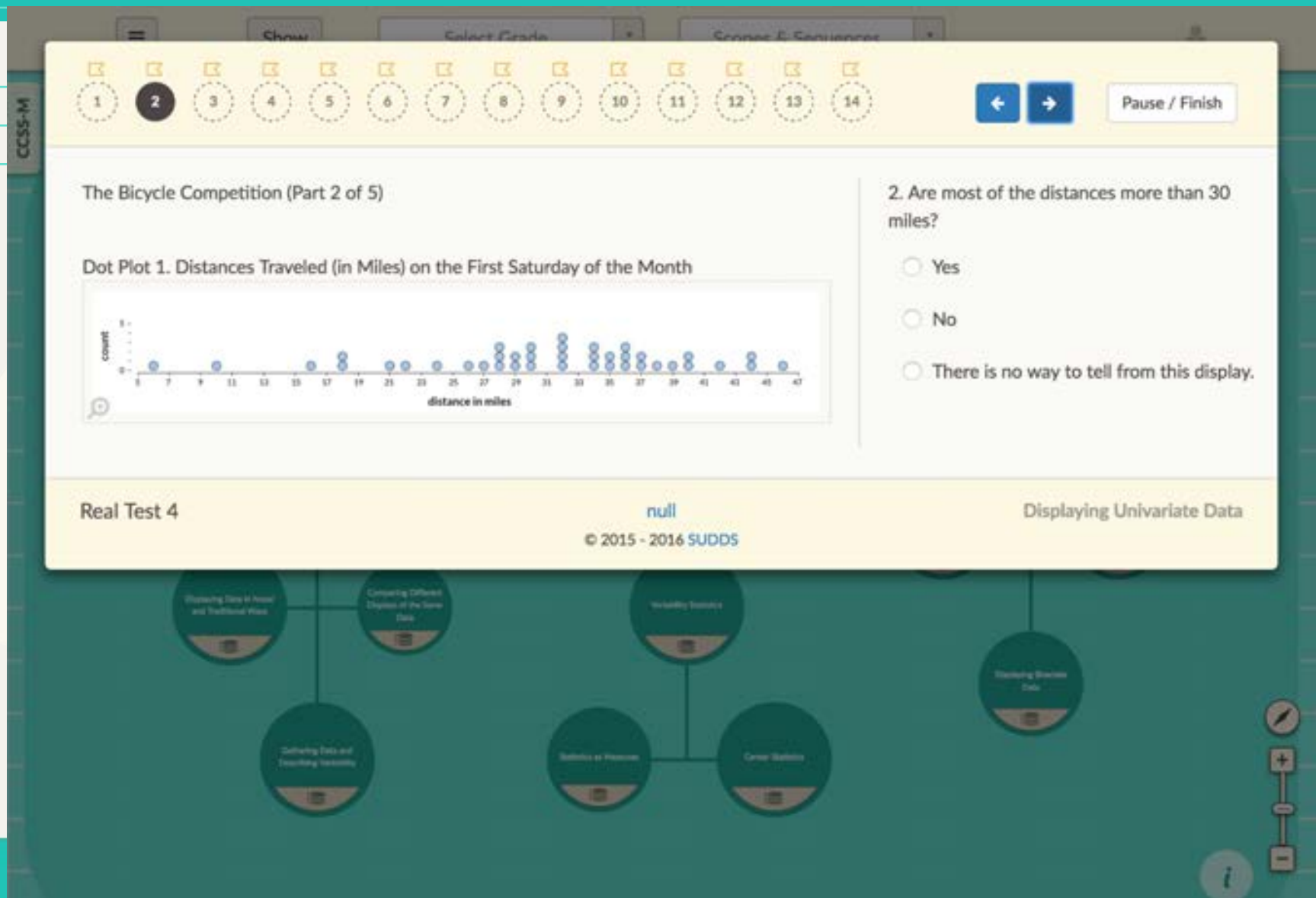
The screenshot shows a web application interface for 'Math-Mapper 6-8'. A modal window titled 'What would you like to do?' is displayed over a background map. The modal contains four main options, each with a button and a description:

- Check My Readiness**: See if I'm ready to study this cluster.
- Take a Practice Test**: Informally practice sample tasks with immediate feedback and sharing.
- Take the Real Test**: Formally take assessment and submit for scoring. This test is due: 03/02/16.
- See My Stats**: Visit the reporting page to see your results from previous tests.

Below these options is a 'Back to Map' button. The background map shows a hierarchical structure of circular nodes representing different mathematical topics. On the right side of the map, there is a legend with two entries:

- 1 Describes simple patterns verbally
- 2 Describes simple patterns using diagrams

MATH-MAPPER 6-8



Tasks Designed to Maximize Learning

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Tomato Seeds

Jeremiah planted 40 tomato seeds from the Fast Grow Seed Company in a new garden. He recorded how many days it took for each plant to sprout. He displayed his data in the dot plot below.

Dot Plot of Tomato Seed Sprouts by Day

| Days | Seed |
|------|------|
| 6 | 2 |
| 7 | 5 |
| 8 | 6 |
| 9 | 4 |
| 10 | 9 |
| 11 | 6 |
| 12 | 6 |
| 13 | 1 |
| 14 | 1 |

Four Data Shapes


A.

B.

C.

14. If Jeremiah planted another 40 seeds and counted the days until they sprouted, choose the the data shape that would best represent his new data.

- ☐ Shape A
- ☐ Shape B
- ☐ Shape C
- ☐ Shape D



Assessments: Student Reports, Student Responses, Promoting Reflection, Discourse, and Learning

Assessment Conditions for Instructional Guidance

Assessment Results must be:

- Timely
- Systematic for all students
- Accurate
- Relevant to what is being taught
- Informative about student progress
- Precise
- Can be taken multiple times

Diagnostic Assessment Features

- Practice Tests focus on each construct and its learning trajectory
- Focus on *conceptual* issues of understanding
- “Real Tests” focus on a Cluster to avoid over-testing
- Each test: 10 items; about 30 minutes
- Coordinated with curriculum
- Used formatively to guide/support instructional decision-making
- Machine-generated, scored immediately

Tasks Are Designed to be Diagnostic



Tasks and items were designed to:

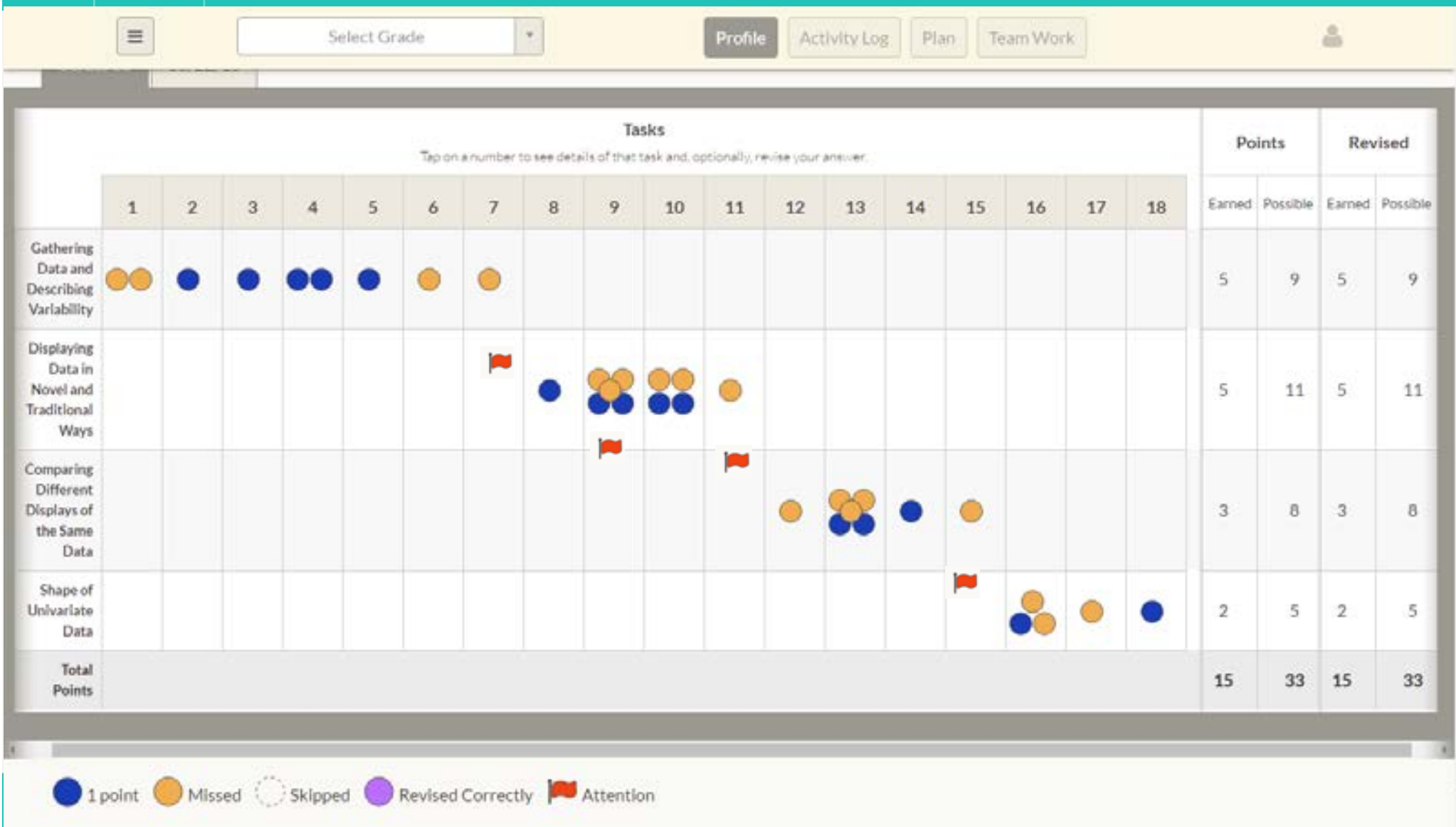
- differentiate between low, intermediate, and pro levels of performance as defined by the Learning Trajectory
- Measure progress along the LT
- Flag misconceptions and systematic errors
- Be consistent with an elaboration document

Feedback Messages Encourage a Growth Mindset



MATH-MAPPER 6-8

Visualize Score Patterns and See Misconceptions



MATH-MAPPER 6-8

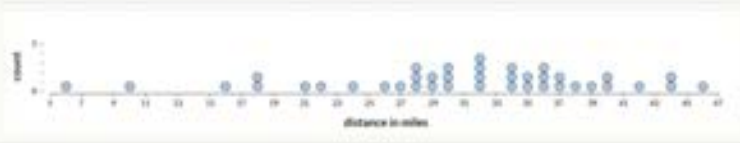
Reveal the Key, Revise or Defend an Answer, Give and Receive Commentary

Test 6, 03/02/16 Question 3 of 14 Points Earned: 0 Points Possible: 1

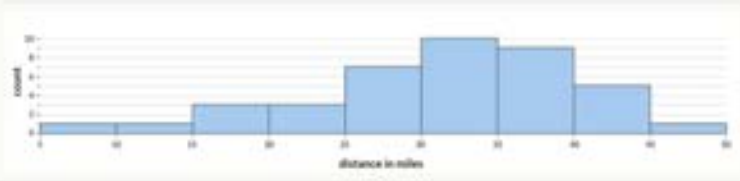
The Bicycle Competition (Part 3 of 5)

The histogram below is based on the same data as the dot plot.

Dot Plot 1. Distances Traveled (in Miles) on the First Saturday of the Month



Histogram 1. Distances Traveled (in Miles) on the First Saturday of the Month



3. Choose the display that shows the farthest distance a bicyclist traveled.

Your Original Answer

Histogram 1

Revise Your Answer

☐ Dot plot 1

☒ Histogram 1

I'm done

Defend Your Answer

I'm done

Reveal Correct Answer

You May Want to Know

The bins of a histogram hide specific numbers.

Teacher's Comments

Test 247
02/08/16

Test 26
03/02/16

Gathering Data and
Describing Variability

Displaying Data in
Novel and Traditional
Ways

Comparing Different
Displays of the Same
Data

Shape of Univariate
Data

Total Points

7 14 7 14

LEGEND: ● 1 point ○ Missed ○ Skipped ● Revised Correctly ■ Attention

MATH-MAPPER 6-8

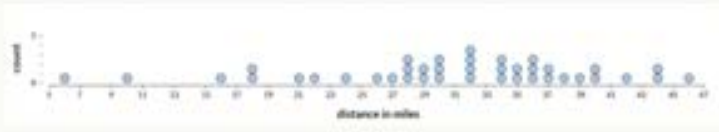
Give and Receive Commentary

Test 6, 03/02/16 Question 3 of 14 Points Earned: 0 Points Possible: 1

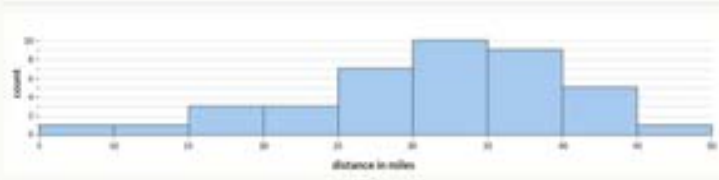
The Bicycle Competition (Part 3 of 5)

The histogram below is based on the same data as the dot plot.

Dot Plot 1. Distances Traveled (in Miles) on the First Saturday of the Month



Histogram 1. Distances Traveled (in Miles) on the First Saturday of the Month



3. Choose the display that shows the farthest distance a bicyclist traveled.

Your Original Answer

Histogram 1

Revise Your Answer

☐ Dot plot 1

☒ Histogram 1

I'm done

Defend Your Answer

I'm done

Reveal Correct Answer

You May Want to Know

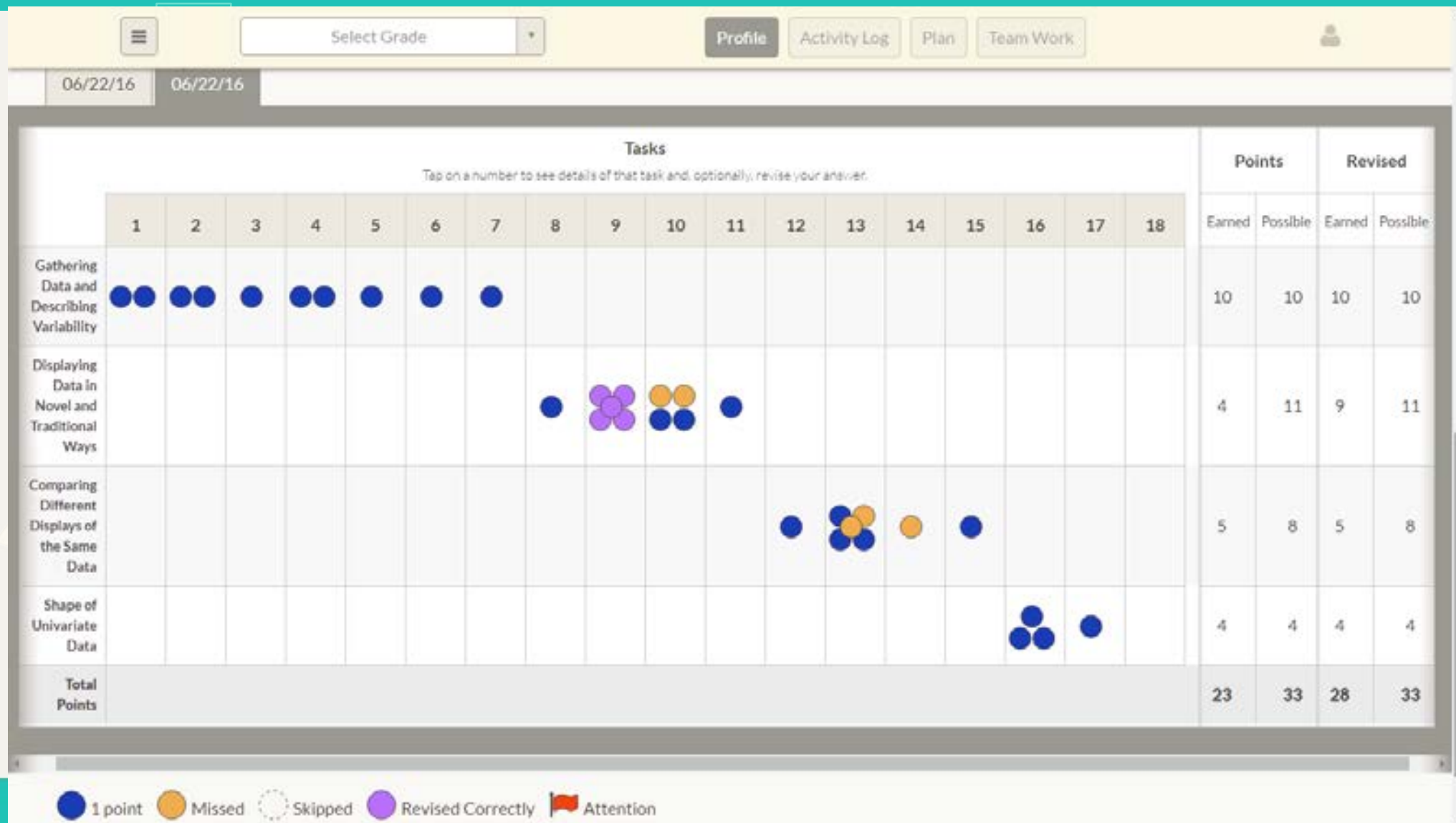
The bins of a histogram hide specific numbers.

Teacher's Comments

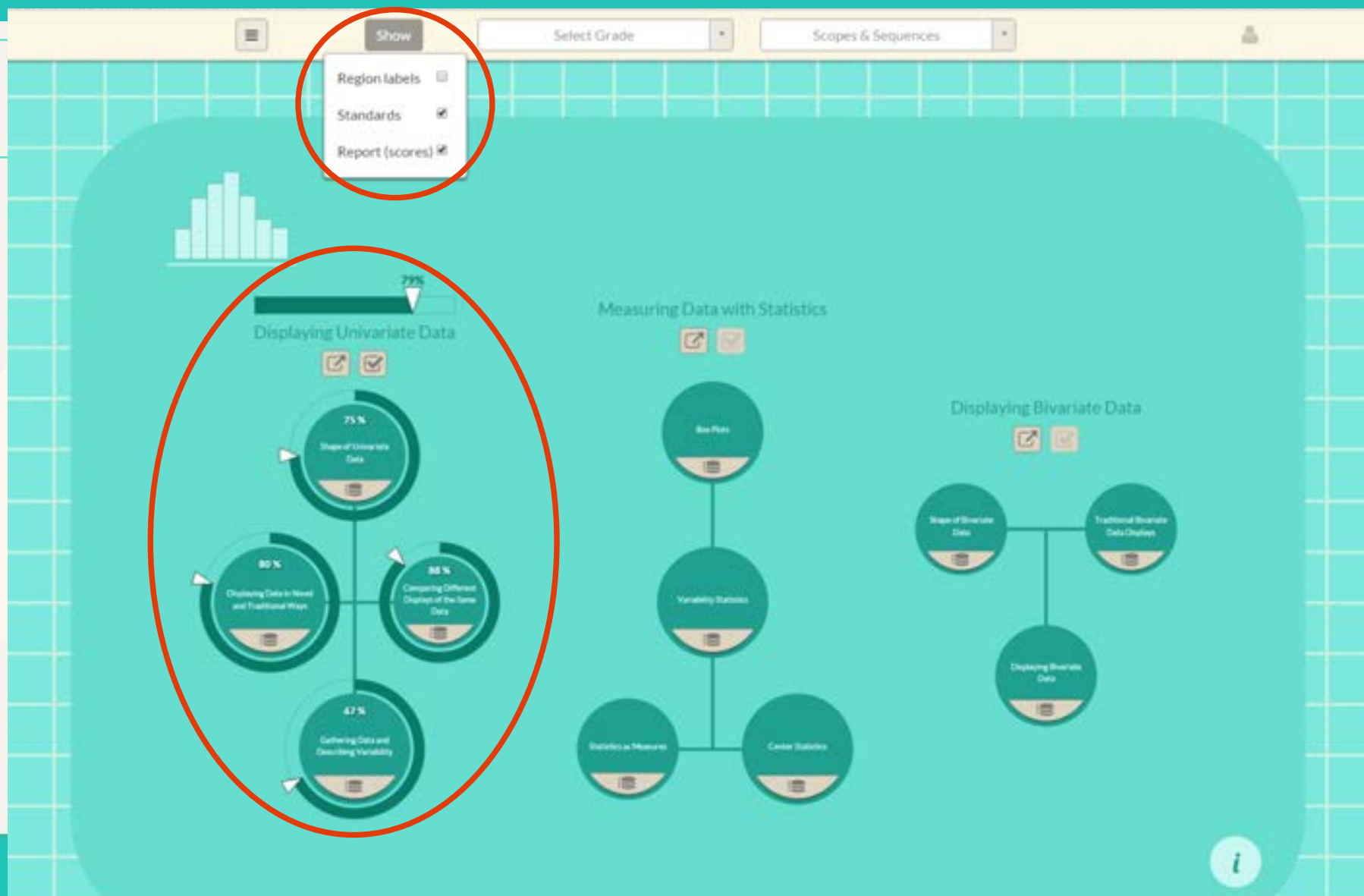
LEGEND: 1 point Missed Skipped Revised Correctly Attention

MATH-MAPPER 6-8

See the Results of Revisions



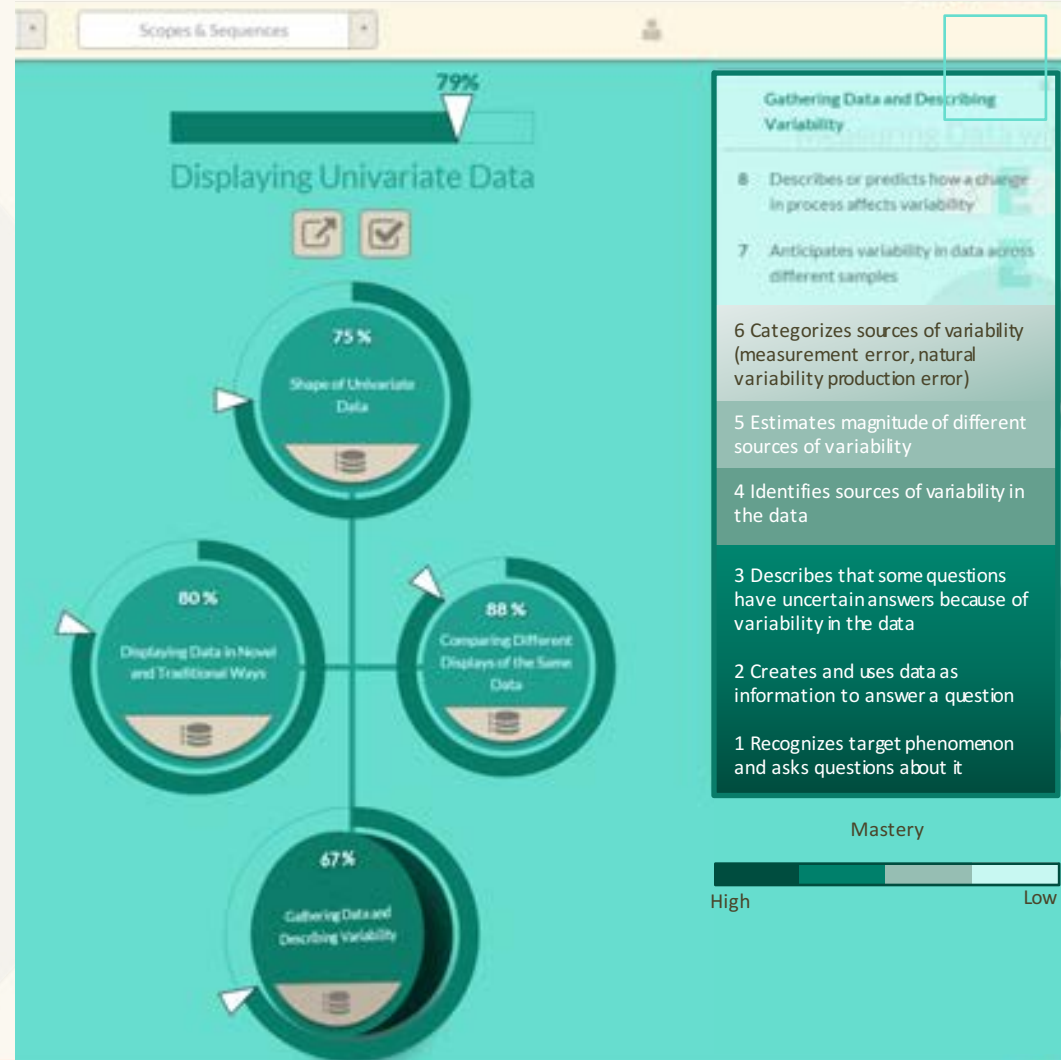
Visualize Score Profiles on the Map



MATH-MAPPER 6-8

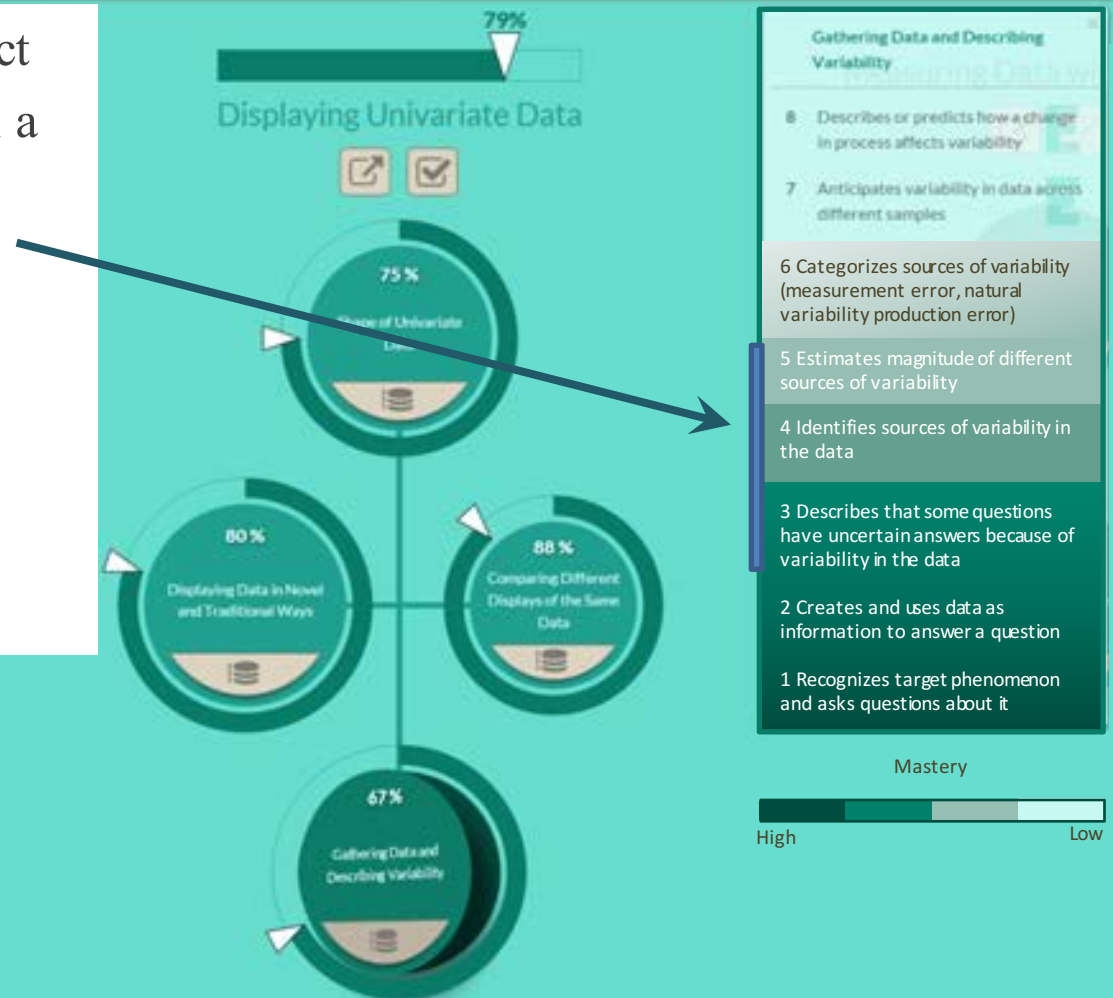
Locating Student Position in the Learning Trajectories


- LTs give a foundation on which we can place our IRT models
- Data modeling is confirmatory in nature
- Theories can be disconfirmed, theories can be improved, and retested through a research agenda
- The LT provides an interpretive framework for scores



Locating Students in the Learning Trajectories

- Students see percent correct by construct
- Students are also placed on the LT with a confidence interval identified
- Percent correct by construct permits students to know where to concentrate construct work
- LT location allows student to know qualitatively what they need to learn





Assessments: Teacher Reports. Using Data to Monitor Class Progress and Guide Instruction and Grouping

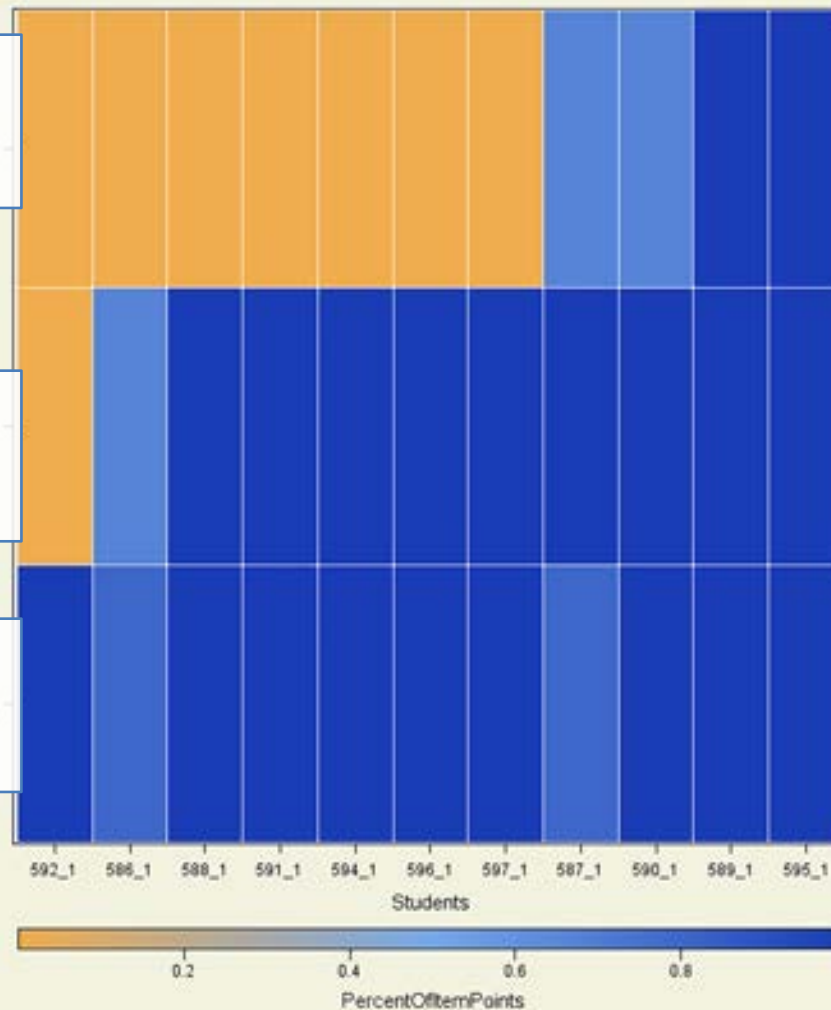
Math-Mapper 6-8: Teacher Reports ("Heat Maps")

Vertical axis:
Levels and Items

Prime factors to
find base ratio

Finds base ratio for
even/odd or odd
values

Finds base ratio for
even values



Teacher Reports:
visual display of
entire class's
performance on all
items for a single
construct

Color Code:

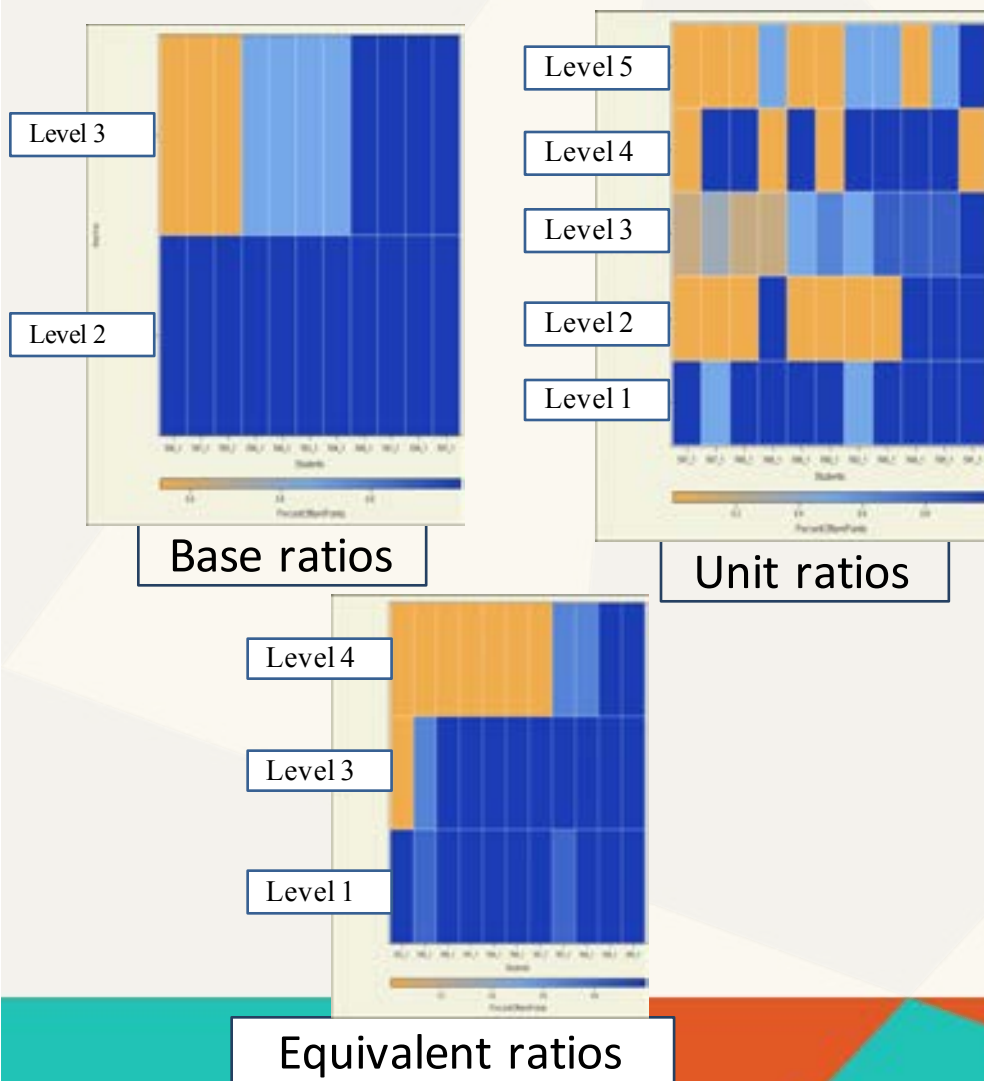
Shades of blue:
partially/fully correct

Orange:
incorrect

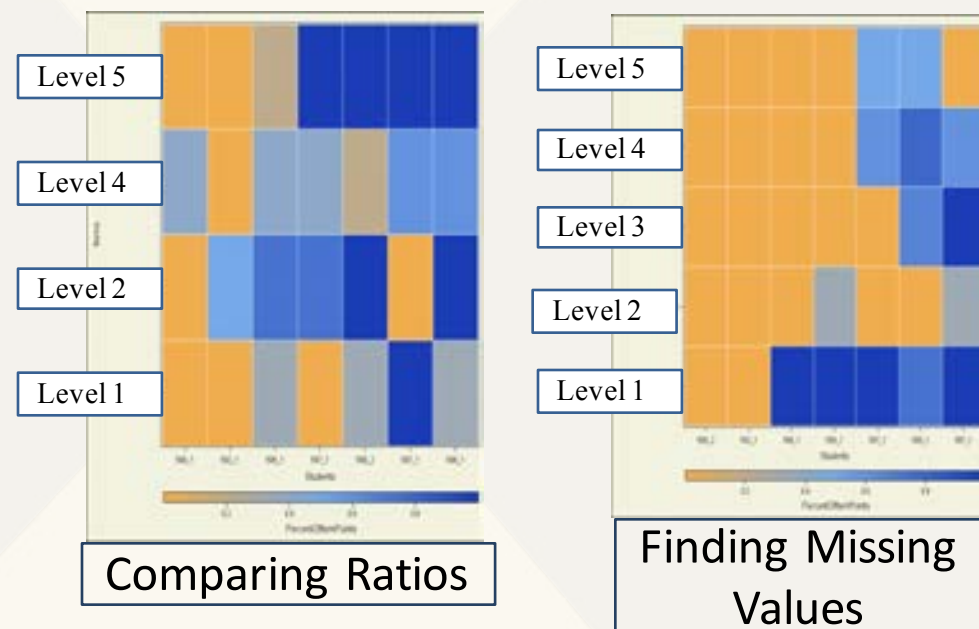
Horizontal axis: students, (total performance on
all items from left to right)

Results for One Sixth Grade Class Across 2 RLCs

1. Finding Key Ratio Relationships



2. Comparing Ratios and Solving Missing Values in Proportion

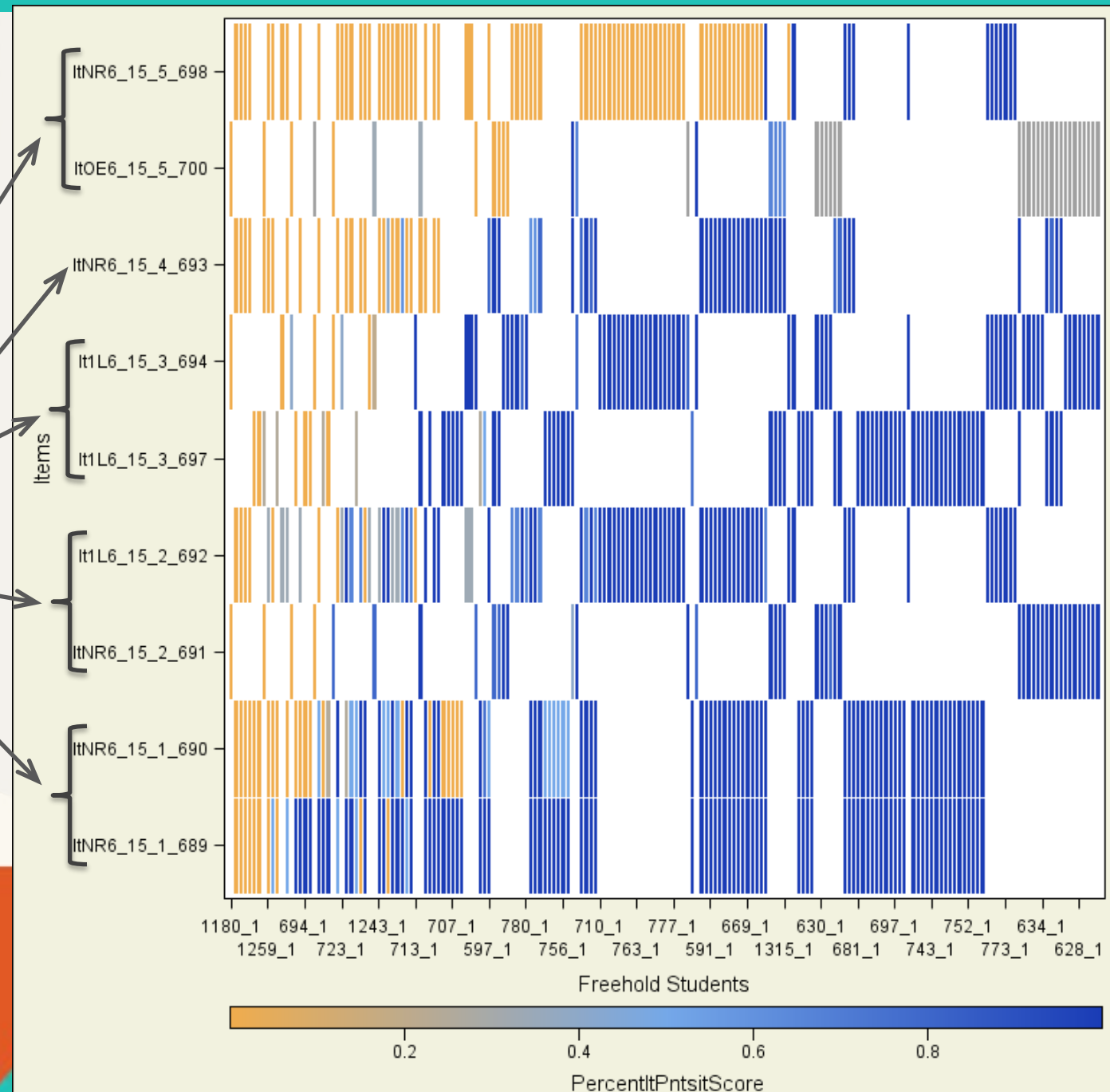


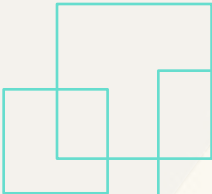

School Level Results for a Single Construct

Construct 15 (Benchmark Percents)

Learning Trajectory Levels

- 5) From percent and its value, finds number in a collection
- 4) Finds percentage of a number with benchmarks
- 3) Understands 25%, 75%, 10% and 1%
- 2) Understands 50%
- 1) 100% is all; 0% is none



- 
- Challenges and Dilemmas. A New Approach
 - Components of a Digital Learning System (DLS)
 - Demonstration: Math-Mapper 6-8 DLS
 - What we have learned from our partnerships
 - Opportunities for Future Partnerships
- 

Using LTs to Drive Professional Development

- Teacher training on the learning map
- Students took diagnostic assessments
- Teachers reviewed results
- A two-week collaborative design study on the introductory clusters in statistics
 - Displaying Univariate Data
 - Measuring Data with Statistics

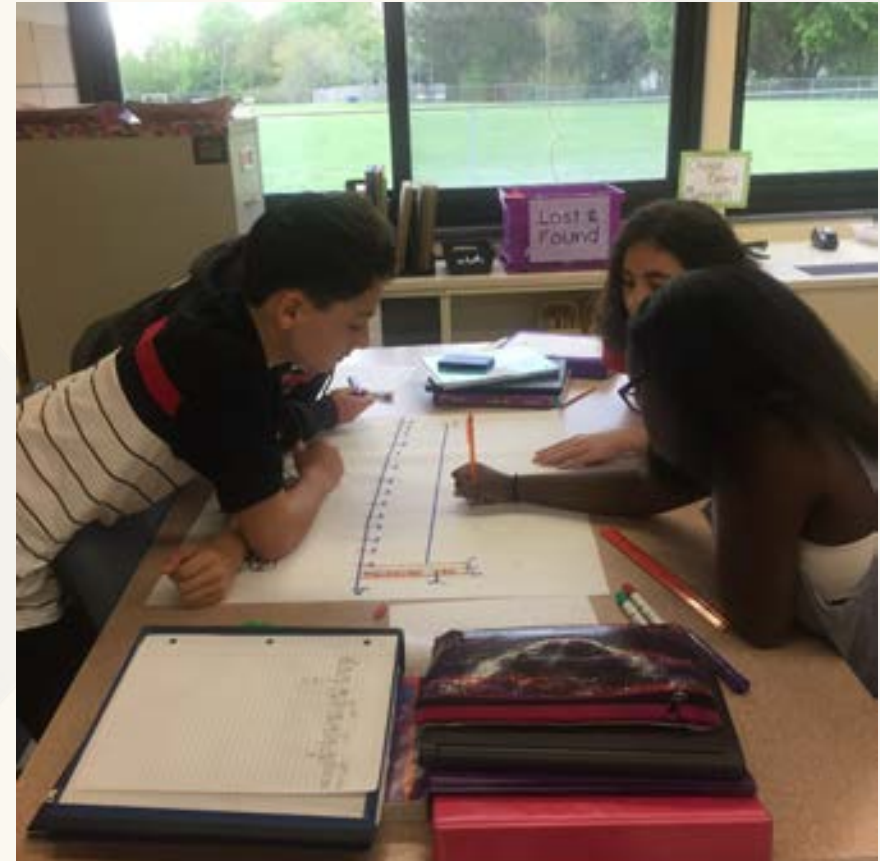
Impact on Student Engagement

- Provide students with open-ended tasks that elicit ideas
- Shift the classroom environment to allow students to express and explore their ideas
- Trust the students
- Include opportunity to learn for all students



Positive Classroom Culture (Margaret Heritage)

- Mutual trust
- Intellectual rigor
- Expectation that ALL students learn
- Shared responsibility for learning
- Models of positive interactions
- Supportive, collaborative relationships



Impact of Immediate Feedback to Students

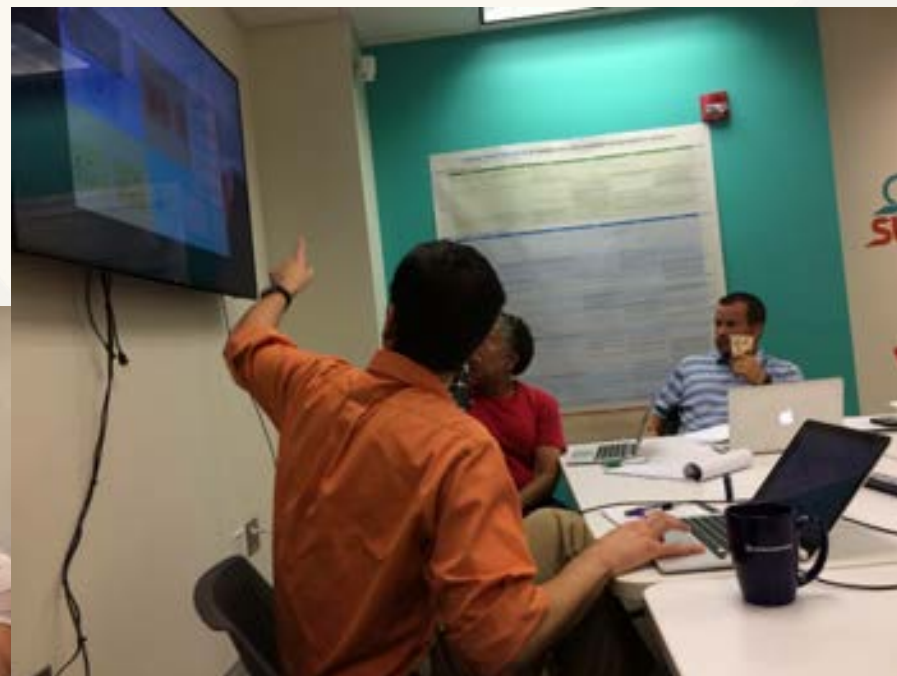
- Students take ownership of their results



Teacher Collaboration Around LTs

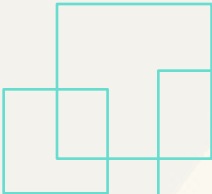

- Teachers discussed evidence of student learning through the LTs
- This impacted their planning the next day's instruction
- The LTs framed their conversations around student learning

Lab Sites



How Kids Create Their Own Knowledge

- The main topic of the debriefing session
- Questions
 - How you pose the question?
 - How do you support students without giving the answer?
 - How do you NOT say too much?
 - How do you help students hear each other's contributions?
 - How do you make sure your mathematical goal is being met?

- 
- Challenges and Dilemmas. A New Approach
 - Components of a Digital Learning System (DLS)
 - Demonstration: Math-Mapper 6-8 DLS
 - What we have learned from our partnerships
 - Opportunities for Future Partnerships
- 

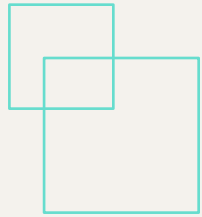
Summary: How our DLS Can Help to Close Gaps

Learning trajectories...

-coupled with professional development, can better prepare less-experienced teachers to plan, prepare for, and instruct students.
- ...and the tests span below-grade giving teachers good leads on foundational gaps that need to be addressed if progress is stymied.
- ... and the tests span above-grade giving teachers the freedom and support to move advanced students above grade.
- ...are aligned with the common core state standards in Mathematics, but *are meaningful without reference to the CCSS.*
- Links provide previously vetted, high-quality open-ed (free) learning materials that align with Learning Trajectories.

Summary: How our DLS Can Help to Close Gaps

- Variety of item types: interesting contexts, engaging visuals, and partial credit scoring that are sensitive to a wide range of student ability levels, keeping students motivated when grappling with challenging problems.
- Item readability is at or below the targeted grade levels. (Items will undergo a bias and sensitivity review in the near future.)
- Growth mindset is supported throughout our design.
- Heatmaps provide a means for teachers to group students according to instructional need.



Partnership Opportunities: and Committments

Piloting Math-Mapper 6-8 during 2016-2017



1. Align curriculum
2. Get student and teacher lists in the system
3. Provide fundamental professional development in use of system (1 day)
4. Commit to give assessments and share data
5. At no cost during pilots

For Further Information, Contact:

- Jere Confrey, Ph.D., Founder and President
jere.confrey@TheMathDoor.com
jere_confrey@ncsu.edu
- Alan Maloney, Ph.D., Vice-President
alan@TheMathDoor.com

To see the Map with one embedded assessment: sudds.co



MATH-MAPPER 6-8