MODULE(S²)

Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

# Engaging Statistics Teachers through Connections to the Teaching of School Statistics and Educational Equity Issues

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Melody Wilson, University of Michigan

*eCOTS Workshop*

*May 21, 2020*

APLU MTE-Partnership Mathematics Teacher Education Partnership

NSF

# Poll

- What best describes your role?
  - * K-12 Teacher
  - College statistics instructor
  - College mathematics teacher educator
  - Graduate statistics student
  - Other

# *Engaging Everyone*

## Pre-service mathematics teachers

- Important part of the ‘everyone’ that this eCOTS theme embraces
- Connect to the teaching of school statistics through purposeful choice of content topics, datasets, school teaching artifacts, & lessons that develop their knowledge of how students learn statistics
- Active learning & equitable teaching practices serve as a model for future teaching

## Use statistics to examine equity and social justice issues

- Brings statistics closer to lived experiences of all students
- Potential for future use to make a difference in the world is motivational
- Very important for pre-service mathematics teachers to develop critical statistical literacy and see as model for use when teaching

# Setting the Context

- **US Curriculum**: Higher expectations for statistical content in secondary schools
- **Teacher Education**: Greater emphasis on learning based on practices of teaching & equity literacy; very limited resources for statistics teacher education
- **New Teachers**: Feel least prepared to teach statistics and demonstrate weak content understanding (Lovett & Lee, 2017; 2018)

Association of Public & Land-grant Universities

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# MODULE(S$^2$)

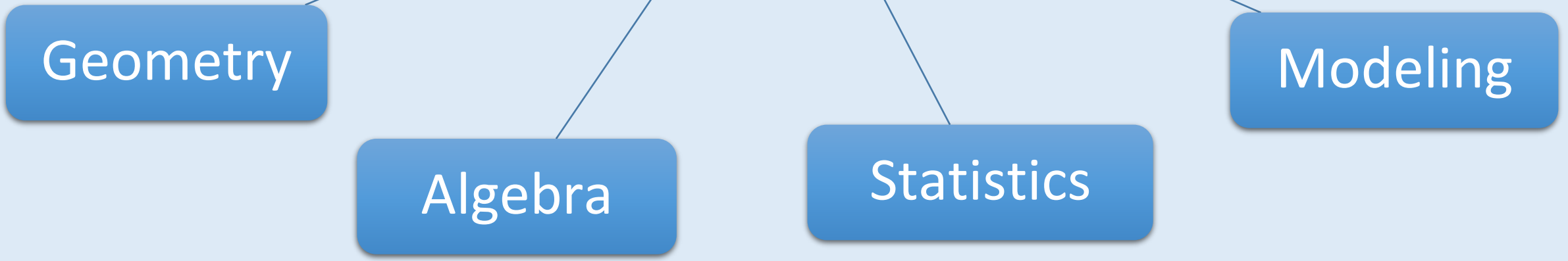
## Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

The University of Arizona | Eastern Michigan University | Middle Tennessee State University | University of Nebraska Lincoln | Utah State University

The Mathematics Of Doing, Understand, Learning, and Educating Secondary Schools (MODULE(S2)) project is made possible through funding from the National Science Foundation IUSE (Improving Undergraduate STEM Education) multi-institutional collaborative grant #1726707 (APLU), #1726098 (University of Arizona), #1726252 (Eastern Michigan University), #1726723 (Middle Tennessee State University), #1726744 (University of Nebraska - Lincoln), and #1726804(Utah State University).

# MODULE($S^2$)

University Mathematics Course Materials with an MKT focus



# Statistics Writing Team

MODULE(S²)
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*To facilitate connecting content with the practice of teaching, writing teams consist of…*

**STATISTICIAN:** Dr. Andrew Ross, statistics professor at Eastern Michigan University, background in operations research

**MATHEMATICS EDUCATOR**: Dr. Stephanie Casey, mathematics teacher educator at Eastern Michigan University, former AP Statistics teacher, researcher in statistics education

**GRADES 6-12 MATHEMATICS TEACHER:** Samantha Maddox, math teacher at Jefferson High School in Georgia, former AP Statistics teacher

**OTHER CONTRIBUTORS**

Melody Wilson: graduate research assistant, former high school mathematics teacher

# Organization and Content

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

Organized into 3 modules, which if taught together would become the curriculum for a 3-credit hour statistics course

**MODULE 1: Study Design & Exploratory Data Analysis**

**MODULE 2: Statistical Inference**

- Simulation-based & Classical procedures
- Confidence intervals & hypothesis tests

**MODULE 3: Statistical Association**

- Categorical & Quantitative

# STANDARDS FOR PREPARING TEACHERS OF MATHEMATICS

AMTE

ASSOCIATION OF MATHEMATICS TEACHER EDUCATORS

# AMTE's *Standards for Preparing Teachers of Mathematics*

## Fundamental Assumption #1

**Ensuring the success of each and every learner requires a deep, integrated focus on equity in every program that prepares teachers of mathematics**

# AMTE Standard C.4

## STANDARD C.4. SOCIAL CONTEXTS OF MATHEMATICS TEACHING AND LEARNING

Well-prepared beginning teachers of mathematics realize that the social, historical, and institutional contexts of mathematics affect teaching and learning and know about and are committed to their critical roles as advocates for each and every student.

| Indicator | Description |
| --- | --- |
| C.4.1 Provide Access and Advancement | Well-prepared beginning teachers of mathematics recognize the difference between access to and advancement in mathematics learning and work to provide access and advancement for every student. |
| C.4.2 Cultivate Positive Mathematical Identities | Well-prepared beginning teachers of mathematics recognize that their roles are to cultivate positive mathematical identities with their students. |
| C.4.3 Draw on Students' Mathematical Strengths | Well-prepared beginning teachers of mathematics identify and implement practices that draw on students' mathematical, cultural, and linguistic resources/strengths and challenge policies and practices grounded in deficit-based thinking. |
| C.4.4 Understand Power & Privilege in the History of Mathematics Education | Well-prepared beginning teachers of mathematics understand the roles of power, privilege, and oppression in the history of mathematics education and are equipped to question existing educational systems that produce inequitable learning experiences and outcomes for students. |
| C.4.5 Enact Ethical Practice for Advocacy | Well-prepared beginning teachers of mathematics are knowledgeable about, and accountable for, enacting ethical practices that enable them to advocate for themselves and to challenge the status quo on behalf of their students. |

# Attention to Equity Literacy

STATISTICS MODULE(S^2) MATERIALS aim to:

- advance preservice teachers' learning related to social contexts of mathematics teaching and learning (**AMTE Standard C.4 Social contexts-all indicators**)
- Increase likelihood to use statistics to uncover and examine equity & social justice issues, both personally and with students (*critical statistical literacy*)
- Improve confidence in teaching equity & social justice topics

MODULE$^{2}$

Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

# Activities

# eCOTS Workshop Sample Activity 1

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

Module 1(Study Design and Exploratory Data Analysis)
Activity 11:Interpreting Graphs

*Teachers will be able to interpret a side-by-side segmented bar graph and critically examine school mathematics tracking practices*

# Sample Activity 1

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools


Pre-service teachers watch this video before coming to class: https://www.youtube.com/watch?v=R4iAwShVIBE

# Sample Activity 1, video clip 2

MODULE(S²)
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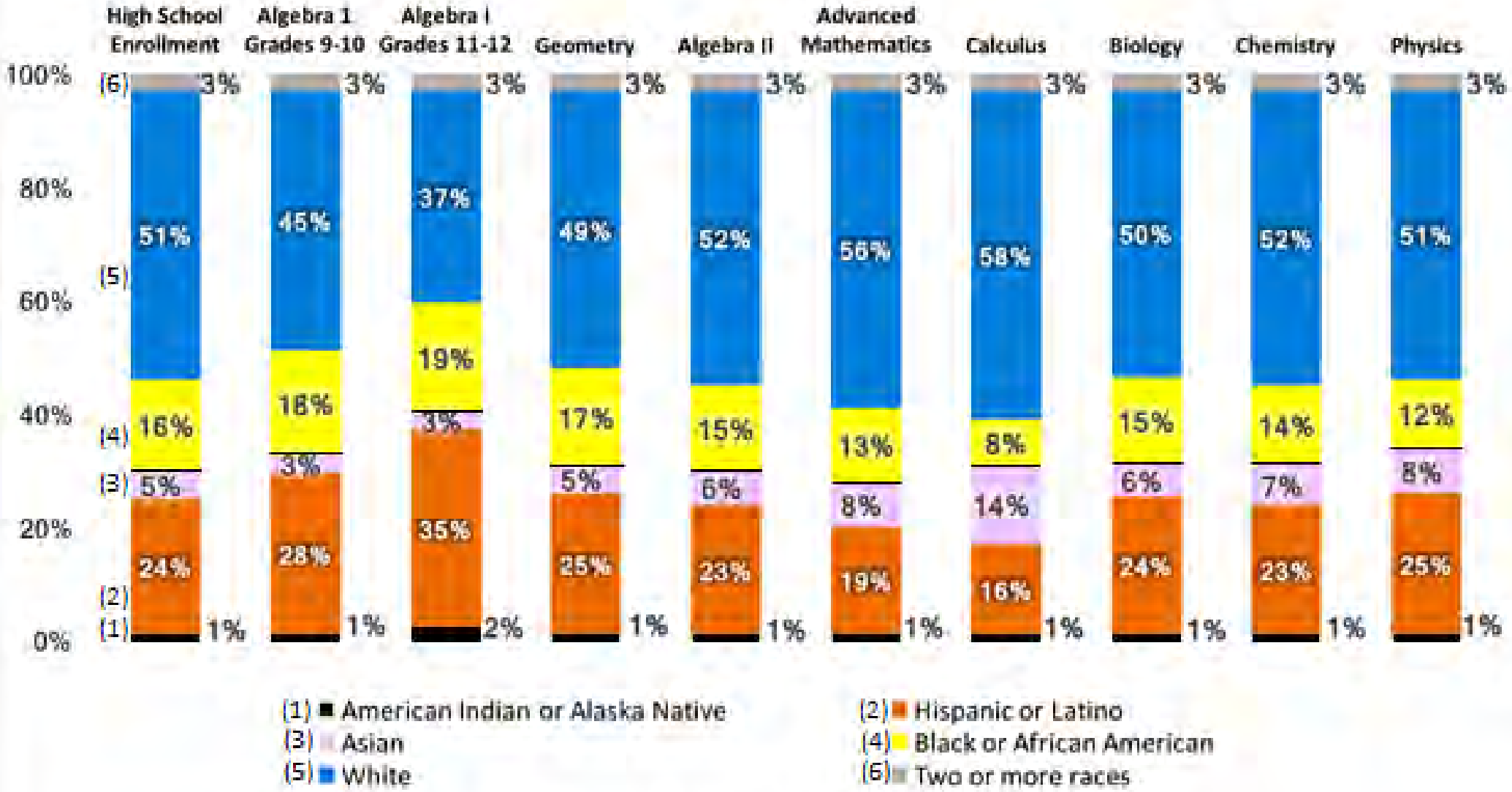
(this slide is redundant in a PDF version of the presentation)

# Sample Activity 1

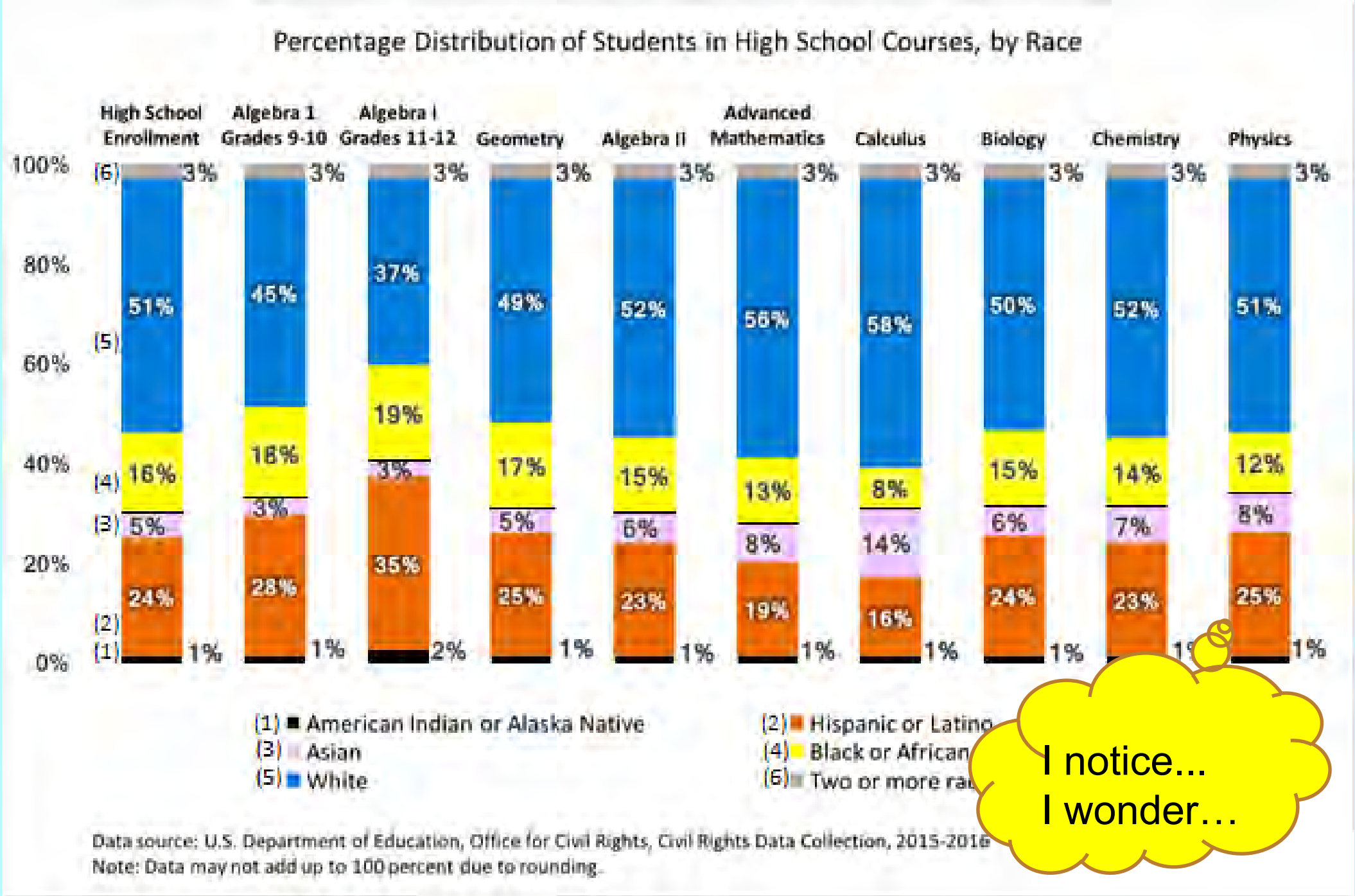
MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

The following graph from an Education Week blog post (Sawchuk, 2018, April 24) displays the percentage of U.S. high school students in math and science courses in 2015-16, by race, along with the racial composition of high schools in general (farthest left bar).

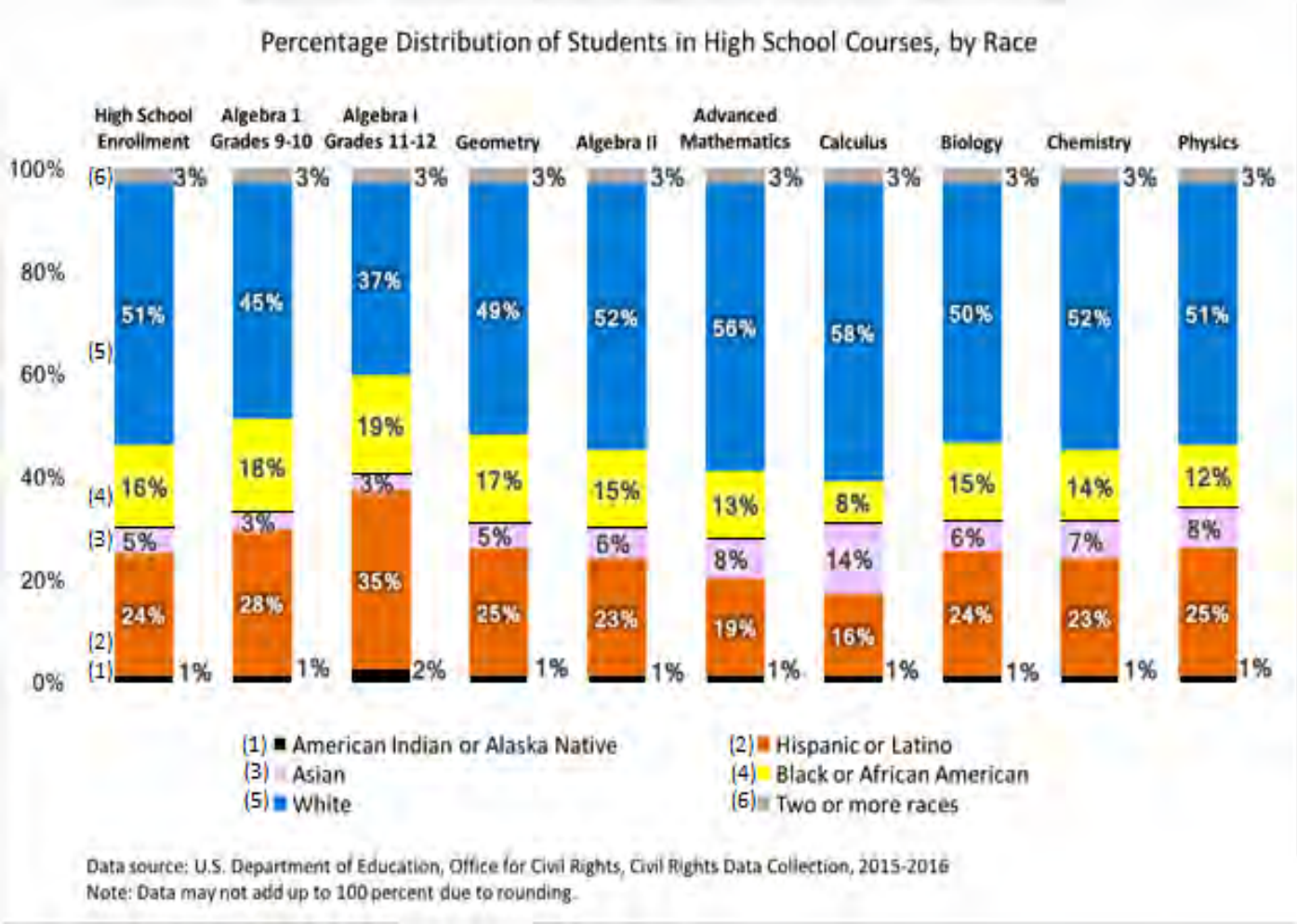
## Percentage Distribution of Students in High School Courses, by Race




Data source: U.S. Department of Education, Office for Civil Rights, Civil Rights Data Collection, 2015-2016
Note: Data may not add up to 100 percent due to rounding.



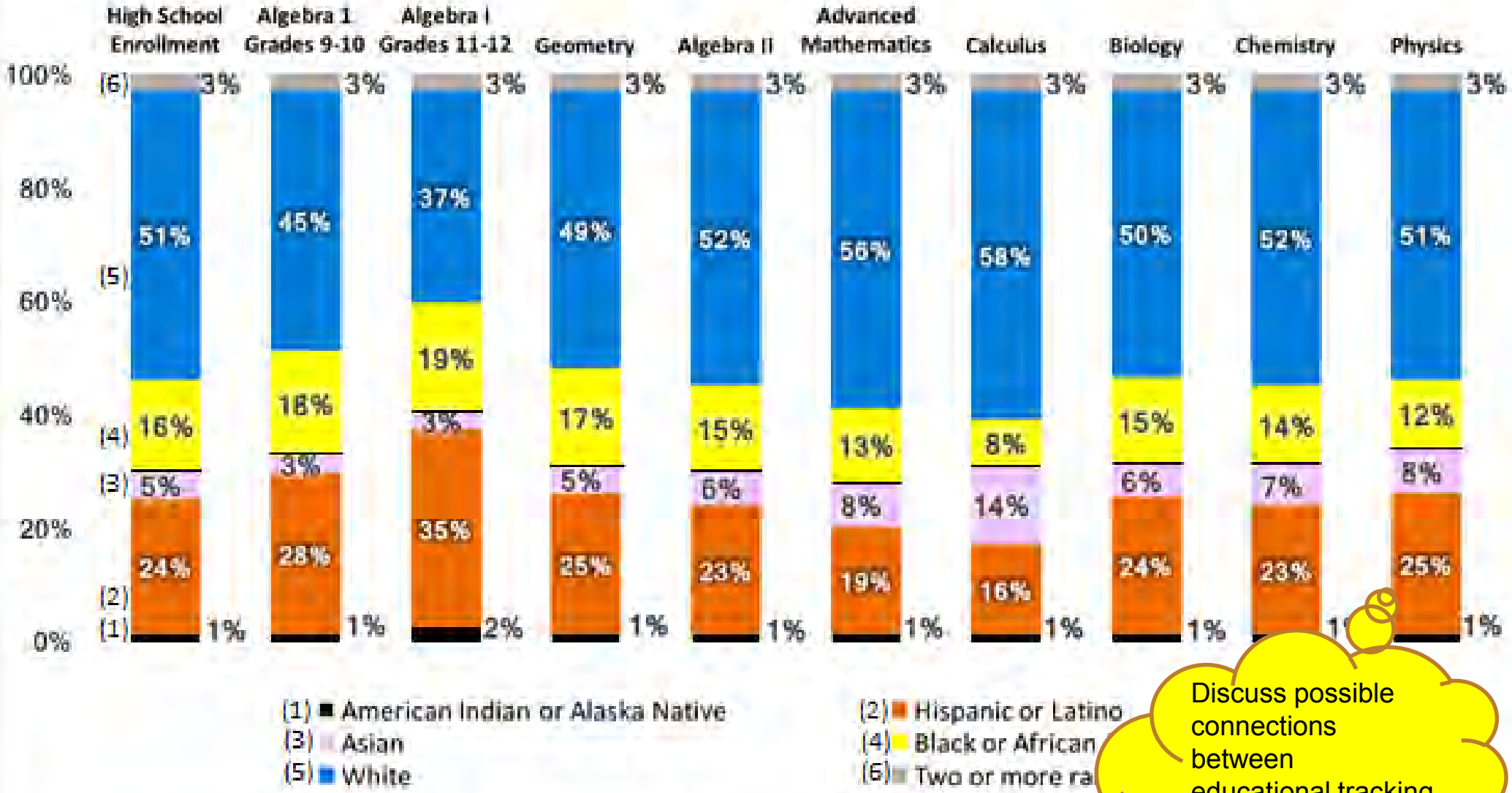

I notice...
I wonder…




In class activity, asked to interpret graph at multiple levels (Curcio framework):
*read data (What percentage of the students in high school physics in the United States are Asian?),
*read between the data (Which high school mathematics and science courses have a higher percentage of Asians enrolled than expected when considering overall high school enrollment composition?)
*read behind the data (Which (if any) of the high school mathematics and science courses have a notably different racial composition than high schools in the United States? What factors might explain that?)

and have courageous conversation with class about this.

## Percentage Distribution of Students in High School Courses, by Race




Data source: U.S. Department of Education, Office for Civil Rights, Civil Rights Data Collection, 2015-201
Note: Data may not add up to 100 percent due to rounding.

Discuss possible connections between educational tracking practices and the data.

# eCOTS Workshop Sample Activity 2

MODULE[S²]
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

## Module 3 (Statistical Association)
## Activity 10: Introduction to Categorical Association

*Pre-service teachers will be able to:*

- *Summarize categorical case data into a two-way table and a segmented bar chart, using CODAP*
- *Interpret two-way frequency tables*
- *Use conditional relative frequencies to describe whether two categorical variables are possibly associated*

- *Consider a common (US) racial stereotype in light of actual data.*

# Activity Launch: Open-Ended

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

- We describe the 2016 US General Social Survey (GSS), and give our pre-service teachers a data extract (n=1134) with demographic variables:
  - Sex, Degree, SpouseDegree, Simplified “Race”, Personal Income, Family Income
- And respondents’ opinions on, among other things,
  - How interested are you in local school issues? (very, moderately, or not at all)
  - Is the nation’s spending on improving the education system too much, too little, or just right?
  - How confident are you in the leaders of our education institutions?
- We ask our pre-service teachers “What interesting statistical questions could you use this data to investigate?”, then small groups agree on a question and investigate it using CODAP to explore the data.

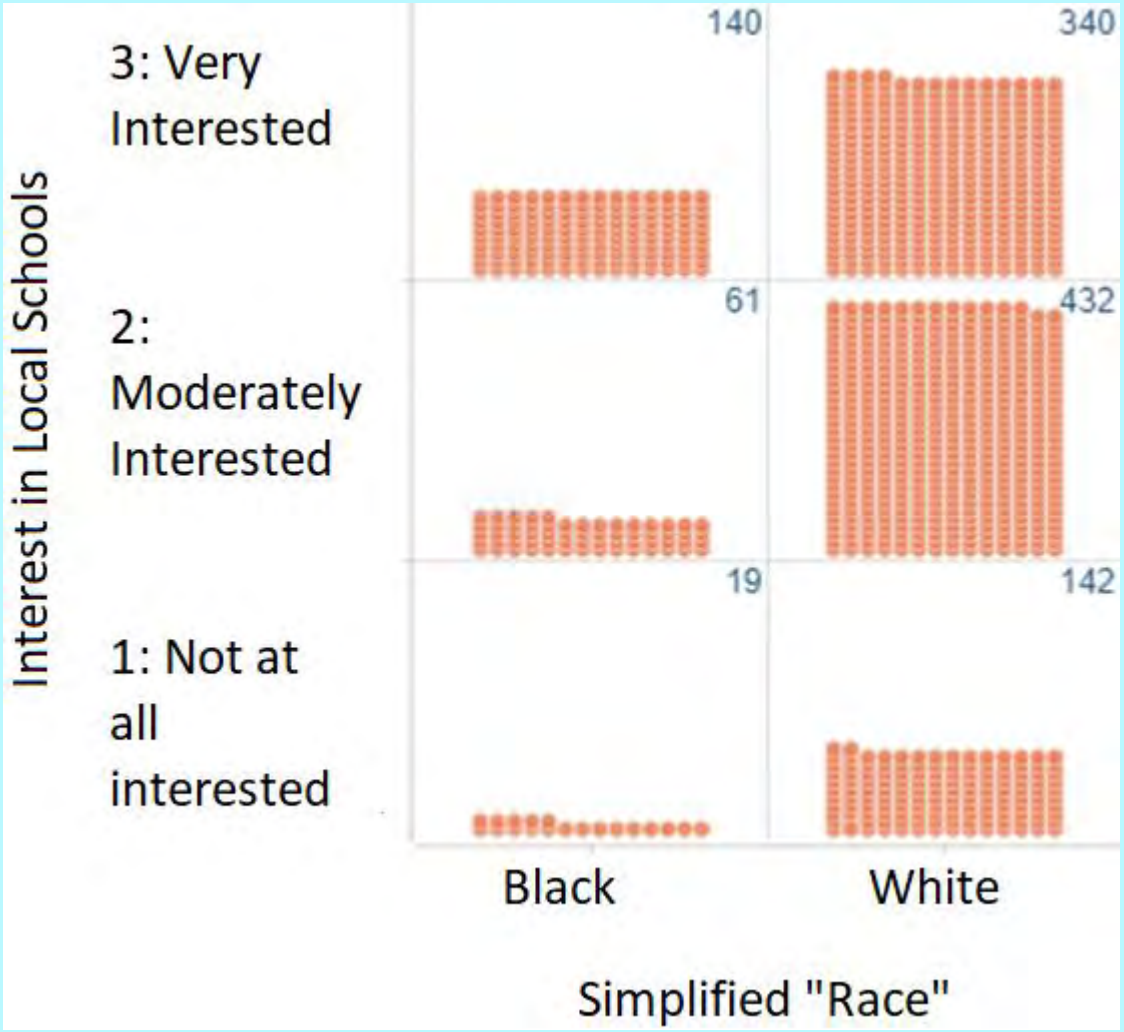
# Activity Focusing

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

- As a class, let's explore a common stereotype that is related to education in our country: that Black families value their children's education less than White families do.

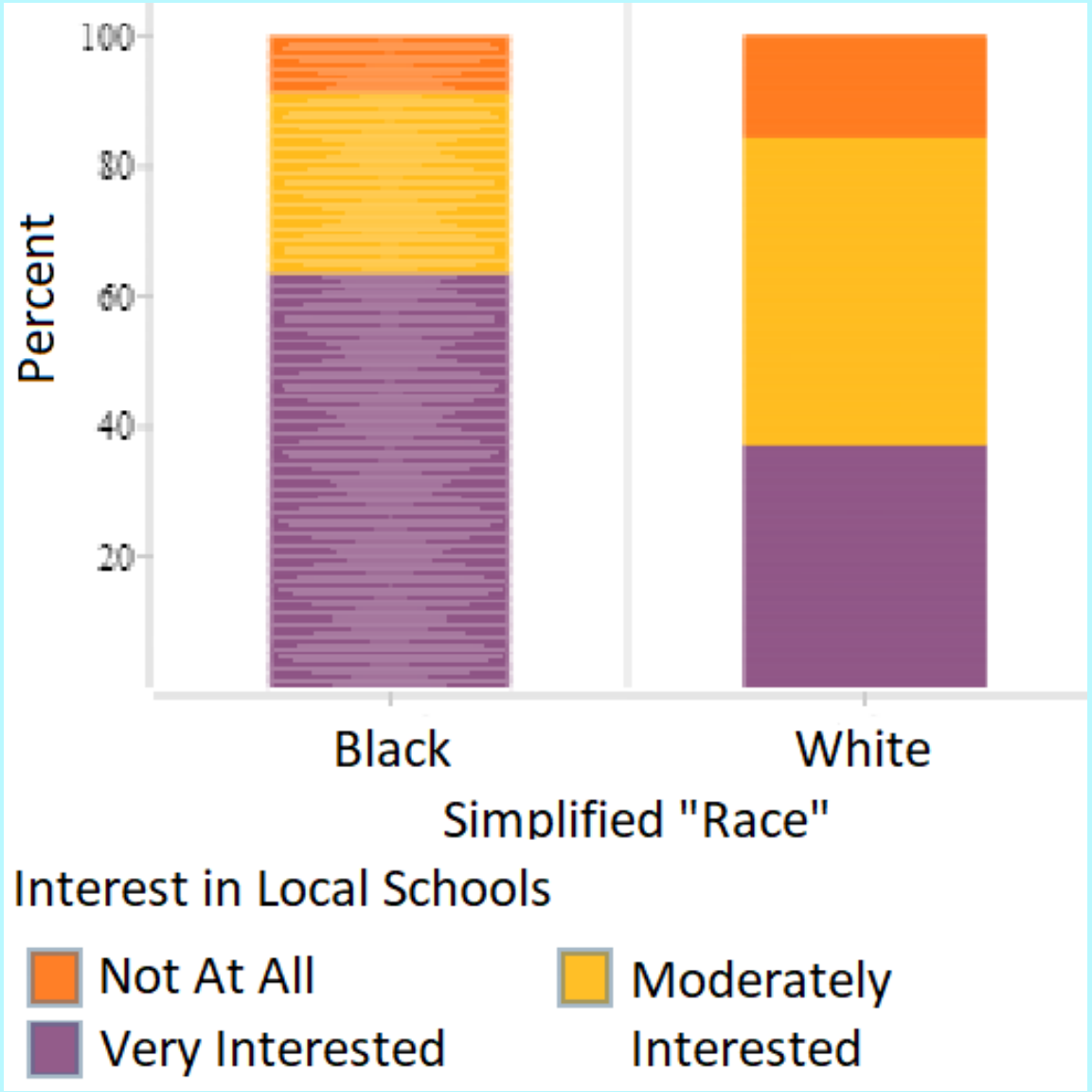
- What does the data set tell you about this idea? Make a graph of the relevant variables. Sketch the graph you made here, and answer: what do you notice?

# First likely graph




- ***Big Question 1***: If a student said "In this graph, 340 White people and 140 Black people are 'very interested' in local school issues, and those numbers aren't the same, so how much they care about local school issues is different.", how would you respond, as their teacher?

# Segmented Bar Graph




- We ask questions that lead to Conditional Relative Frequencies.
- Then, show them how to make this graph.
- And, we define association.
- “Would you say that there is association between the two variables here? Explain.”
- Later, we say: update your list of what is/isn’t influencing racial gaps in income, etc.

# eCOTS Workshop Sample Activity 3

MODULE[S²]
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

## Module 1 (Study Design and Exploratory Data Analysis) Activity 12

- *Pre-service teachers will be able to explain and apply Konold et. al's (2014) case- to aggregate-view framework.*
- *Pre-service teachers will be able to sequence a class discussion of student univariate graphs in the context of a real-life, student-led project.*
- *Pre-service teachers will be able to scaffold student understanding of histograms.*

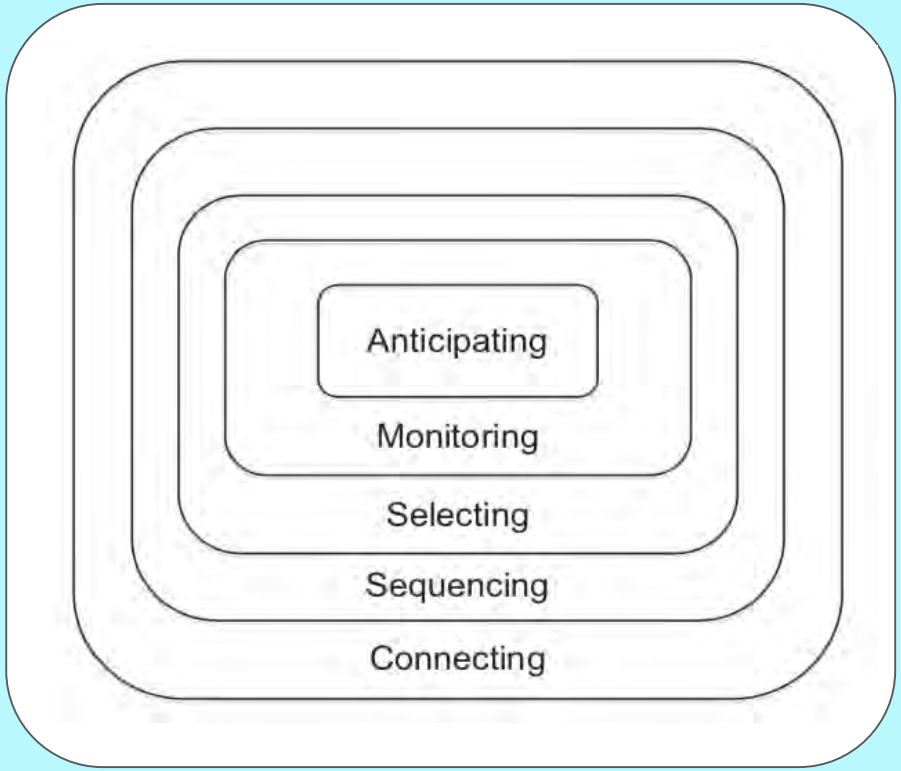
Konold, C., Higgins, T., Russell, S. J., & Khalil, K. (2015). Data seen through different lenses. *Educational Studies in Mathematics*, *88*(3), 305-325.

# Sequencing a class discussion

In this pedagogical activity, future teachers choose how they will sequence a discussion of student work.

- Statistics content goals: Students will be able to create and interpret dot plots, box and whisker plots, and histograms.

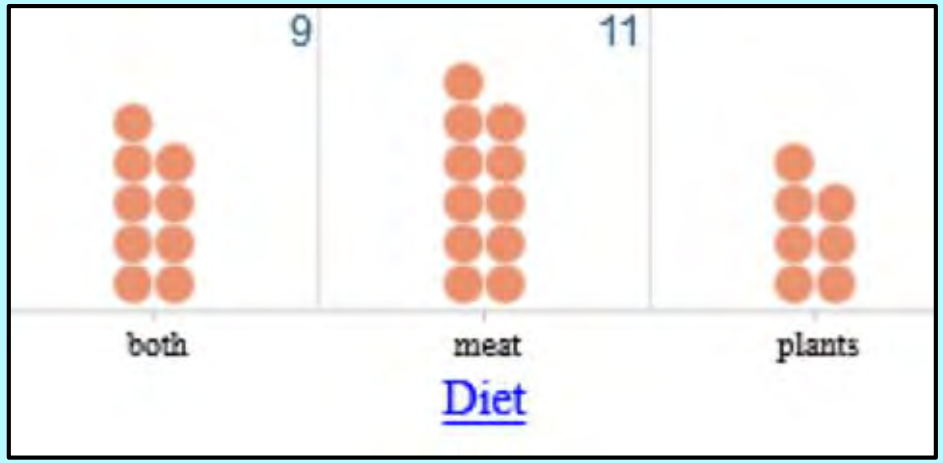
"By making purposeful choices about the order in which students' work is shared, teachers can maximize the chances that their mathematical goals for the discussion will be achieved." (Stein et al., 2008, p. 329)




Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning*, *10*(4), 313–340. https://doi.org/10.1080/10986060802229675

# Case-to-aggregate learning framework (Konold et al, 2014)

Viewed as a hierarchy (from data as case value to data as aggregate), higher levels integrate lower ones and reorganize what one is attending to. However, lower level perspectives should not be viewed as levels to move past ... but as perspectives to learn to use cooperatively with higher level perspectives.




| PERSPECTIVE | DESCRIPTION | STUDENT OBSERVATION OF GRAPH |
|---|---|---|
| **Case Value** | Attend to one particular case, often the student's own, the largest, or the smallest | My favorite mammal is the lion. [Student clicks on lion in data table and point is highlighted in CODAP graph]. Lions eat only meat. |
| **Classifier** | Attend to the frequency of cases with a chosen attribute value | Seven of the mammals eat just plants. |
| **Aggregate** | View the data as an entity with properties that individual cases can't have, such as center, shape, or linear model | Less than half of the mammals eat both meat and plants. |

We asked our future teachers to imagine how a knowledge of statistics could help empower students. https://youtu.be/Hw12xZBpC68

Your students collect the following data from the class on their travel time to school.

| Name | Travel time to school (min.) | Student reapportioned from Southwestern? |
|---|---|---|
| Aidan | 55 | yes |
| Alicia | 8 | no |
| Aliyah | 40 | no |
| Armando | 19 | no |
| Candace | 49 | yes |

. . .

***Question 12-a*** While exploring the data with CODAP, your students make the following graphs (below). Their comments, beside each graph, are made while presenting their graphs to the class.

***i.*** Which students have made case value graphs? _____

***ii.*** Name each type of graph in the space provided.

***iii.*** Number the graphs in the order you will sequence the class discussion, to help students move through a learning progression from a case view to an aggregate view of the data.

In a moment, we will send you to break-out rooms to work through this activity in groups.

Please find the activity at

https://bit.ly/MODULESact3

How did your group choose to sequence the students' work?

Why did you choose this sequence?

Other comments?

# eCOTS Workshop Sample Activity 4

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

## Video Simulation of Teaching Practice

### Module 1 (Study Design and EDA)

Students in your eleventh-grade math class have learned about designing a study and then analyzing the results of that study. For your unit assessment, students will do a project. They must ask a statistical question, design a study, collect data, and then analyze that data. Before they are able to start they must turn in a project proposal to their teacher describing their question and data collection process, as well as briefly describing how they plan to analyze their data and the limitations of their study.

# Video Simulation of Teaching Practice

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

Cameron's proposal:

- Question: Does an energy drink affect the speed of a student?
- Design: I already have 30 student volunteers who are ready to participate. I will have students run once around the track (¼ of a mile). I will record their time in seconds. Then each student will drink the same energy drink. We will wait one hour and each student will repeat the run around the track. I will record their time in seconds again.
- I will make a box plot for the "before" times and another box plot for the "after" times. I will compare the medians and quartiles to determine if the energy drink affected the students' speed. I will also see if there is much overlap between the two box plots.
- Limitations: Since I am only using students from my high school I will only be able to describe if the energy drink caused a difference of speed for students like those at my school. I am using one type of energy drink so my results can only be applied to that energy drink alone.

Our pre-service teachers, as part of their homework, record a video of themselves (a) describing their thoughts about the proposal, and (b) responding to this student.

# eCOTS Workshop Sample Activity 5

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

Module 3 (Statistical Association)
Lesson 1: Considering Student Approaches to Placing the Informal Line of Best Fit

*Teachers will consider advantages and disadvantages to commonly proposed informal methods for fitting a line to data that suggests a linear relationship, crafting responses to students.*

# Sample Activity 5

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

In eighth grade, students begin to learn about association of quantitative variables and place a line of best fit informally (i.e., by eye, without technology) for data that displays a linear association.

*CCSS.Math.Content.8.SP.A.2: Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association,* ***informally fit a straight line****, and* ***informally assess the model fit by judging the closeness of the data points to the line.***

# Sample Activity 5

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

- In Lesson 1, the MODULE(S^2) users learn about common student approaches for placing the informal line of best fit based on my work
    - Casey, S. (2015) Examining student conceptions of covariation: A focus on the line of best fit. *Journal of Statistics Education, 23*(1).

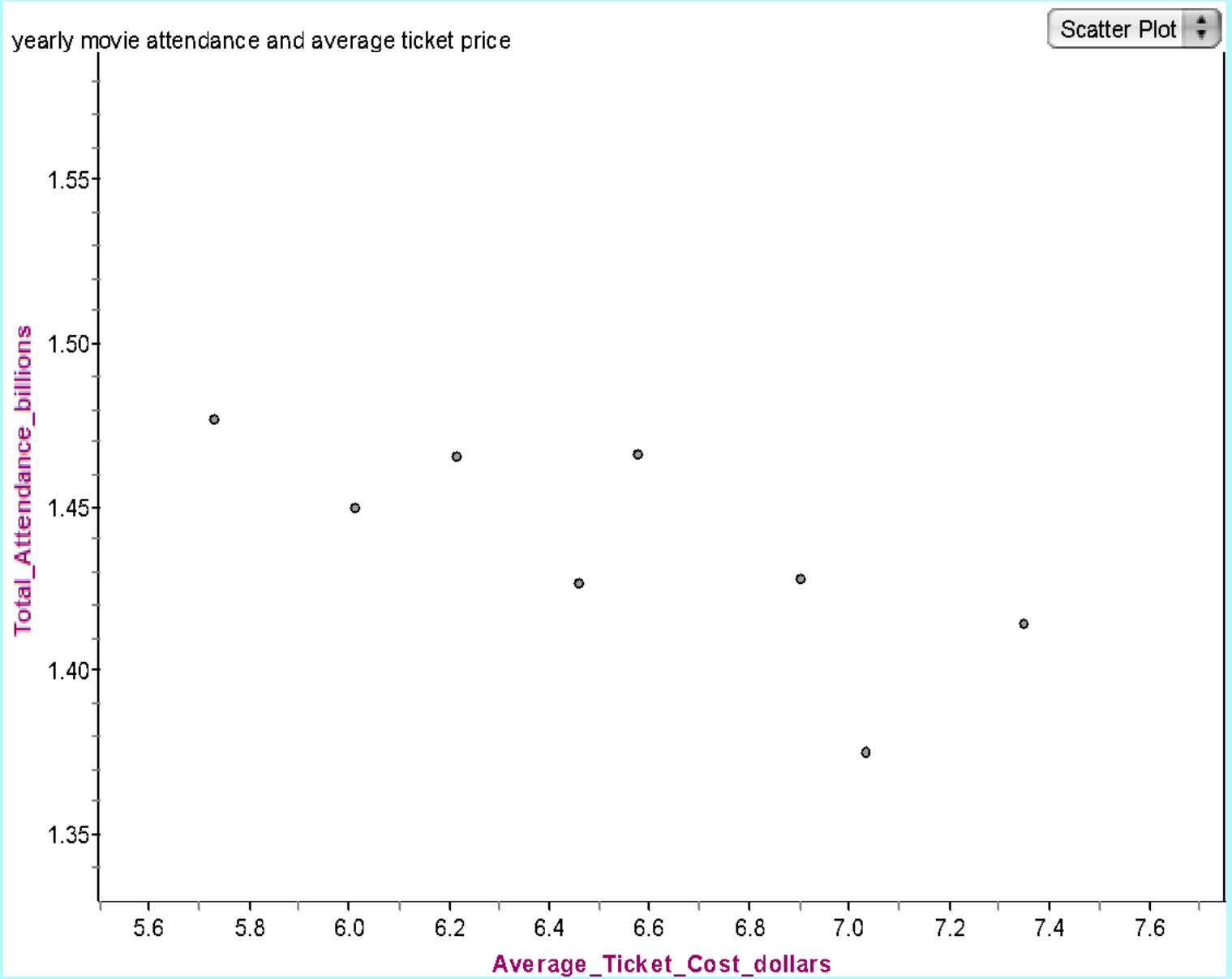
- Users watch videos that depict common student approaches then note what the approach is, potential reasons/sources for the approach, analyze whether the approach is generalizable and if not, draw a counter example
- Craft a response to one of the students
- Plan discussion-based lesson around students' approaches

# Sample Activity 5

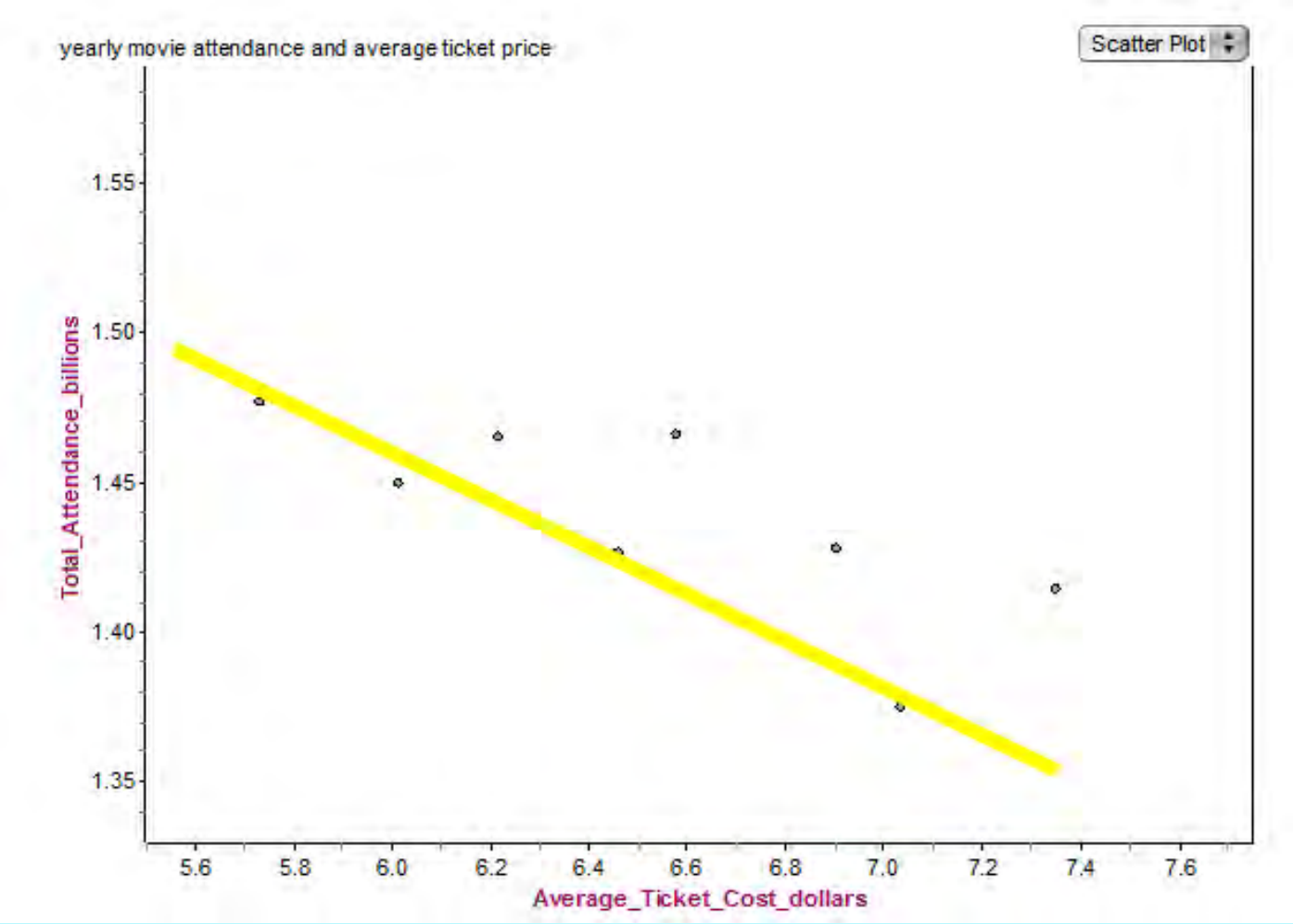
MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

## Video Simulation of Practice:

- Presented with two students' work when placing an informal line of best fit
- Record a video interpreting each student's work and explanation and provide a response in the role of the teacher.

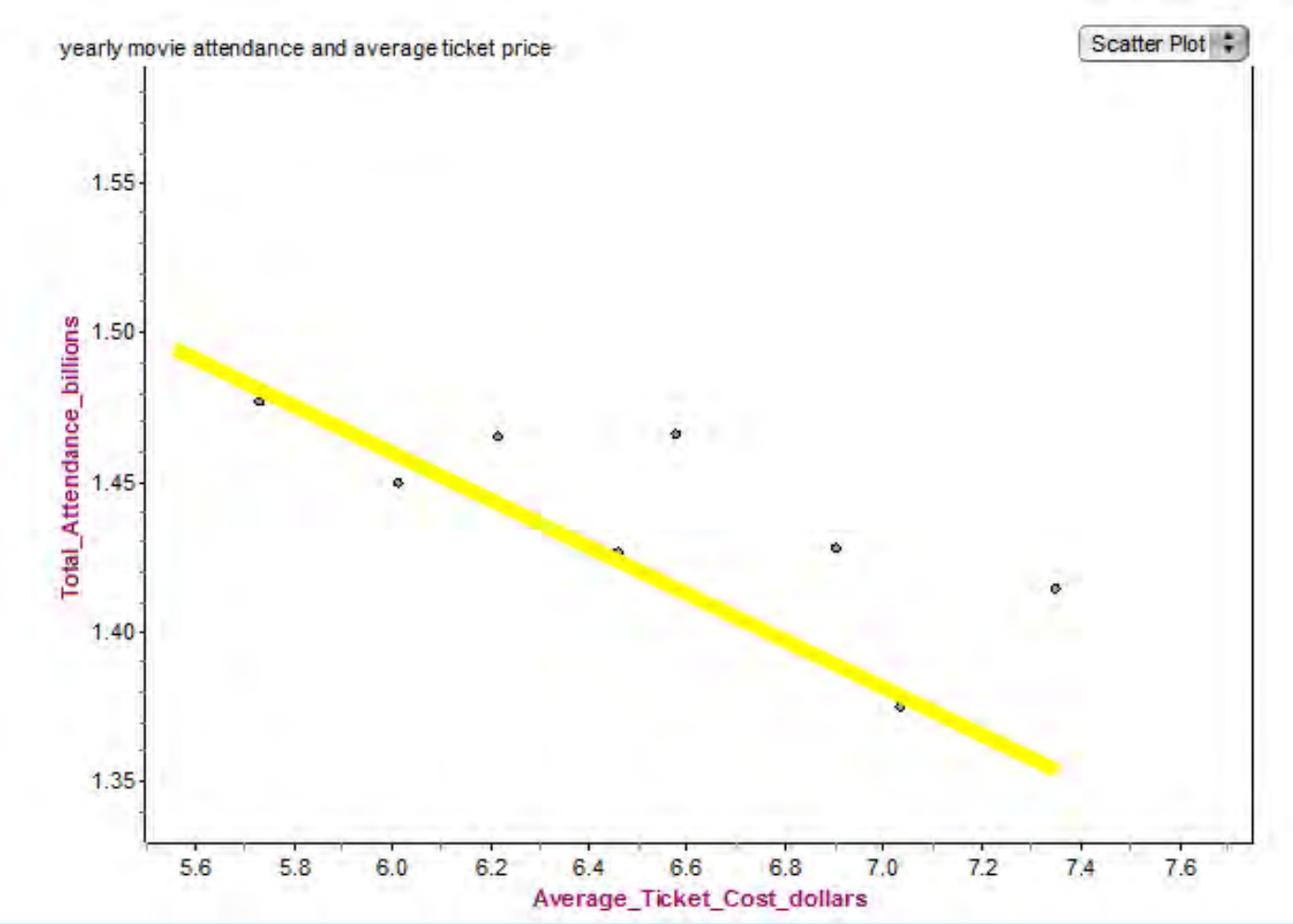

yearly movie attendance and average ticket price
Scatter Plot
Total_Attendance_billions
1.55
1.50
1.45
1.40
1.35
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
7.6
Average_Ticket_Cost_dollars

# Martha’s response




**I was trying to get the spaghetti on as many dots as I could**

# Martha's response

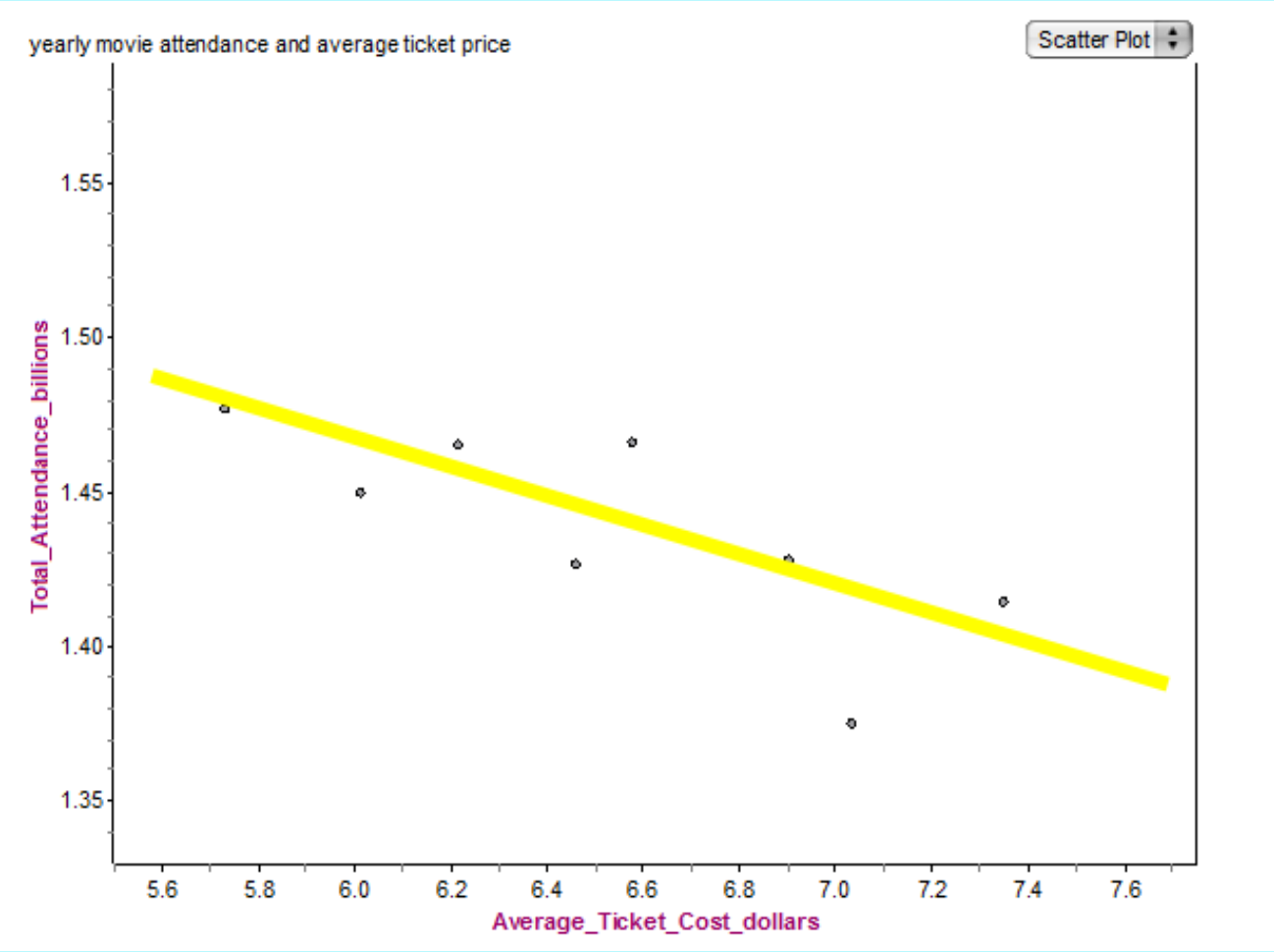



**I was trying to get the spaghetti on as many dots as I could**

1) *Interpret Martha's work and explanation, including what Martha may be thinking and what is worthwhile or reasonable in her thinking*

2) *Provide a response to Martha as her teacher. Your response should help the student complete their thinking (if there are gaps), prompt the student to investigate an error (if one is present), and help the student move forward in her understanding of the line of best fit.*

# Taio's response




**I wanted four points above and four points below**

1) *Interpret Taio's work and explanation, including what Taio may be thinking and what is worthwhile or reasonable in her thinking*

2) *Provide a response to Taio as his teacher. Your response should help the student complete their thinking (if there are gaps), prompt the student to investigate an error (if one is present), and help the student move forward in her understanding of the line of best fit.*

# Feedback chart

| Descriptor | Meets Expectations | Does Not Meet Expectations |
|---|---|---|
| **Is the interpretation of student thinking reasonable?** | Interpretation points to reasonable explanation of student responses. | Interpretation does not attend to what students might have been thinking. |
| **Is the response to Martha appropriate?** | Response to Martha appropriately helps the student complete their thinking, prompts the student to investigate an error, or helps the student move forward in their thinking. | Response to Martha does not accurately assess student understanding and move the student in a reasonable direction. |
| **Is the response to Taio reasonable?** | Response to Taio appropriately helps the student complete their thinking, prompts the student to investigate an error, or helps the student move forward in their thinking. | Response to Taio does not accurately assess student understanding and move the student in a reasonable direction. |
| **Is the language used appropriate?** | Language used in responses to students is mathematically accurate yet appropriate for eighth grade students. | Language used in responses to students is not mathematically accurate and/or appropriate for eighth grade students. |

# Reflections prompts to complete after receiving feedback from instructor

- How would you change your responses to Martha and Taio after receiving feedback?
- What are some takeaways for you about how to build on student thinking to help students move forward toward a learning goal?
- How do the current responses you provide to students differ from those you gave prior to this course?

# eCOTS Workshop Sample Activity 6

MODULE[S²]
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

Module 3 (Statistical Association)

Lesson 9: Curriculum Standards: CCSS-M through AP Statistics

*Teachers will analyze secondary curriculum standards relevant to statistical association, and compare and contrast CCSS-M & AP Statistics standards*

# Sample Activity 6

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

*CCSS-M*: Below are two standards from the CCSS-M (corestandards.org) that focus on association of categorical data.

Grade 8: 8.SP.4. Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables. *For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?"*

**Secondary: HSS-ID.B.5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.**

What pre-requisite knowledge do students need in order to be prepared to learn the content described in standard 8.SP.4?

# Sample Activity 6

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

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Grade 8: 8.SP.4. Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables. *For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?"*

**Secondary: HSS-ID.B.5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.**

Both of these standards explicitly mention tables but neither mention graphs. Should teachers use graphs to help students understand association of categorical variables? If so, why and in what ways? If not, why?

# Sample Activity 6

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

*CCSS-M*: This is a probability standard

> Secondary S-CP.4:. Construct and interpret two-way frequency tables of data when two categories as associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities.

What are similarities and differences between the probability standard and the categorical association standards?

# Sample Activity 6

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

***AP Statistics standards relevant to association of categorical variables***

*Exploring categorical data*

*1. Frequency tables and bar charts*

*2. Marginal and relative frequencies for two-way tables*

*3. Conditional relative frequencies and association*

*4. Comparing distributions using bar charts*

*Sampling distribution for chi-square*

*Chi-square test for independence*

Name at least two ways the Chi-square test for independence depends upon ideas developed when exploring categorical data.

# Interested in more information?

MODULE(S²)
Mathematics Of Doing, Understanding, Learning and Educating for Secondary Schools

- Project website: tinyurl.com/MODULESproject

  Materials available spring/summer 2022

- Interested in piloting the materials: tinyurl.com/MODULES2pilot

  $4000 stipend +Professional Development

  Next piloting opportunity for statistics: Summer 2021 professional development+teach with materials during 2021-22 academic year

- Contact us: scasey1@emich.edu andrew.ross@emich.edu melody@umich.edu

# Abstract

Pre-service teachers often feel the university-level statistics courses they have to take are disconnected from both the statistics content they will have to teach and the work of teaching. Data examined in these courses is also often disconnected from the realities of the United States' K-12 school system, where inequity is a fact of life that teachers and students can work together to uncover and change. In this workshop, we will share new statistics teacher education curriculum materials from the MODULE(S^2) project which engage middle and high school teachers through their purposeful connection to the statistics content they will teach, inclusion of school teaching artifacts like classroom video and student work, lessons that develop their knowledge of the ways in which students learn statistics, and statistical activities that develop their understanding of equity issues pertinent to education.