NC COLLABORATIVE FOR MATHEMATICS LEARNING

NC²ML UNIT BRIEF

NC Math 1 – Univariate Statistics

STATISTICAL VS. MATHEMATICAL THINKING

Statistics is a unique field of study from *mathematics*. At the college and career levels, it is recognized that general training in one field does not prepare you for work within the other. Key in distinguishing statistical thinking from mathematical thinking is the understanding and treatment of the fact that there is variation in every aspect of statistical investigation. Variation occurs naturally within a data sets, exists between data sets, and can be induced by data collection and sampling techniques. It is important for both students and teachers to draw attention to these differences (Lee & Tran, 2015).

STATISTICAL HABITS OF MIND

Lee and Tran (2015) have pointed out the importance of students developing what they term as *statistical habits of mind*. This describes the general way students should approach any statitical situation. These habits include:

- Always consider the context of the data
- Ensure the best measure of an attribute of interest
- Anticipate, look for, and describe variation
- Attend to sampling issues
- Embrace uncertainty, but build confidence in interpretations
- Use several visual and numerical representations to make sense of data
- Be a skeptic throughout an investigation (p. 1)

BUILDING FROM STATISTICS IN NC 6-8 MATHEMATICS

The North Carolina 6-8 Mathematics Standards lay the foundation for developing students' abilities to *think statistically* and to apply calculated *statistics* to reasoning through questions best answered with data. In 6th grade, students develop an understanding of an expectation for variation, while learning about measures of center. In 7th grade, students begin to measure variability by calculating the statistics of spread, IQR, and mean absolute deviation. In 6th and 7th grade, students will also have experiences with various representations of univariate data including stem and leaf plots, dot plots, and box plots. They will be using both statistics and visual representations to compare different data sets. In 8th grade, students will begin working with bivariate measurment data, using scatter plots to investigate association between two quantities. This will include informally fitting a straight line to scatter plots of data that suggest a linear association.

When preparing for this statistics unit, it's important to note that students have less engagement with univariate statistics in grade 8 than in grades 6 and 7. The reason for this is that the corresponding development of linear functions and its use in modeling bivariate data takes up a lot of space in 8th grade standards and is further explored in Unit 2 of NC Math 1. In NC Math 1, students continue this development into becoming statistical thinkers as they engage in the final unit of the NC Instructional Framework for Math 1, which contains three statistics standards regarding univariate data (NC.M1.S-ID.1-3).

CONTEXT, STATISTICS, & REPRESENTATION

The goal for this unit is for students to understand how to summarize, represent, interpret, and compare univariate data by using technology to represent data with dot plots on the real number line (NC.M1.S-ID.1); using the shape of distributions to compare measures of center and spread of different data sets in contex (NC.M1.S-ID.2); and examining effects of outliers on statistical measures (NC.M1.S-ID.3).

Since the majority of the related work in this content occurs prior to 8th grade, it may be reasonable to anticipate that students will need to be reminded of what measures of center and variability are as they prepare to add *standard deviation* to their statistics toolkit. Connecting the values of the statistics of a data set to the characteristics in the graph of that data set will allow students to make comparisons of

data distributions. These comparisons can be brought forth within the context of the data and may allow students to make distinctions between data sets.

STUDENTS' CONCEPTIONS OF STATISTICAL MEASURES

Researching students' understanding of ***measures of center***, Mokros and Russell (1995) found that students often conflate mean or median with a specific data point and have difficulty discussing data when the mean or median is not an actual data point. Extending this work, Konold and Pollatsek (2002) theorized that students may hold various perspectives on mean and argued that *instruction grounded in the context of comparing sets of data* supports students understanding of measures of center.

Variability is the term describing the natural differences that exist among data points and between data sets. In the summary of the research on students' understanding of variability, Shaughnessy (2006) found that students hold a number of different conceptions of variability. Namely, they may see variability as attending to extremes or outliers, as the whole range of possible values, or as the distance from a given point. He concluded by encouraging teachers to explicitly include variability as a central issue in statistics education and to draw upon students' intuitive conceptions of both center and spread to guide instruction.

WHAT DOES STATISTICS INSTRUCTION LOOK LIKE?

Many NC secondary mathematics teachers are exploring ways in which they can use mathematics tasks and student-focused instruction to support students in engaging with mathematics in meaningful ways. Recognizing that statistical and mathematical thinking are different, the GAISE report (Franklin et al., 2005) outlines four components to support students in statistical problem solving tasks.

1. *Formulate Statistical Questions* – Drawing upon the distinction between mathematics and statistics, teachers can consider ways to support students in understanding differences between deterministic (mathematical) questions and a question that anticipates an answer based on varying data.
2. *Engage in Data Collection* – Building from students' conceptions of variability, spending time collecting and building data sets and acknowledging issues of variabilty can support students statistical mindset.
3. *Analyze Data and Distributions* – "The main purpose of statistical analysis is to give an accounting of the variability in the data" (p. 10).
4. *Look Beyond the Data to Interpret Results* – As the culmination to statistical investigations, it is imperative that students be given time to interpret results of their investigation in context to determine reasonable generaliztations to their statistical question.

AN EXAMPLE: COMPARING DATA SETS

Providing students opportunities to compare data sets and make decisions in context is central to the statistics standards in NC Math 1. In this example, students are asked to compare nutritional data for different peanut butters. You might launch this task using a video. Next, present students with the quality rating values of both regular and natural peanut butters.

Quality rating data for Natural Peanut butters:
34, 40, 52, 57, 57, 60, 60, 63, 67, 69, 69, 69, 71, 89
Quality rating data for Regular Peanut butter:
11, 23, 23, 26, 29, 31, 31, 33, 34, 34, 35, 40, 40, 43, 45, 46, 49, 54, 54, 60, 76, 83, 83

Then pose the question, which type of peanut butter is better? Why? To answer this question students should calculate measures of center and spread and create appropriate representations of the data utilizing those statistics (e.g., stacked box plots). Their responses to the overall question should be in the context of the data and explicitly address shape, center, spread and outliers.

Three new free resources that provide access to real data using dynamic statistic software usable on any technological platform are CODAP, TUVA Labs, and Desmos. Each of these resources include classroom ready activities.

QUESTIONS TO CONSIDER WITH COLLEAGUES

- *Why do you think it is important to draw distinctions between statistical and mathematical thinking?*
- *In what ways are students hindered from understanding statistics if they approach problems using mathematical (deterministic) thinking?*

References

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SUGGESTED CITATION

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