NC COLLABORATIVE FOR MATHEMATICS LEARNING

NC²ML Research-Practice Brief #20

NC Math 3 - 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 and 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 statistical 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)

Given that NC Math 3 students have appropriated many statistical tools over the course of their years in schools, automatically taking such a stance toward statistical situations should be the ultimate goal for all NC Math 3 students.

A VERTICAL VIEW OF THE STATISTICS STANDARDS

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. NC Math 1 Standards ensure that students can calculate and interpret the univariate statistics that provide meaning to a data set within its context.

In 6th grade students develop an understanding of and 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. Students in NC Math 1 will be utilizing univariate statistics to analyze and compare data sets, expanding their tools for measuring variability to include standard deviation.

The statistics strand of NC Math 2 does not include the use of statistics to study data sets, and instead is focuses on the study of probability. At first glance, this treatment of *Statistics and Probability* across NC Math 1, 2, and 3 may seem disjoint. However, the "missing" standard in NC Math 3 that appears in NC Math 2 highlights the statistical connection across the three courses:

NC.M2.S-IC.2 *Use simulation to determine whether the experimental probability generated by sample data is consistent with the theoretical probability based on known information about the population.*

DATA COLLECTION: SAMPLE VS POPULATION

Standards **NC.M3.S-IC.1, 3, & 6** call for student understanding of how *sample data* may be used to represent a *population*. The standards require that students develop a critical eye for statistical studies, surveying, and sampling techniques, with the knowledge that a random sampling method is vital in order to avoid *sample bias* and to truly represent a population.

Chance (2000) suggests one way to help students develop a sense of skepticism is by presenting examples where the results of a study were invalidated due to faulty techniques

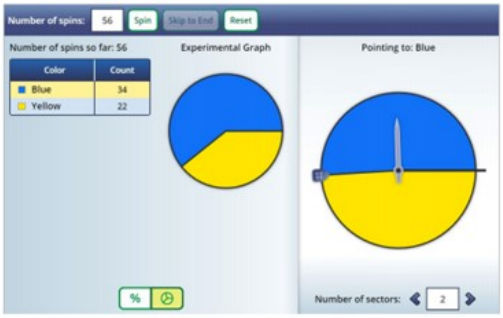
when collecting data. Students should ask questions of the data like, "How was the data collected? What sampling technique was used? Do the conclusions follow from the data? Was there intentional or unintentional bias?"

Another way to help students develop a critical eye is through designing and carrying out their own studies. While time consuming, research has shown that opportunities to develop well-developed research questions and data collection/ sampling techniques helps to clarify the importance of these steps in any study (e.g. Sole, 2015).

THE IMPORTANCE OF SIMULATIONS

Simulation is a task common to both NC Math 2 and NC Math 3. Simulation is used to create multiple instances of a sample from a population, so that students might study ***population parameters*** (the population's characteristic that is of interest), while attending to the natural variation that occurs between different samples. Opportunities to reason about variation from an expected value is important for all students. Such reasoning relies on imagining a repeated process, each with a different result. Research has shown that this is difficult for students (e.g. Noll and Shaughnessy, 2012). Research on how sample size affects variation from expectation has shown that students often reason that statistics from small samples vary more from the expected value than do statistics from large samples (e.g. Lee and Lee, 2011; Starling, 2011). These researchers have shown that students that have had opportunities to simulate events, especially including large data sets, have a better understanding of the relationship between statistics and expected events.

For example, consider the NC Birth Statistics task shown here. Engaging in a task like this from a simulation approach can



assist students in reasoning about empirical sampling distributions of large data sets. After examining the entire data set (found at North Carolina Center for Health Statistics). This event could be simulated using a coin toss to simulate male/female births. Even more powerful would be to use a technology tool like the Illuminations Adjustable Spinner applet to build a model and simulate the births. A full description of this task, including sample student work, can be found in here, but you can get a snapshot of the task in the next section.

See the NC Math 3 Mathematical Resources for Instruction for more examples of simulations for the classroom, and note that the tools involved may or may not utilize technology. Another useful resource for tasks is the Statistics Education Web (STEW), hosted by the American Statistical Association. When using STEW resources for simulation activities it's important to remember that NC Math 3 students will not be asked to calculate and interpret confidence intervals, as many of those tasks require.

SAMPLE SIMULATION PROBLEM FOR STUDENTS

Each county in a state records and reports data about births, including the number born of each gender. We examined data of birthds recorded in North Carolina counties and noticed two events that piqued our interest. Consider the events from Hyde County and Madison County, listed below. Which event is more likely to occur? (a) Hyde County recorded 42 births, of which slightly more than 50% were male; (b) Madison County recorded 184 births, of which slightly more than 59% were male; (c) These events are equally like to occur. (Lee, Starling, and Gonzales, 2014).

QUESTIONS TO CONSIDER WITH COLLEAGUES

- *Why do you think it is important to draw distinctions between statistical and mathematical thinking?*
- *We are constantly being bombarded with data and information in our everyday lives, how could you incorporate these real-world contexts when teaching statistics in your classroom?*

References

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SUGGESTED CITATION

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