ENHANCING STATISTICS TEACHER EDUCATION WITH E-MODULES

Mod 1: Part 1

How is Statistics Different from Mathematics?

Differences Between Statistics and Mathematics

In most countries, including the US, statistics is placed within mathematics in K-12 school curriculum; yet, there are subtle differences between mathematical and statistical reasoning.

In statistics, we use mathematical tools in solving problems (e.g., the use of algorithms and formulas, theoretical probability models, and several forms of graphical representations). However, we rely heavily on **data and context** in statistical reasoning. Statistical questions begin with a context from which individuals must make decisions about how to collect data to investigate problems. In some situations, data are already collected, and statistical questions can be developed based on one's interest(s) related to the dataset. In all situations, it is impossible to make sense of a statistical problem without knowing details of the situation surrounding the data. The context can help shed light on why there might be outliers or particular clusters within a distribution or whether we should exclude outliers. For example, when examining the typical value of foot length, one can identify outliers by looking at a dot plot of the distribution of foot lengths. The age of the people whose foot was measured (in inches) may make a significant contribution to understanding how data values vary and may be clustered. If a data value of 26 inches was present, knowing that the context is foot length of students ages 11-13 may warrant a decision to exclude the value in the analysis and interpretation of findings.

The issue of **measurement** is another important distinction between statistics and mathematics. In mathematics, measurement typically refers to understanding units and precision in problems that deal with most concrete measures such as length, area, and volume. But, in statistics, measurement can be a bit more abstract. For example, when considering how you might measure intelligence or a city's pace of life, there is not a straightforward method. Instead, researchers and statisticians have to decide how to best measure what is being studied and often do so in different ways.

Variability and the uncertainty of conclusions is another major difference between statistics and mathematics. In mathematics, results are usually reached by means of deduction, logical proof, or mathematical induction and typically there is one correct answer. Statistics, however, utilizes inductive reasoning and claims made are always uncertain. This is largely due to the interpretation of the context and methods surrounding data collection and analysis. It also stems from the nature of variability in the world around us, and thus in data. For example, "How old are the teachers in my school?" is a statistical question expecting the variability in age. One will need to decide where to get the data from (school teachers), to measure (age) and choose appropriate statistics (measures of central tendency or variation) and graphical displays to answer the question. In contrast, given a set of data points of teachers' age and asking students to find the mean is not a statistical question since the answer is definitely a single number found using an algorithm. Another example in bivariate data is about fitting a linear function between height and weight. In mathematics, students are often asked to find a (deterministic) function through a set of points. In contrast,

statistical questions focus on the level of certainty one can make when using a “best fit” function to predict one variable based on the other. In particular, one considers how far such an extrapolation can be made based on the context and how much error is associated with the prediction.

In summary, some salient features that we attend to in statistical questions include the **role of context, measurement, variability, and uncertainty**. Mathematics serves as a tool to help investigate statistical questions, but not the only end of the statistics itself.

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