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BMI Teaching Trends Newsletter – March 2023

Teaching Matters
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This is the second installment of the *Teaching Trends* newsletter describing the new *Critical Thinking in Science Course* that Kevin Theis and I developed and delivered last fall. Here, I describe the lessons that our students learned regarding sources of error and the impact that the lack of critical thinking skills has on public health.

A critical thinking in science curriculum would introduce students to the three major sources of error (1): i) unintentional cognitive biases caused by the error-prone heuristics that humans use to make decisions such as confirmation and anchoring biases; ii) irreproducible results due to experimental error or fraud; and iii) data error or manipulation. Data errors can range from the inappropriate use of statistical tests to purposeful attempts such as cherry-picking or mining data in search of statistically significant p values. The pervasive influence of the p (probability) value has led to the confusion and overemphasis on validation of experimental results based on a p value less than or equal to 0.05. In reality, R. A. Fisher who introduced the p value did not intend for it to be interpreted as a single extremely significant result but rather an indication that additional testing is warranted. Hypothesis testing should rely on the observation of replicated results which make statistical significance testing unnecessary (2,3). Awareness of the inappropriate use of statistical analyses has resulted in policy changes by some journals requiring disclosure of the power of a study in advance, a minimum sample size, and disclosure of covariables affecting study outcomes (4,5).

Vaccine hesitancy can be used to illustrate how the paucity of critical thinking skills and inappropriate communication can affect a public health crisis (6-10). It is a topic which can be used to facilitate a classroom discussion of the pervasiveness of errors in reasoning that can dominate public forums and how a free market society contributes to the dissemination of misinformation (11). This type of discussion illustrates the need for scientists to be more engaged in public debates particularly when it wanders into their area of expertise (12). Awareness of the sloppy and unwarranted use of statistics in arguments within science and the misuse of statistics in public discussion is needed. There are studies that have demonstrated how topic and technique rebuttal strategies can be used by advocates of critical thinking to reveal the flawed reasoning that

is used by science deniers (13,14). Inculcating beginning graduate students with an awareness of their responsibility as advocates for scientific reasoning has the potential to effect public policy change.

Next, the roles of inductive and deductive reasoning in science will be discussed.

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