Nature of Science and Math: Analyzing the Presence in Everyday Communication
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Part A. *3 of the tenets of Nature of Science discussed in NGSS*

- Scientific Knowledge is Based on Empirical Evidence
  As stated in the NGSS matrix (2013), "scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest ethical reporting of findings." This article highlights that the researchers took a logical approach to the formation of their research question and testable hypothesis. The researchers sought to test whether a fecal transplant would improve both the behavior and the gastrointestinal symptoms of children with severe autism. These scientists built off of the gut-brain axis theory, which is the belief that the microbial flora present in the intestines have an influence on the brain chemistry. They utilized similar studies to help provide support to test their hypothesis. The article mentioned fecal transplants have shown success in adult patients who suffer from Clostridium difficile (C. diff) infections. (Ricks, 2019) Another important takeaway message from this article is that there was an honest ethical reporting of the findings. The lead author was truthful in highlighting the flaws presented in the study (such as small sample size and lack of a placebo-controlled study) and that there is a need for further testing and additional data. (Ricks, 2019)

- Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
  The research presented in this article utilized a hypothesis to test a theory. The article presented the theory of a gut-brain axis in autism, where it is believed that the microbial flora of the intestines can have an influence on the brain chemistry in patients of autism. The hypothesis that they wished to test is whether the patient's autism symptoms (and gastrointestinal problems) can improve when given a fecal transplant to "reboot" the microbiome of the intestines. (Ricks, 2019) Teachers can use this as a teachable moment to illustrate that a scientific theory is "based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted" (NGSS, 2013). The teacher can also provide this as an example to showcase to students that "scientists often use hypotheses to develop and test theories and explanations" (NGSS, 2013) Even though this study displayed promising results, the lead author of the study identifies that there are issues surrounding the design of the experiment that require additional research. Flaws of the study are recognized, such as the low sample size (only 18 patients) and the fact that this study was not placebo-controlled. The lead research also explained that, "she and her team have only a hypothesis to explain why children's behavior improved after the fecal transplant." (Ricks, 2019) This showcases that the scientific method is not always rigid and that most scientists often discover either new questions to ask or new parameters to test. This article can also be utilized to help minimize misconceptions about science and that the scientific process is not the application of a set of "rigid steps" to obtain a "wright/wrong answer" or "provable" result, as mentioned in Schwartz (2007).

  This article also presented logical arguments and skeptical review (NGSS, 2013). Currently, there is discrepancy between doctors and pharmaceutical companies regarding whether feces should be considered a regular drug that could be prescribed as a treatment regimen by doctors. (Ricks, 2019) If a teacher utilizes this article, a discussion/debate can be had between students where they can voice their opinions on the matter (after being given the opportunity to investigate the topic more and gather evidence). Ultimately, more data and evidence needs to be gathered in order to support or refute the ability to consider this a viable option for doctors to prescribe to patients.

- Science is a Way of Knowing
  As stated in the NGSS matrix (2013), "science is both a body of knowledge that represents current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this

knowledge." This article showcases a group of scientists who conducted a study to assist in the extension and elaboration of knowledge. The scientists set out to gain more understanding of the connection between the microbiome of the gut and the brain. Currently, the mechanism of action behind the severity of the autism is unknown, but it is believed that a diverse bacterial community in the intestines promotes health benefits. (Ricks, 2019) Also, this article explains to the audience what a fecal transplant actually is. A lot of people can wrongfully assume the process and generate misconceptions. Ricks (2019) explains that the fecal transplant is comprised of highly purified "good" bacteria that was extracted from feces samples of a healthy donor. The introduction of this "good" bacteria helps diversify the flora of the gut. (Ricks, 2019)

Part B. *3 of the practices in Common Core Mathematics Practices*

- Reason abstractly and quantitatively
  According to the Common Core Standards Initiative (2019), "mathematically proficient students make sense of quantities and their relationships in problem situations." The article presented the findings of the study as follows: "At the onset of the initial 18 week research period, 83 percent of the children were found to have what Krajmalnik-Brown described as severe autism. Two years later, only 17 percent could be described as having severe symptoms of the neurodevelopment disorder while 39 percent were found to have mild or moderate symptoms. 44 percent were below the cutoff for mild autism symptoms." (Ricks, 2019) The teacher can discuss the meaning behind each percent and that the sample size is important information to provide further context to the results of the study. Given this information, students can determine how many patients fall into each category from the 18 patients tested. The students can then discuss whether or not this information has enough evidence to support the gut-brain axis theory. This also aligns with the credence that "quantitative reasoning entails habits of creating a coherent representation of the problem at hand" (Common Core Standards Initiative, 2019)

- Construct viable arguments and critique the reasoning of others
  This common core practice (2019) discusses that mathematically proficient students "justify their conclusions, communicate them to others, and respond to the argument of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose." This article showcases that the data achieved in the study was analyzed and a plausible argument was generated. The researchers understand the trends that exist in their findings and explain that the research provides some support for the gut-brain axis theory. The scientists recognize that there are limiting factors in their study (as previously mentioned) and that more data is needed and additional investigations need to take place to obtain a better understanding of the relationship between the gut and autism.

- Model with mathematics
  According to the common core practice (2019), students "interpret mathematical results in the context of the situation and reflect on whether the results made sense." In this study, the students can further examine the results achieved in relation to the symptoms experienced by patients of the study post-fecal transplant. In the study, the results are modeled in percentages. Students can transform this into a numerical representation to gain a greater understanding of how many patients fit into each category (severity of autism). The researchers in this study did exactly that. The results that were achieved gave insight to the researchers that there may be a link between the microbiome of the gut and the brain, and that further investigation needs to take place to further test this theory. (Ricks, 2019)

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