ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 24, NO. 2, 1-5

How the COVID-19 Pandemic Reveals Gaps in Science and Mathematics Instruction

Mark A. Bloom
Dallas Baptist University

Sarah Quebec Fuentes
Texas Christian University

Introduction

While most of the outcomes of the current COVID-19 pandemic are decidedly not good, occasionally one can identify a positive outcome from even the worst situations. The Coronavirus outbreak has provided a special opportunity to get a pulse on how well our society understands science and mathematics processes. Every day, one can find news anchors reporting the newest findings of scientists studying the virus as well as predictions and speculations from scientists, doctors, mathematicians, and political leaders. These predictions and speculations have changed dramatically over time and sometimes contradict each other, especially when one compares various news outlets.

Early in the pandemic, for example, one such message was that young people were mostly unaffected by the virus. Weeks later, new findings were indicating a connection between coronavirus and Kawasaki Disease in children. Further, children are indeed succumbing to COVID-19, and the numbers of children with the disease are likely far undercounted (Lerner, 2020). Just this month, a World Health Organization (WHO) official drew strong pushback from medical experts when she stated in a press conference that asymptomatic people spreading the disease was "very rare;" she later clarified that the actual number of cases caused by asymptomatic transmission is unknown (Joseph, 2020). But by then, the metaphorical bell had been rung, and those who doubted the seriousness of COVID-19 clung to this miscommunication as justification to skip wearing masks when in public. Others considered this another example of how scientists just do not know what is going on, stoking a mistrust of science in general.

Social media amplifies the voice of citizens allowing a window into how people feel about these changing views and, oftentimes, which information they choose to accept and which they choose to reject. For instance, in early April, Texas Senator John Cornyn posted a tweet denigrating the "use and abuses of 'modeling' to predict the future" stating that "[Modeling] isn't the scientific method, folks" (Figure 1). Sometimes, how these views are presented reveals gaps in a person's understanding of the nature of science and mathematics and how they contribute to recommendations. Recognizing these gaps and realizing how they can impact one's ability to understand and appreciate scientific recommendations is the focus of this editorial. Knowing that our readership is composed of science and mathematics educators, this will serve as an alarm – an alarm that alerts us all to topics that we must focus upon more explicitly in our science and mathematics teacher preparation programs and within our science and mathematics classrooms.

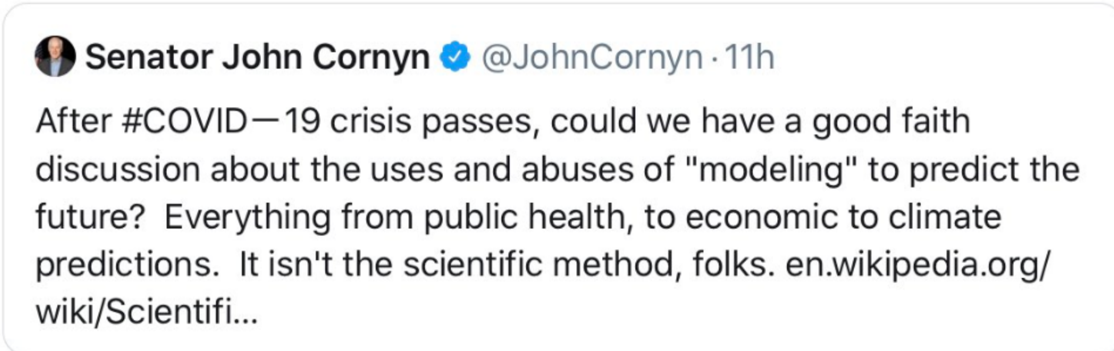

Figure 1. Twitter post by Senator John Cornyn (R – Texas) on 4/10/2020.

The Nature of Science

Several cultural forces, including religious skepticism of science, politicization of science, and post-modern distrust of science, have each contributed to the erosion of public trust in the recommendations of scientists (Bloom, 2020). Adding to this declining trust in science is a lack of understanding, among the general public, of several important characteristics of science and the scientific process.

The Tentative Nature of Science

The claims and recommendations of science are tentative, meaning they are subject to change as further research and exploration provide more information. While some might imply this means one cannot have confidence in science, the tentative nature of science implies that scientific understanding is constantly being refined and improved to accommodate the new discoveries. For example, new hominin discoveries may necessitate a refinement of the hominin family tree, but they do not substantively change our understanding of the relationship between hominins and other primates. Rarely, do new discoveries call for a complete abandonment of previous scientific claims. For example, for decades scientists held the notion that neural tissue, when lost or damaged, could not be regenerated. In more recent years, however, through new discoveries by cell biologists, the process of neurogenesis was discovered (Bernardo, 2014).

Establishing the current body of scientific knowledge has taken decades to be achieved. However, in the current climate with COVID-19, people want answers now. This need to have an answer and, if possible, find someone to blame for bad circumstances like the COVID-19 pandemic drives so many to accept the claims of the conspiracy theory documentary *Plandemic* (now removed YouTube video "documentary" film) over the uncertain and changing recommendations of the Centers for Disease Control and Prevention (CDC), WHO, and other medical experts. The public has been presented science in textbooks and on websites and fail to see the "messy side" of science. If we can emphasize the process of science, recognizing the "trial and correction" cycle that scientists enact, the public might not be so surprised by the changing and uncertain recommendations of medical experts that are being communicated through press briefings and news outlets.

The Subjective Nature of Science

Scientists approach new situations armed with the information they have gleaned from prior experiences. Too often, in textbooks, hypotheses are described as "educated guesses." However, scientists rely upon their prior knowledge to make an educated guess to explain a new phenomenon, and then create a hypothesis to test their educated guess (Bradford, 2017). If the public understood how scientists began formulating ideas and then developed hypotheses to test them, they would better appreciate why initial claims may turn out to be incorrect and understand how, with every test, scientists are getting closer to the correct understanding.

Early in the pandemic, health experts knew very little about the new coronavirus and based much of their assumptions and advice upon what they knew of its close relative, the SARS-CoV of 2002. While there are many similarities in how these two viruses affect humans (Hewings-Martin, 2020), differences exist, to be expected as SARS-CoV-2 has changed over the last 17 years. If the public understood that when scientists are facing a new problem, like COVID-19, they are making some speculative claims that must be confirmed over time, then perhaps they would not be surprised when recommendations change and guidelines are disruptive. Understanding the subjectivity of science helps the public understand the initial claims were not made arbitrarily, but rather based on prior related evidence.

The Communal Nature of Science

Science is conducted in the context of a community of scientists who are collectively working towards solving problems and better understanding the world. The findings of scientists, before being published in academic journals, are subject to a stringent peer review process. Only after passing the critique of established scientists within the field are scientific discoveries supported by the scientific community. After being published in esoteric scientific journals, the findings are then communicated to the public via magazines, newspapers, and other public news outlets. While the peer review does not work 100% of the time (see Eggerston [2010] regarding the Lancet's withdrawal of paper implying autism link to MMR vaccine), the process usually prevents bad science from moving forward to misinform the public.

However, in April of this year, two California urgent care doctors posted a YouTube video downplaying the risks of the Coronavirus, without passing the peer review process. These doctors, not epidemiologists, erroneously extrapolated data from their clinics to the California population as a whole and then, bypassing the critical eye of the scientific community, moved forward with announcing their findings to the public. Immediately, the scientific community pushed back, pointed out the flaws in the doctors' findings, and the video was removed from YouTube for violating their policy on misinforming the public (Rappard, 2020). The general public should be fully aware of this important aspect of how scientific knowledge is vetted. Armed with this understanding, people might be less inclined to go to Facebook and YouTube for scientific information and, instead, view such postings with a more critical eye.

Mathematical Modeling

Mathematical modeling is "the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions" (NGA & CCSSO, 2010, p. 72). A key aspect of mathematical modeling is that it is an iterative process that involves the identification of a problem, articulating assumptions, delineating relevant variables, integrating existing data, developing the model, executing the model, analyzing the model, and repeating the process to further refine the model (NGA & CCSSO, 2010; Munakata, 2006; Pollak, 2011). Some misconceptions center on this process as well as its purpose and limitations.

In the context of COVID-19, models have been used to examine the impact on the healthcare system as well as the impact of various interventions (e.g., social distancing, stay-at-home orders, wearing masks). For instance, in a model related to the latter, the value of the variable for the number of contacts will decrease with social distancing measures in place or the probability of transmission will also decrease with increased handwashing and mandates to wear masks (University of Minnesota School of Public Health, 2020). As described, part of the modeling process is making assumptions. These assumptions are revised as more data are collected, which then contributes to the refinement of the model. This cyclical process results in an increasingly complex and representative model (WHO Eastern Mediterranean Region, 2020). With knowledge about how models are developed and refined, people will understand why the models presented in the media will change over time.

Conclusion

Ethical and responsible medical experts, politicians, and leaders who are making recommendations to the public as to how best deal with the coronavirus pandemic are forming these directives with the input of scientists and mathematicians. As the scientific understanding of coronavirus and the associated mathematical models continue to change, so do the recommendations. The general public is currently demonstrating a lack of understanding of both the nature of science and mathematical modeling through their skepticism of the information grounding current COVID-19 health guidance. In essence, the COVID-19 pandemic is bringing to the forefront the importance of integrating the nature of science and mathematical modeling into the K-12 curriculum. In fact, the two are present in current standards documents (NGA & CCSSO, 2010; NGSS Lead States, 2013). Ensuring that students learn the nature of science and mathematical modeling will contribute to the development of an informed citizenry that is able to listen to and interpret information presented by experts as well as evaluate with a critical lens those messages not grounded in science and mathematics.

References

Bernardo, A. (2014, May 9). *Science myths III: Can adults generate new neurons?* Blogthinkbig.com. https://blogthinkbig.com/science-myths-iii-can-adults-generate-new-neurons

Bloom, M. A. (2020). The links between the virtues, science and science education. In W. Melville & D. Kerr (Eds.), *Virtues as integral to science education: Understanding the intellectual, moral, and civic value of science and scientific inquiry* (pp. 15-33). Oxford, UK: Routledge.

Bradford, Alina (2017, July 26). *What is a scientific hypothesis? Definition of hypothesis.* Live Science. https://www.livescience.com/21490-what-is-a-scientific-hypothesis-definition-of-hypothesis.html

Eggerston, L. (2010, February 4). *Lancet retracts 12-year-old article linking autism to MMR vaccines.* CMAJ. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2831678/

Hewings-Martin, Y. (2020, April 10). *How do SARS and MERS compare with COVID-19?* Medical News Today. https://www.medicalnewstoday.com/articles/how-do-sars-and-mers-compare-with-covid-19

Joseph, A. (2020, June 9). *'We don't actually have that answer yet': WHO clarifies comments on asymptomatic spread of Covid-19.* Statnews.com. https://www.statnews.com/2020/06/09/who-comments-asymptomatic-spread-covid-19/

Lerner, S. (2020, May 1). *New research suggests significant undercount of children with coronavirus.* The Intercept. https://theintercept.com/2020/05/01/coronavirus-children-undercount/

Munakata, M. (2006). A little competition goes a long way: Holding a mathematical modeling contest in your classroom. *Mathematics Teacher, 100*(1), 30-39.

National Governors Association (NGA) Center for Best Practices, & Council of Chief State School Officers (CCSSO). (2010). *Common Core State Standards Mathematics.* Washington, D.C.: Author.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, D.C.: National Academy Press.

Pollak, H. O. (2011). What is mathematical modeling? In H. Gould, D. R. Murray, A. Sanfratello, & B. R. Vogeli (Eds.), *Mathematical modeling handbook* (pp. vi-vii). Bedford, MA: COMAP.

Rappard, A-M. (2020, April 29). *Dubious coronavirus claims by California doctors condemned by health experts.* CNNhealth. https://www.cnn.com/2020/04/29/health/california-doctors-coronavirus-claims/index.html

University of Minnesota School of Public Health. (2020, May 5). *The science behind COVID-19 mathematical models.* YouTube. https://www.youtube.com/watch?v=C8zCWBDXD_c&feature=youtu.be

World Health Organization (WHO) Eastern Mediterranean Region. (2020, May 15). *What is mathematical modeling and how can it help control the #COVID-19 pandemic?* YouTube. https://www.youtube.com/watch?v=y5VLQpGIlEI&feature=youtu.be

SPECIAL ANNOUNCEMENT

ICRSME
International Consortium for Research in
Science & Mathematics Education

In our previous editorial, we shared that the ICRSME XVI Consultation was planned for March 2021 in Panama City, Panama. After careful consideration of the current uncertainty regarding travel restrictions, budgets, and most importantly health and safety, we have decided to delay ICRSME XVI until March 2022.

As pointed out in the current editorial, sometimes unfortunate situations reveal opportunities. In the unexpected interim, to continue the camaraderie and collaboration, hallmarks of ICRSME, we are excited to announce a virtual meeting, which will take place in spring of 2021. Details about date, participation, and format will be forthcoming over the next couple of months.