Curriculum Units by Fellows of the National Initiative
2021 Volume V: Human Centered Design of Biotechnology

# Math by Design; Creating Innovators in a Post-Pandemic Classroom

Curriculum Unit 21.05.04, published September 2021
by Christianna C. Loza

## Introduction

Mathematics is a gateway subject; it allows students to access crucial fields of study that lead to higher education. Though Math is undoubtedly one of the most important subjects in school, it is not treated that way. Poll people at random; ask the person next to you at the checkout line, your server, friends, a random stranger on the street (or be a middle school math teacher who gets unsolicited opinions when asked what she does for a living). More often than not, these people will tell you that math was their least favorite subject in school and the one they struggled with the most.

In fact, my struggle as a mathematics teacher is not the complexity of the math concepts that I'm teaching. Rather, I am constantly battling the fixed mindsets of my students.

Mathematics is more than numbers and operations. I enjoy teaching math because I truly believe in the practice of problem-solving that could transcend computation. Yes, I am teaching my students how to solve proportional relationships. I am also teaching them how to study patterns and test ideas by repeatedly failing until they have refined their 'slow hunches[1] ' into feasible solutions.

I want to help my students see mathematics as an experimental opportunity. Not only would they be given a more comprehensive range of options for higher education, but they will also have the tools to find creative solutions to problems in their lives. Better yet, they will feel empowered to find creative solutions to the present and future issues in our world.

## Rationale

How do we know we are being told the whole story? How do we separate fact from fiction to make informed decisions for our health, communities, and country? Through numeracy and analysis, we can find a deeper story in information and numbers.

Since Spring of 2021, vaccinations have slowed from tens of thousands to an average of just under 5,000 new doses[2] in Oklahoma. We are also sitting at the 11th lowest percentage of our population for fully vaccinated people at 39.4%, compared to the national average of 49%.[3] Furthermore, we see increased cases as COVID-19's Delta Variant is making its way through neighboring states and rural parts of Oklahoma.

With the constant barrage of information and posts on our newsfeeds urging us to mask up (or not), to get vaccinated (or not), how do we make decisions that may affect the health of ourselves and our community?

Being data literate in the 21st century is critical; now more so than ever. Much of our daily lives revolve around data, whether we are interpreting it or it is being mined from us. Data-informed decisions show up in nearly every profession, whether that profession is in the STEM field or not. As an adult, outside of my classroom, I cannot tell you when I used formal algebraic equations, calculus, or trig. However, with certainty, I can tell you that I've interacted with some form of data every day this year; scrolling social media, listening to the news in the morning, making decisions for my health, planning instruction for my students, or showing up for my community as a registered voter at the polls.

In the age of so much digital noise, when opinions and agendas are being pushed everywhere you turn, it is a moral imperative for k12 education to give our students tools to sort out the fact from fiction.

This unit will aim to get middle school mathematics students thinking about the importance of data literacy and give them critical data problem-solving tools that they can use in the real world. In addition to this objective the unit will teach how essential mathematics is, and the role that numbers play in telling us the whole story instead of being misrepresented through data. In a two week span, this unit will build data literacy through the lens of public health, and by exploration of visual data representation. This unit will also attempt to tackle students' mindsets about how innovation happens through discussion and practice.

## Content Objectives

This unit will introduce data science via vaccine technology, public health, and design thinking. Students will study the past while learning that good ideas must come from somewhere. They are slow ideas that are refined and altered over time before becoming successful. Students will also hone in on a present-day problem: vaccination rollout rates in our nation and the developing world. Students will have the opportunity to prototype their solutions for widespread vaccination while understanding that good ideas take experimentation and time. Students will get hands-on experience with data analysis, proportions and ratios, and the design thinking process.

**Innovation**

When I say 'innovator,' who immediately comes to mind? For me it’s the white men I hear about most commonly, Elon Musk, Steve Jobs, Bill Gates, Thomas Edison, etc. Some personal favorites in education I admire that also come to mind are Eli Luberoff, the founder of an online calculator Desmos, Sal Khan of Khan Academy, and Jo Boaler, a Stanford professor whose work has primarily focused on mathematics and mindset education in k12 schools born out of environments and their experiences in education.

All those people had some good idea that created a new piece of technology or practice that changed us for the better. What does it take to develop new technology or processes that could be useful to people? Thanks to my obsessions with cartoons as a kid, I have always envisioned some genius type of person with a mind like Einstein that has a literal lightbulb moment, and is then able to create a genius idea. Good ideas don't just come from Eureka moments or out of nowhere. According to Steven Johnson, good ideas come from our environments.[4] They take time, long thought, collaboration, sometimes even centuries of ideas and technological advancements. Ideas come slowly.

As a learner, I often felt shame in how slowly it took to understand a mathematical idea. This shame grew from the evident impatience and frustration of my teachers. As a math teacher myself, I have also had moments of impatience and frustration with my students. This perpetuates the continuous cycle of teacher expecting learners to grasp concepts immediately, and the learners inevitably failing to live up to those expectations.

This mindset needs to change first for me as a teacher, before the mindset can then be passed down to my students. When I think of how this perseverance can benefit myself and my students, it feels imperative to carry this thinking into every piece of instruction I give in my classroom.

The evolution of vaccine technology is an excellent example of 'the slow hunch', and how good ideas evolve over time. The idea has been around for centuries, and new ideas have slowly evolved into new technology that could one day keep up with global pandemics or eradicate older diseases that still plague the globe today.

**Vaccine Introduction**

Life expectancy is a statistical measurement of the average lifespan a cohort could expect to live. Factors such as race, income, gender, and geography each influence life expectancy. We can assess a population's health and tell a larger story with this measurement. We are getting older! Not in the sense that my 30th birthday is around the corner, but global life expectancy has doubled since the 1900s.[5] From 1900 to 2010, the United States life expectancy increased from 48.3 to 78.7.[6] While all global life expectancies since the 1900s have risen above 50 years, gaps and divides exist between countries, races, and gender.

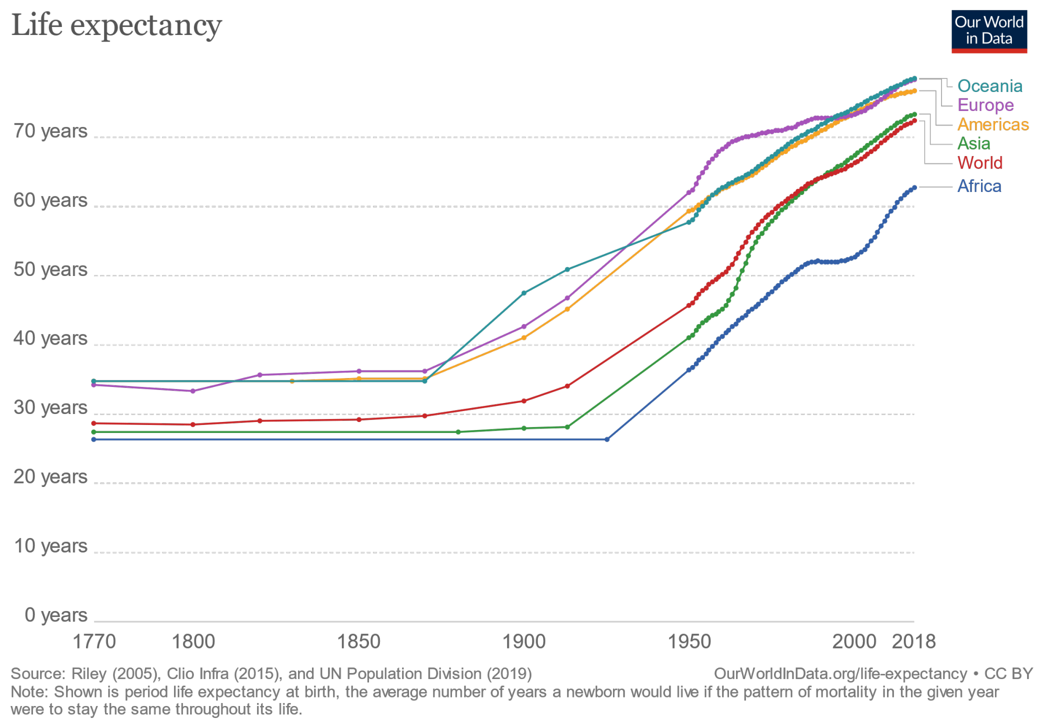


Figure 1: Graph depicting how life expectancy has changed.[7]

Why are people getting older? What will this mean for our society in the future? What factors may have contributed to differences in lifespans between populations? Technological advances in public health are one answer to some of these questions.

Significant advancements towards improving disease control, sanitation, and clean water contributed to the largest life expectancy gain from 1880 to 1920.[8] One might think that medical advancements such as surgical techniques and medical treatments would have made the most significant change. However, simply improving conditions and taking steps towards prevention and control of diseases paved the way for our global trend up.[9]

Most notably, vaccines' advancement and widespread use in the 1900s[10] have greatly improved public health by eradicating diseases that once plagued the globe for centuries.

**History of Vaccines**

Until recently, millennials and later generations of wealthier nations have not had to contend much with the threat of fatal viruses. Due to the development of vaccines, diseases such as polio and smallpox do not plague our minds when we step out for the day. Who do we have to thank for the eradication of these diseases?

Though the history of vaccines is thought to have begun with Edward Jenner, it is more accurate to state that the concept of vaccination came from a collection of ideas long before his time. These ideas continued after Jenner; vaccines have been engineered throughout eras of discoveries and innovators.[11]

Due to the expansion of civilization and later colonialism, smallpox was once a global threat. After its centuries-long reign, this highly contagious and deadly disease was officially declared eradicated in 1980 by the World Health Assembly. The origin of smallpox is unknown, its existence dates back at least 3000 years with the discovery of rashes on Egyptian mummies.[12]

As smallpox was ravaging communities for many centuries, early thinkers were coming up with methods of combating the disease.

Enter Edward Jenner, whose work we attribute to being the foundation of vaccination and later influenced later inoculations of other diseases. Jenner's work was influenced by the idea of variolation, a process of exposing yourself to the disease through scratching a dried smallpox scab or puss into your arm or inhaling it. The earliest evidence of variolation comes from Africa, China, and India[13] hundreds of years before Edward Jenner.

Smallpox is the only disease thus far to be eradicated, thanks to vaccination efforts.[14] Because smallpox has been eliminated, we no longer vaccinate populations for it. The smallpox vaccination is where the words 'vaccine' and 'vaccination' derive from because of the cowpox virus, *vaccinia,* that was extracted for immunization.[15] Smallpox vaccine is a live attenuated vaccine because it comes from a weaker but similar cowpox virus that was not harmful to humans.[16]

**How Vaccines Work**

Vaccinations, or at least the concept of vaccines, have been common practice for centuries. Technology has improved the way vaccines are delivered and how they work. In more recent times new technological advances, such as mRNA vaccines, are changing the way vaccines are created entirely.

Understanding how vaccines work starts with understanding how your immune system works when faced with the threat of germs. Your immune system's job is to protect your body from invaders such as germs and viruses when they enter. When your immune system is weak or meets a foe it has not encountered before, you become sick. How your body reacts to the threat is what vaccines replicate without causing you harm. Your immune system activates when antigens (the foreign invader) enter your body and finds their way to a cell whose job is to find the antigen and gather information from the virus. Once it does, your immune system learns how to fight the invader better the next time it is faced with the same virus again.[17]

Vaccines work by fooling your immune system into thinking it's the actual disease, without being as harmful, causing your system to start up its defense mechanism and learn. There are different types of vaccines that work to trigger this response.

Vaccines come in different types: live-attenuated, inactivated vaccines, subunit, viral vector, and messenger RNA (mRNA), see figure 2.

| Vaccine Type | How it works | Protection | Storage | Diseases it protects against |
|---|---|---|---|---|
| **Live-Attenuated** | Uses a weakened form of the germ | Lifetime after 1-2 doses | Cold Temperatures | measles, rotavirus, smallpox, chickenpox, yellow fever |
| **Inactivated** | Uses a killed version of the germ | No lifetime protection (requires booster shots) | Cold Temperatures | Hepatitis A, Flu, Polio, Rabies |
| **Subunit** | Uses a piece of the germ | May require another shot over time | Cold Temperatures | Hib, Hepatitis B, HPV, Whooping cough, Pneumococcal, Meningococcal, Shingles |
| **Toxoid** | Uses a toxin created by the virus | No lifetime immunity | Cold Temperatures | Diphtheria, tetanus |
| **Viral Vector** | Uses another modified virus | Unclear | Ultra-Cold Temperatures | Ebola, Covid-19, and studies are ongoing for use for Zika, flu, and HIV |
| **Messenger RNA (mRNA)** | Uses no live virus and replicates RNA protein by sending a message into the body and triggering the immune response system | New vaccine and unclear of lifetime immunity | Ultra-Cold Temperatures | Covid-19 |

Figure 2: Table Depicting Vaccines by Type.

**Measles**

Measles, one of the most contagious diseases, was nearly eliminated in the United States but has reemerged in unvaccinated populations. Refusal of the Measles Mumps and Rubella MMR vaccine and anti-vaccination movements of the 1990s illustrate just how infectious misinformation could be.[18]

**The Wakefield Epidemic**

The epidemic of the anti-vaccination movement was primarily fueled by Andrew Wakefield's study on Measles Mumps and Rubella published in the Lancet in 1998.This study was retracted in 2010, and Wakefield's license has since been stripped. This study claimed that MMR caused autism in children and is an excellent example of how sample size matters when conveying information. As a result, the UK's vaccination rates of MMR took two decades to recover; more than 12,000 cases of measles resulted in hospitalizations, serious complications, and at least three deaths.[19]

**Culture: Public Perception of Vaccines**

Because technology has changed the speed and access to communication, misinformation is able to spread faster than ever before. Anyone can post their thoughts on the internet, and it can catch on as quickly as the spread of diseases. Therefore, data literacy has become a vital skill. We must now read the flood of data and statistics, and navigate through the misinformation to find the facts. Critical thinking and discerning of misinformation could be life-saving measures with which we could potentially arm future generations.

#### COVID-19 And mRNA

Messenger RNA (mRNA) vaccines, a brand new approach to vaccines, are changing the speed at which we create vaccines. Unlike previous vaccines, mRNA uses no form (weakened or killed) or piece of the organism.[20] These vaccines work by delivering a message to our cells to build spike proteins and trigger our immune response.[21] Because these vaccines don't use a virus, they can be created and modified rapidly. Most notably, although studies have been ongoing for decades for different viruses like the flu and Zika, mRNA has got its time at-bat in the wake of the pandemic to prevent COVID-19.

#### Herd Immunity

A critical part of the eradication of a disease is herd immunity. Herd immunity slows down the spread through communities[22] , but it depends on people in the communities being vaccinated. If individuals choose not to vaccinate, as in the case of the measles outbreak following the Wakefield study, then herd immunity can not play its role in eradicating a disease

### Data

Much of our life is defined by data. We live in a world where everything is tracked. Data explains how Spotify keeps suggesting incredible headbangers because it knows me. Or why it's hard to stop scrolling Tiktok because every video is so relatable. It also helps us keep track of more important matters, such as the state of our world, economy, and health. Yet, our education system isn't doing much to prepare students for this data-filled world.[23] We explain to students that they need to know math to succeed in the real world, but outdated math curriculums do not prepare students for contemporary problems. By not helping students to become more data literate, we are potentially leaving them vulnerable to being misled by data.[24]

Further, the public's response to the pandemic has made it very clear that my responsibility as a math educator is to build my students' data science and data analysis skills. For this reason, this unit will allow students to practice looking at graphs and other data representations while asking questions that help build a story and literacy for the information they are interpreting.

#### Sample Size

The sample size is a statistical term that refers to the study of a representative smaller number of a larger population. Selection of your sample size in a study is essential because you are finding a representation of a total population. The larger the sample size, the more accurate your findings may be. In Wakefield's case, he studied only 12 children[25] and is a great discussion piece on how data could be swayed. Students should discuss why data literacy is essential when misinformation is a matter of life and death.

#### Epidemiology

Epidemiology is the study of quantitative data and public health; epidemiologists can hypothesize health outcomes and diseases in populations by analyzing patterns. Essentially, epidemiologists study the data of public health in order to better understand outcomes and decide appropriate actions and responses.[26]

### Prevalence and Incidence

These two numbers can tell a story across history. Prevalence and incidence are specific population proportional measurements of a particular time or period for a disease. The differences between these epidemiological evaluations are that prevalence is the number of disease cases, and the incidence is the rate of new cases.[27]

## Design Thinking

The design thinking process is an approach to innovating technology and systems with the user at the center, a human-centered approach. This framework is nothing new to the tech or business world, but it is catching on faster in higher education and k12 schools. Some schools, such as the North Phillips School of Innovation in North Carolina, are even letting their students design their school entirely from the ground up; from their physical classroom space to learning standards through passion projects.[28] Criticism for design thinking in schools is that many of the tenants of the design thinking process are approaches and activities that teachers are already doing. Empathy, the first step in design thinking, is what those who lead design thinking workshops need work through with teachers. Empathizing with teachers could help better understand us and speak our language to implement design thinking practices accross all contents, including those that are not traditionally STEM.[29] Now that I have had a couple of years of slowly thinking about the process since the first workshop I sat in as a teacher, I see design thinking in almost everything I do as a teacher. Design thinking is just a different approach to thinking and problem-solving; it's putting students at the center of my lessons when planning.

The design thinking process consists of 5 phases including, empathize, define, ideate, prototype, and test. In the first phase, designers begin to empathize with their users through observations and interviews. In the second phase, you start to put the information you've gathered in the first phase to define your problem (analysis and synthesis) and create a problem statement. The third ideation phase is where you start to generate ideas from what you have gathered in the first phases. Finally, you move into the final stages of making quick, inexpensive prototypes and then test those designs. Most importantly, design thinking is not a linear process; but instead, you can work on multiple phases simultaneously and repeat phases as many times as needed.

This is where we land back on how teaching design thinking can be challenging. It is not a linear curriculum but a framework or approach[30] to problem-solving. It does not have to be a lengthy project; in fact, many teachers ask students to emphasize and define problems through existing practices. In design thinking the user is at the center, in a school setting this means our students are being centered in everything we do.

### The Speed of Innovation

Mathematics enables us to reason and explain how things work for just about anything, including the rate at which technology grows. Millennials, in my best opinion, have had the best seat in which to observe this change. Our world started with few technological devices, but everything has changed so quickly. Our families were excited to bring home those massive computer boxes home, the ones that slowly connected us to the web and took up the phone connection. Now we can instantaneously stream movies from the phones in our hand. We listened to Walkman, which was quickly replaced for an iPod, which quickly turned into having all those devices in one place: our smartphones. Technological progress can be explained by more math because it exponentially increases.[31]

There is much hesitancy towards the COVID-19 vaccine due to the perception of how quickly it was developed. However, our knowledge and new technology have contributed to the rapid development of a new vaccine.[32]

## Strategies

---

**Student-Centered Math Instruction**

I believe student-centered and collaborative learning can lead to deeper understanding and engagement. Teaching students to become problem solvers and critical thinkers should involve modeling what it is like in the real world. This, to me, brings back the beauty of mathematics by allowing students to make decisions, predictions, and explore instead of relying on me to spoil the ending by modeling how to finish the puzzle or identifying the pattern. Student-centered activities involve working in groups or independently to make inquiries, conjectures, discuss ideas, and critique one another's work. Student-centered learning, in a sense, feels identical to the design thinking process and may help grow students to become innovators in the classroom first and then beyond.

**Student-Generated Inquiry-Based Questions**

When presenting new data for students to analyze, have them ask good questions. Carefully crafted open questions can set students up for deeper dialogue and exploration. Moving your instruction to a student-generated inquiry-based instruction could give students hands-on experience finding meaning in the data we interact with to make better-informed decisions.

When presenting new data to my class, I ask, "What do you notice, and what do you wonder?" I'll give students a moment to silently reflect and write down their thinking before expanding with their shoulder partner, then finally idea-generating via whole-class discussion. This method could be a more engaging way to present new ideas on life expectancy or vaccine technology instead of defining these terms and lecturing students on these high-level scientific concepts. Middle school students have been through many historical events and should be trusted to explore and find meaning from their world views and experiences.

**Design Thinking to Solve Mathematics Problems**

Mathematics is not linear or an isolated subject. Math is everywhere and in every discipline, from art to science. Math is a beautiful tool that helps tell a larger story and helps us find understanding. Design thinking is not just about coming up with a final material product; it is about a framework of thinking.[33]Put two ideas together in mathematics, and we could give students a frame of thought that centers them as problem solvers.

Design thinking has its users asking collaborating questions, attempting ideas, and accepting failure as part of problem-solving. Fear of failure often results in students not attempting a problem at all, which ultimately leads to them missing out on that opportunity to learn how to problem-solve and persevere with a challenging problem. It's time to dismantle this idea students carry into the classroom that math is about having the correct answer; math is more about asking questions and testing hypotheses to find patterns. This means finding the incorrect solution or failing is a part of the process because it gets us another step forward to the answer. I implore every math teacher to enter their classroom with the design thinking mindset.

How can you implement a design thinking mindset in math class when every Google search seems to come up empty handed? After much thought, I began to think how the process resembled the Launch, Explore, Discuss framework, which has students asking questions, working collaboratively, and getting feedback. This thinking of lesson structure then got me refining my search and led me to discover Mary Cantwell's simplified process of design thinking, DEEP (Discover, Empathize, Experiment, Produce).[34]

In the first phase, Discover, Cantwell explains how students research and understand the problem. While they're using this process in a different classroom context, I believe this phase is much like a Notice and Wonder. When tackling a math problem, the Discover phase is about making sense and scope before even beginning to solve.

Empathy is the ability to understand others; in a math classroom, this could look like understanding how peers notice different things and see a math problem differently. Discussion helps with collaboration and sharing ways of seeing a problem, which gives us a pathway to building empathy for the contribution of others and their thoughts to help us solve problems.

The Experiment phase is where we encourage students to dare to fail. Testing is an essential start because getting it right the first time rarely happens. This is where we get to normalize those mistakes as part of the problem-solving process.

Finally, we move into Producing, which doesn't have to be an actual product but more of students sharing their process. This is the part of the lesson cycle where students can have the platform to share how they solved, and then get feedback from their peers.

This DEEP Design Thinking process could be practiced in a week, a unit, a day, with the cycle repeating itself as many times as needed.

**Reflection**

The ability to reflect leads to deeper thinking, understanding ideas, and self-understanding.[35] According to Jo Boaler, it is also another strategy towards students building more awareness for the mathematics they are learning.[36] Often, I find the lesson period cramped and reflection skipped. However, I'm leaving out an effective way for students to think deeper about what we are learning, why we are learning it, and how it could be applied in the future. During this unit, setting aside time at the end of each lesson allows students to reflect on the day's learning, data, and public health in their journals to start building their awareness and ability to analyze. At the end of the unit, let students record a final reflection based on their previous reflections throughout the unit.

## Classroom Activities

---

**Notice and Wonder Data Talks**

When writing this unit, I realized how little I know about reading data. Jo Boalar gives me good news when she explains, "In a data talk, the teacher does not have to be an expert in the topic of the data visualization – if a student asks a question, you can say that you do not know the answer but would love to find out, together![37] "

Data Talks can serve in our practice towards becoming more data literate when analyzing visual data.

To elicit a daily data talk, present a graph to your class. A resource you can use to find graphs for data talks can be found on www.nytimes.com/column/whats-going-on-in-this-graph where you can access an archive of visual data and discover new ones as they are published weekly on New York Times that illustrates relevant information from a wide variety of topics; from Covid-19 to high school sports. Even further, Jo Boaler has done extensive work on teaching data science in k12 education and has resources for facilitating data talks in the classroom that can be found on *https://www.youcubed.org/resource/data-talks/.* This is also another way of presenting data around vaccines and diseases in the daily instruction of this unit to give students a platform for analyzing and drawing their conclusions. More charts and graphs surrounding vaccination data can be found on ourworldindata.org.

After displaying the visual data for your class and giving your students a silent moment to analyze the information, prompt them to share by asking, "What do you notice? What do you wonder?" Facilitate a 5-to-10-minute discussion about what students see and are curious about. You can even ask students if they agree or disagree with a student who has shared a thought. Questions like "How do you know? Or "Tell me more?" Can prompt the sharer to explain their thinking further.

Notice and wonder, data talks, and number talks can help students dig deeper into higher-level thinking[38] and normalize how problem-solving actually happens. However, if students have not engaged in math problems, the discussion may not flow so easily. Practicing this activity weekly before the unit and beyond will help push students towards better math problem-solving habits. They analyze, look for patterns, and ask questions just like data scientists, mathematicians, politicians, athletes, designers, community members, etc.

Alternatively, you can facilitate similar discussions by using think-pair-shares, stronger clearer, jigsaws, or a graph gallery walk.

**Disease Case Analysis Jigsaw**

To build background knowledge on the different types of vaccines and the diseases they've been used to protect against, have students divide and conquer through a Jigsaw discussion. A jigsaw is a group work protocol where students get a different piece of research to conduct and answer questions, move into another expert group who have the same part assigned, and return to their original groups to share their findings. More about how the protocol works can be found on Better Lesson, https://betterlesson.com/strategy/14/jigsaw-discussions.

Spend one instructional day of this unit by organizing students in groups of 5 and assign the following five diseases: Covid-19, Flu, Measles, Polio, and Smallpox. I recommend that you pull articles from the CDC and World Health Organization to set them up as pages in your learning management system, post hyperlinks, or print handouts to aid students in finding the research prior to this lesson.

Have students describe the disease, identify the vaccine type used, and find if the disease has been eradicated or is still prevalent. An example handout with these questions can be found under the resources section of this unit. I would also suggest having students gather and organize the information onto a poster or online on a slide deck.

**Design Thinking and Vaccine Hesitancy**

Because of vaccination efforts, we have seen the complete eradication of smallpox, and near eradication of other diseases. Despite vaccine technologies' success in saving millions of lives, vaccine hesitancy runs rampant in our world of miscommunication and mistrust. Students will use design thinking framework to generate ideas and prototypes on how to combat this problem. In the first phase, students will build awareness of vaccine hesitancy by looking at data and building understanding as to why hesitancy has existed in the past and learn the concerns of the present. Next, students will start to ask questions. Here, I would encourage students to speak with their families and find out why they have not been vaccinated. It may also be helpful to bring in virtual speakers for students to question further. Once students have built an understanding of the scope of the problem, students will brainstorm ideas with a partner. Finally, students will then prototype their ideas, test, and revise. The project will then culminate with a final presentation. Because this activity requires much brainstorming and revision, I would recommend spending the last quarter or half of your class hour almost every day of this two week unit.

**Data Portfolio**

A data portfolio can be used as a final assessment. Students will answer reflection questions, show their work from gathering data, and ask whether they think vaccines should be mandatory. Students must site data given in the unit as to why they think so. Suppose you have an online learning management system such as Canvas or Google Classroom. In that case, it may be helpful to have graphs and data posted in a module for students to access again as they're working on completing their portfolios. Ask students to reflect on data science by asking, "What was the main idea or concept of this unit?" "What questions do you have about data, vaccines, and public health?" "What questions have come up in this unit that has interested you?" "What are you thinking about data now?" "What did you learn today that surprised you?"

Students data portfolio could be completed in the last day or two of the unit. Organize a rubric before hand with expectations on what to include and a template on a digital platform such as GoogleDrive or OneDrive for students to gather their artifacts on.

## Appendix on Implementing District Standards

---

**Common Core State Standards:**

MP1: Make sense of problems and persevere in solving them.

Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt.

7.SP.A.1

Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

7.SP.A.2

Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

**Oklahoma Academic Standards**

7.D.1: Display and analyze data in a variety of ways.

7.D.1.1

Design simple experiments, collect data and calculate measures of central tendency (mean, median, and mode) and spread (range). Use these quantities to draw conclusions about the data collected and make predictions.

## Resources

---

**Student Reading List**

ICMEStudio. *WiDS Education Outreach Video.* YouTube video. 8:22. June 16, 2020. https://www.youtube.com/watch?v=KYvhoH5AzHA

The History of Vaccines. *Timeline.* https://www.historyofvaccines.org/timeline/all

The History of Vaccines. *How Vaccines Work. https://www.historyofvaccines.org/content/how-vaccines-work*

**Classroom Materials**

Our World in Data. *https://ourworldindata.org/.*

A resource for graphs and articles on life expectancy, public health, diseases, and vaccinations.

The New York Times. *What's going on in this graph?* www.nytimes.com/column/whats-going-on-in-this-graph. Retrieved July, 2021.

Website containing an archive of graphs, maps, and charts, with new content posted weekly during the school year and live student discussion boards.

YouCubed. *Data Talks. https://www.youcubed.org/resource/data-talks/*

A resource for data talk in the classroom wth precreated graphs and prompts.

Boaler, Jo; LaMar, Tanya; Williams, Cathy. *Making Sense of a Data-Filled World.* July, 2021. youcubed.org/wp-

content/uploads/2021/07/MTLTPK-12-Making-Sense-of-a-Data-Filled-World.pdf. Retrieved August, 2021.

Page 4 has a graph that illustrates the need for more data literacy in education. This graph could be a great data talk for explaining why they're spending time on this unit.

BetterLesson. *Jigsaw Discussions.* https://betterlesson.com/strategy/14/jigsaw-discussions.

A resource explaining the Jigsaw strategy with helpful tips and accommodations.

## Handouts

### Vaccine Case Study Sample Handout

1. Description of the disease and health implications
2. Is it eradicated?
3. Vaccine Form; killed intact, live attenuate, subunit…
4. How does it need to be stored?
5. Immunization Schedule
6. Route of administration
7. Cost
8. Global Distribution and Availability

## Bibliography

"200 Years of Public Health Has Doubled Our Life Expectancy - San Juan Basin Public Health." 2017. San Juan Basin Public Health. https://www.facebook.com/sjbpublichealth. April 3, 2017. https://sjbpublichealth.org/200-years-public-health-doubled-life-expectancy/.

Adalja, Amesh A. 2020. "Powerful New Technologies Are Speeding the Development of a Coronavirus Vaccine - Leaps.Org." Leaps.Org. March 2, 2020. https://leaps.org/powerful-new-technologies-are-speeding-the-development-of-a-coronavirus-vaccine/particle-3.

Bankston, Krystal. n.d. "Student-Generated Inquiry-Based Questions | BetterLesson Coaching." BetterLesson. BetterLesson. Accessed August 6, 2021. https://betterlesson.com/strategy/138/student-generated-inquiry-based-questions?from=search.

Bland, Shakkiyya. n.d. "Everyday Inquiry in Mathematics | BetterLesson Coaching." BetterLesson. BetterLesson. Accessed August 6, 2021. https://betterlesson.com/strategy/1166/everyday-inquiry-in-mathematics?from=search.

Boaler, Jo. 2016. "MATHEMATICAL MINDSETS: Unleashing Students Potential through Creative Math, Inspiring... Messages and Innovative Teaching." S.l.: JOSSEY-BASS, 2016.

Boaler, Jo, Tanya LaMar, and Cathy Williams. 2021. "Making Sense of a Data-Filled World." YouCubed. The National Council of Teachers of Mathematics. July 2021. https://www.youcubed.org/wp-content/uploads/2021/07/MTLTPK-12-Making-Sense-of-a-Data-Filled-World.pdf.

Boylston, Arthur. "The Origins of Inoculation." Journal of the Royal Society of Medicine 105, no. 7 (2012): 309–13. https://doi.org/10.1258/jrsm.2012.12k044.

Branham, Dana. 2021. "As COVID-19 Cases Rise, Officials Repeat Pleas for Unvaccinated Oklahomans to Get a Shot." The Oklahoman. July 10, 2021. https://www.oklahoman.com/story/news/2021/07/10/covid-19-cases-rising-oklahoma-areas-low-vaccination-rates/7906636002/.

Burd, Katherine. 2020. "Design Thinking: The Problem With Education's Latest Trend (Opinion)." Education Week. Education Week. February 3, 2020. https://www.edweek.org/leadership/opinion-design-thinking-the-problem-with-educations-latest-trend/2020/02.

Colley, Binta, Andrea Bilics, and Carol Lerch. n.d. "Reflection: A Key Component to Thinking Critically." The Canadian Journal for the Scholarship of Teaching and Learning: Vol. 3: Iss. 1, Article 2. Accessed August 6, 2021. https://files.eric.ed.gov/fulltext/EJ985735.pdf.

Collins, Megan. 2019. "Design Thinking Is a Challenge to Teach — and That's a Good Thing | EdSurge News." EdSurge. EdSurge. July 31, 2019. https://www.edsurge.com/news/2019-07-31-design-thinking-is-a-challenge-to-teach-and-that-s-a-good-thing.

Crimmins, Eileen. 2015. "Lifespan and Healthspan: Past, Present, and Promise." PubMed Central (PMC). Oxford University Press. November 10, 2015. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4861644/.

———. n.d. "Data Talks Archives - YouCubed." n.d. YouCubed. Accessed August 6, 2021. https://www.youcubed.org/resource/data-talks/.

Ford, Georgina. 2020. "Prevalence vs. Incidence: What Is the Difference? - Students 4 Best Evidence." Students 4 Best Evidence. November 6, 2020. https://s4be.cochrane.org/blog/2020/11/06/prevalence-vs-incidence-what-is-the-difference/.

———. n.d. "History of Smallpox | Smallpox | CDC." n.d. Centers for Disease Control and Prevention. Accessed August 6, 2021. https://www.cdc.gov/smallpox/history/history.html.

———. 2020 "How Does the Immune System Work? - InformedHealth.Org - NCBI Bookshelf." 2020. National Center for Biotechnology Information. April 23, 2020. https://www.ncbi.nlm.nih.gov/books/NBK279364/.

Johnson, Steven. *Where Good Ideas Come From: The Seven Patterns of Innovation*. London: Penguin, 2011.

Kennefick, Kelly. n.d. "Notice and Wonder | BetterLesson Coaching." BetterLesson. Accessed August 6, 2021. https://betterlesson.com/strategy/219/notice-and-wonder?from=strategy_details.

Kinlaw, Robert. 2019. "How Public School Educators Built a Radically Innovative School - EducationNC." EducationNC. May 13, 2019. https://www.ednc.org/how-public-school-educators-built-a-radically-innovative-school/.

Markel, Howard. 2015. "The Origin Of The Word' Vaccine.'" Science Friday. November 2, 2015. https://www.sciencefriday.com/articles/the-origin-of-the-word-vaccine/.

Najera, Rene. 2019. "A Brief History of Measles | History of Vaccines." History of Vaccines - A Vaccine History Project of The College of Physicians of Philadelphia |

History of Vaccines. February 20, 2019. https://www.historyofvaccines.org/content/blog/brief-history-measles.

Ninde, Claire. 2017. "200 Years of Public Health Has Doubled Our Life Expectancy - San Juan Basin Public Health." San Juan Basin Public Health. April 3, 2017. https://sjbpublichealth.org/200-years-public-health-doubled-life-expectancy/.

Quick, Jonathan, and Heidi Larson. 2018. "The Vaccine-Autism Myth Started 20 Years Ago. Here's Why It Endures Today | time." Time. Time. February 28, 2018. https://time.com/5175704/andrew-wakefield-vaccine-autism/.

Rao, T S Sathyanarayana, and Chittaranjan Andrade. "The Mmr Vaccine and Autism: Sensation, Refutation, Retraction, and Fraud." Indian journal of psychiatry. Medknow Publications, April 2011. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3136032/.

Reports, From Staff. 2021. "Biden Administration Provides Oklahoma with $9 Million for Rural COVID-19 Response | State and Regional News | Tulsaworld.Com." Tulsa World. July 14, 2021. https://tulsaworld.com/news/state-and-regional/biden-administration-provides-oklahoma-with-9-million-for-rural-covid-19-response/article_0ae88380-e40a-11eb-8813-6fb0a8be2ce5.html.

Robinson, Kynan. 2020. "Design Thinking & Mathematics Teaching — Change Your Mindset | by Dr. Kynan Robinson | Medium." Medium. Medium. June 22, 2020. https://medium.com/@kynanrobinson/how-to-use-design-thinking-with-design-thinking-mathematics-teaching-change-your-mindset-94b16917409e.

Roser, Max, Esteban Ortiz-Ospina, and Hannah Ritchie. 2013. "Life Expectancy - Our World in Data." Our World in Data. 2013. https://ourworldindata.org/life-expectancy.

Roser, Max, and Hannah Ritchie. 2013. "Technological Progress - Our World in Data." Our World in Data. 2013. https://ourworldindata.org/technological-progress.

———. 2014. "HIV / AIDS - Our World in Data." Our World in Data. 2014. https://ourworldindata.org/hiv-aids.

Ryder, Dan. 2019. "Teacher's Corner: A Story of Design Thinking in the Classroom | American English." American English | For English Language Teachers Around the World. November 2019. https://americanenglish.state.gov/resources/teachers-corner-story-design-thinking-classroom.

———. n.d. "Herd Immunity and COVID-19 (Coronavirus): What You Need to Know." Mayo Clinic. Mayo Foundation for Medical Education and Research, June 9, 2021. https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/herd-immunity-and-coronavirus/art-20486808.

———. 2012. "Principles of Epidemiology." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, May 18, 2012. https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section1.html.

———. 2016. "Smallpox Vaccines." 2016. WHO | World Health Organization. May 31, 2016. https://www.who.int/news-room/feature-stories/detail/smallpox-vaccines.

Spector, Carrie. 2020. "Bringing Math Class into the Data Age | Stanford Graduate School of Education." Stanford Graduate School of Education. February 28, 2020. https://ed.stanford.edu/news/bringing-math-class-data-age.

———. n.d. "Timeline | History of Vaccines." n.d. History of Vaccines - A Vaccine History Project of The College of Physicians of Philadelphia | History of Vaccines. The College of Physicians of Philadelphia. Accessed August 6, 2021. https://www.historyofvaccines.org/timeline/all.

———. n.d. "Understanding Mrna Covid-19 Vaccines." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention. Accessed August 19, 2021. https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/mrna.html.

———. n.d. "Vaccine Basics | Smallpox | CDC." n.d. Centers for Disease Control and Prevention. Accessed August 6, 2021. https://www.cdc.gov/smallpox/vaccine-basics/index.html.

———. n.d. "What Is Epidemiology? | Teacher Roadmap | Career Paths to Public Health | CDC." n.d. Centers for Disease Control and Prevention. Accessed August 6, 2021. https://www.cdc.gov/careerpaths/k12teacherroadmap/epidemiology.html.

## Notes

---

[1] Johnson, *Where Good Ideas Come From*

[2] Branham, *As COVID-19 Cases Rise.*

[3] Staff Reports, *Biden Administration Provides Oklahoma with $9 million.*

[4] Ibid.

[5] Roser, Ortiz-Ospina, and Ritchie, *Life Exectancy.*

[6] Crimmins, *Lifespan and Health Span.*

[7] Roser, Ortiz-Ospina, and Ritchie, *Life Expectancy.*

[8] Ninde, *200 Years of Public Health.*

[9] Ibid.

[10] Ibid.

[11]*The History of Vaccines.*

[12]*History of Smallpox.*

[13] Boylston, *The Origins of Innoculation.*

[14]*Smallpox Vaccines.*

[15] Markel, *The Origin of the Word 'Vaccine'.*

[16]*Vaccine Basics.*

[17] Cologne, *How does the immune system work?*

[18] Najera, *A Brief History of Measles.*

[19] Quick and Larson, *The Vaccine-Autism Myth.*

[20]*Understanding Mrna Covid-19 Vaccines.*

[21] Ibid.

[22]*Herd Immunity and Covid-19.*

[23] Spector, *Bringing Math Class into the Data Age.*

[24] Boaler, *Making Sense of a Data-Filled World.*

[25] Rao, *The MMR Vaccine and Autism.*

[26]*Principles of Epidemiology.*

[27] Ford, *Prevalence vs. Incidence.*

[28] Kinlaw, *How Public School Educators Built a Radically Innovative School.*

[29] Burd, *Design Thinking: The Problem with Education's Latest Trend.*

[30] Collins, *Design Thinking is a Challenge to Teach.*

[31] Roser and Ritchie, *Technological Progress.*

[32] Adalja, *Powerful New Technologies Are Speeding the Development of a Coronavirus Vaccine.*

[33] Robinson, *Design Thinking & Mathematics Teaching.*

[34] Ryder, *Teacher's Corner: A Story of Design Thinking in the Classroom.*

[35] Colley, Bilies, and Lerch, *Reflection: A Key Component to Thinking Critically.*

[36] Boaler, *Mathematical Mindsets.*

[37] Boaler, *Data Talks.*

[38] Kennefick, *Notice and Wonder.*