YALE NATIONAL INITIATIVE
to strengthen teaching in public schools®

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

The Curb Cut Effect: A Local and Global Citizen Bioengineering Challenge

Curriculum Unit 21.05.06, published September 2021
by Michelle Melby

Introduction

In March of 2020, the Norwegian University of Science and Technology released a message to their students abroad:

> "In accordance with the recommendations from the Ministry of Foreign Affairs (UD), NTNU strongly recommends that all NTNU students who are outside Norway return home. This applies especially if you are staying in a country with poorly developed health services and infrastructure and/or collective infrastructure, for example the USA. The same applies if you do not have health insurance."[1]

The American medical system is an agglomeration of some of the best, most innovative minds in the world. Unfortunately, these fantastic innovations are usually only accessible if you have expensive or employer sponsored medical insurance or are wealthy. The US Census Bureau found that 27.5 million did not have health insurance in 2018.[2] Fortunately, there are a growing number of innovators who are designing low cost, rugged, and sustainable medical technology for those in our vulnerable populations. Many of these innovations are so useful and well-designed that they are mainstreamed to the general public. This happened with curb cuts, the dip in the sidewalk where one can access crosswalks. These were originally designed for those in wheelchairs, but they benefit the whole population: baby carriages, delivery persons, bikes, etc. Helping the larger population by designing for the most vulnerable is called The Curb Cut Effect.[3] This unit will prepare the next generation of innovators to innovate accessible and valuable medical technology.

James Lick Physiology (grades 11 and 12) students will work with various organizations to identify a local population that could benefit from rugged and sustainable medical technology. The students will interview and empathize with that population (or experts who care for that population), define a health issue that could be improved through innovative engineering, and build a prototype of the technology.

Background

Room for Innovation

I would like students to focus on the needs of lean, or resource poor, countries and create medical technology that is inexpensive, accessible, and durable. According to the Curb Cut Effect, this technology can most likely be scaled to other communities with similar needs.

Human Development Index

The terms "First-world", "Third-world, "Developed", and Undeveloped" are outdated terms to describe a country's place in the world as solely based in GDP. The Human Development Index (HDI), as stated by the United Nations Development Programme (UNDP), "was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone."[4] The HDI is calculated from life expectancy at birth, access to education, and Gross National Income (GNI is similar to GDP but gives a better picture of standard of living). For example, Norway has a 2019 HDI value of 0.957 and Niger has a 2019 HDI value of 0.394. Norway is #1 in the HDI Ranking and has high levels of life expectancy, education, and GNI. Niger is 189 in the ranking and has very low levels of life expectancy, education, and GNI.[5] Adjustments can be made to the HDI to take into account human development inequality, poverty, gender inequality, planetary pressures, etc.

Gini Coefficient

The Gini Coefficient (GC) compares a graph of perfectly equal wealth distribution in a country to the actual wealth distribution in that country (the graphical representation of the income distribution in country is called The Lorenz Curve).[6] The comparison yields a number between 0 and 1 (sometimes represented as a percentage). A 0 (0%) value indicates perfect equality and a value of 1 (100%) indicates complete inequality. For example, Norway has a GC value of 0.276 (27.6%) and Niger has a value of 0.343 (34.3%).[7] Therefore, Norway has better wealth distribution than Niger. This value, of course, has limitations. The GC is a broad brush and can misrepresent the factors leading to wealth inequality. It is also very important to recognize the different between income and wealth and make sure that the calculated GCs being compared are consistently calculated. Income has more to do with labor markets while wealth has more to do with the balance of power. Therefore, this statistic should be used along with other data and models.

Lean vs. Fat

The HDI and GC are useful for identifying what are known as "lean" and "fat" countries. Since lean countries have less resources than fat counties, they "approach consumption and production with scarcity in mind".[8] Lean economies are perfect to focus on for medical innovation because there is a great need for inexpensive, accessible, and durable technology and they can avoid some of the growing pains and infrastructure problems present in fat countries. Americans have more money, more infrastructure, and more access to medical care while Africans "waste less food and water, owe less money, and maintain a regional carbon footprint that is that lowest in the world."[9] Conversely, Americans are more vulnerable to financial crises while Africans are more vulnerable to pandemics.

Innovation happens in both types of countries, but looks very different. Women in Japan, a fat country,

frequently waste a lot of water in public restrooms because they flush multiple times in order to cover up embarrassing noises. A Japanese company, Toto, created the Otohime (Sound Princess) which simulates the sound of a flushing toilet. These devices were installed in public restrooms and became a best-seller in Japan. Halfway around the world in the lean country of Kenya, a very different bathroom issue kickstarted innovation. "Flying toilets" are bagged refuse that are thrown as far as possible from settlements in order to avoid water contamination and night time crime around public toilets. To help illuminate this form of pollution and help African communities, The Umande Trust built a biodigester which is inexpensive and doesn't use water. It also creates biogas (mainly methane and carbon dioxide produced during the breakdown of waste) which can be used as a reliable source of power in the community.[10]

5 Medical Challenges for Lean Countries

There are five typical challenges that innovators face when designing medical technology in a lean country.[11] One, there is little reliable infrastructure. An electricity grid could be unreliable or nonexistent. Water quality and supply is low. Roads are poor and transportation mostly consists of walking long distances. Two, local medical staff is not trained to use and maintain the equipment. Three, equipment maintenance is too difficult and expensive. Parts may be difficult to obtain. Four, equipment consumables are expensive or difficult to obtain. Sterility standards often requires parts to be replaced between patients. Five, the equipment is not durable. Because the equipment is often used in harsh, extreme, or outdoor environments which they are not built for, they don't last long. These five challenges need to be considered when designing medical technology for use in lean countries.

The Adjacent Possible

Do you know where your medical records are? Do you still have your birth certificate? Millions of people throughout the world can't say yes to these questions. Enter Khushi Baby, the result of many years of hard work and collaboration at the Yale Center for Engineering Innovation and Design.[12] This small device takes advantage of a relatively new technology called Near Field Communication tags (NFC) to store vaccine records without the need for batteries. NFC tags are typically small stickers.[13] In this case, the tags were integrated into the kala dhaga, a black thread traditionally used in some Indian communities to ward off the "evil eye". Kushi Baby has become very popular in underserved Indian communities as an easily integrated way to decrease infant mortality. This did not happen in a vacuum. The design team utilized something called the Adjacent Possible, a phrase coined by scientist Stuart Kauffman in 2002.[14] While he was referring to the process of Evolution, the phrase applies to all successful innovative processes. Basically, most innovations are small steps forward which rely on previous innovations. In the case of Kushi Baby, the step forward in medical care relied on the recently developed NFC technology. NFC in turn relied on RFID technology. Brilliance is rarely a huge jump forward with a single burst of inspiration, but is actually a series of small hops. In order for my students to be truly innovative, they will need to rely heavily on the adjacent possible. They will need scaffolding into the engineering process and guidance from field experts.

Diffusion of Innovation Theory

The Diffusion of Innovation Theory describes the spread of technology and new ideas through a population.[15] There are five adopter categories that can be considered when trying to popularize new technology. The *innovators* take risks and try the technology first. The *early adopters* are leaders who enjoy adopting new ideas. The *early majority* feel comfortable following the early adopters. Most of the population falls into the early majority category. The *late majority* will wait to find out more information about how well the

technology performs. The *laggards* are the most reluctant to adopt new technology and hold out the longest. The public adopts or rejects new technology based on the perceived value of the new idea, compatibility with existing beliefs, difficulty of use, and proven effectiveness and safety.

Vulnerable Populations

Vulnerable populations abound in San Jose, CA. My students can choose to focus on geriatric populations, newborns, those with vaccine allergies, etc. For introductory purposes, I will focus on the homeless population in this area because it has become more visible in the past few years. According to the 2019 City of San Jose Homeless Census & Survey, the homeless population increased by almost 2,000 people between 2017 and 2019 in San Jose. This population has a high rate of psychiatric conditions, and the consequent drug and alcohol abuse, which rarely receive adequate care. Numerous studies from the 1980s to the current day state that "People who are homeless have higher rates of illness and die on average 12 years sooner than the general U.S. Population".[16] This problem is widespread and was greatly exacerbated by a massive pandemic. What can we possibly do?

Demographics for James Lick High School and San Jose, CA

In order to properly serve my students, it is important to understand their demographics. James Lick is a small school (approximately 1100 students) composed mostly of Socioeconomically Disadvantaged (86%) and Hispanic students (80%). We also have fairly high populations of English Language Learners (18%) and Students with Disabilities (15%). A large percentage of our population (20-24%) tests below average on the California Assessment of Student Performance and Progress Research and Inquiry section, so they will need a high level of scaffolding in order thrive during this project.[17]

San Jose is a large and diverse city (population estimate 1,021,795). According to the 2019 US Census, San Jose's ethnic breakdown is White 39.9%, Black or African American 3.0%, American Indian and Alaska Native 0.6%, Asian 35.9%, Native Hawaiian and Other Pacific Islander 0.5%, Two or More Races 5.3%, and Hispanic or Latino 31.6%. English is the primary language in 43% of San Jose homes while 57% speak another language. Poverty levels in San Jose can be deceiving because large areas of San Jose and the rest of Santa Clara county have low levels of poverty and high levels of education (High school graduates 84.6%, Bachelor's degree or higher 43.7%, Persons in poverty 8.7% in 2019). However, the area of San Jose that is of special interest, typically called "East Side", has a high level of poverty (36% child poverty in 2010). Poverty continues to be tied to race and education in California (22.9% Latinos in poverty and 30.6% Adults without a high school diploma in 2018).[18] Most of my students are part of or directly in contact with someone from a vulnerable population.

Teaching Strategies

"Improvement is not forcing something; it is releasing something."[19]

Project Based Learning

The traditional education model is lecture-memorize-test. That is an outdated model. Project Based Learning

(PBL) allows students to deep dive into a real-life problem for an extended period of time and develop critical thinking, collaboration, and communication skills. The culmination of most projects is a public presentation in front of an audience, preferably outside of the sphere of the school. PBL is different from just "doing a project" because the project is the whole unit instead of being the culmination of the unit. During PBL, the teacher becomes more a coach rather than the source of all knowledge.[20]

Universal Design of Learning

The Universal Design of Learning (UDL) has three components: Engagement, Representation, and Action and Expression. Taking these three ideas into consideration while designing a project makes them more engaging and meaningful for learners. Developing *Engagement* helps students understand the *why* of what they are learning. Engagement helps motivate and stimulate interest. *Representation* encompasses the *what* of learning. Representation is activated by presenting information in different formats. *Action and Expression* is the *how* of learning. Students can express their learning in different ways.[21] UDL will ultimately help me create the Curb Cut Effect in my classroom.

Engineering Design Process

The Engineering Design Process (EDP) is similar to the Scientific method in that an idea is tested and evaluated. In this case though, students will need to build a prototype to solve a problem. In order to do this in a precise way, students will Define, Identify, Evaluate, Prototype, Test, Iterate, Communicate, and Reflect. Students will first need to *define* and research a problem. Then students will *identify* the constraints and criteria for a solution to the problem, including consumer and environmental impacts. Next, students will brainstorm solutions and pick the most promising idea (*evaluate*). Students will then build a *prototype* of their solution and *test* the effectiveness of their prototype. *Testing* will yield data that can be used to improve the prototype. *Iterations*, the cycle of improvement, can be done as long as time and money permit. At the end of the project, students will present their prototype (*communicate*), get feedback, and *reflect* on the process.[22] EDP will help students create the Curb Cut Effect for a medical need.

Design Thinking & Wicked Problems

"It might help us in the wealthy world to pause for a moment and reflect not on what we lack but on our good fortune. And the best way to do that is to look at those with less in their hands."[23]

Design Thinking is very similar to EDP, but adds one very important step: Empathize.[24] In this stage, students must think about the consumer, user, or target audience. While most of my students are low socioeconomically, they will most likely be designing for people who are even less fortunate. It is difficult to understand the motivations and needs of other people unless one actively tries to empathize. The other stages of Design Thinking follow EDP closely: Define, Ideate, Prototype, and Test. This process is ideal for solving "wicked problems": problems that are complex and have many potential solutions.[25]

SAMR

The SAMR model, developed by Dr. Ruben R. Puentedura, is a way to evaluate changes in technology or the advance of innovation.[26] The model divides innovation into *enhancement*, making existing technology better, and *transformation*, totally changing technology to fit a changing world. Enhancement encompasses *substitution* and *augmentation*. Substitution is the interchange of one technology for another. Augmentation

is substitution, but with improvement to the existing technology. Transformation encompasses *modification* and *redefinition*. Modification is a significant redesign of technology, allowing for new tasks. Redefinition is the creation of new technology by the creation of new tasks or needs. It is important for students to know that their innovative designs can fit into any of these categories and do not always need to be completely new ideas.

SWOT

The SWOT Analysis is a common tool for businesses to evaluate ideas, designs, and products.[27] The main areas of analysis are *strengths, weaknesses, opportunities, and threats*. Strengths and weaknesses are thought of as internal characteristics of a business or product while opportunities and threats are thought of as external. This can also be simplified to positives (strengths and opportunities) and negatives (weaknesses and threats). This process encourages discussion of what is going right and what could go wrong, including strategies to encourage innovation and mitigate issues. Doing a SWOT Analysis as a form of Peer Review can help students honestly celebrate the strengths and build strategies to deal with the weaknesses of their design. Peers can help identify issues and brainstorm solutions, reevaluate project goals, and create next steps. For students, creating an action plan as the final step of a SWOT Analysis is essential in order to avoid project paralysis because of perceived failures.

Intelligent Failure

"Only leaders can create and reinforce a culture that counteracts the blame game and makes people feel both comfortable with and responsible for surfacing and learning from failures."[28]

Failure is a key component of learning. It is just as important to know what doesn't work as it is to know what works. This is a difficult concept for most people to accept, but valuing and using failure can be taught. Students might never design a working prototype or might come across an insurmountable piece of our vast bureaucracy. That's ok! Going through the design process and participating in version failure (taking small steps) instead of abject failure (total failure which impedes learning) encourages a "growth mindset".[29] According to Dr. Carol Dweck, students perform better when they believe that they can improve with practice and hard work instead of believing that their talent and intelligent are fixed ("fixed mindset").[30] Communication of failure is also important because this will save other innovators time, and open up the problem to other minds and viewpoints, thus increasing the innovative brainpower.

Different types of failure require different responses from leaders. Failure happens with routine work, complex tasks, and cutting-edge research. Routine task failure often requires a review of procedures while failure during cutting-edge research often requires a new experiment. It's also important to recognize which types of failure are preventable, which are related to how complex a problem is, and which failures are intelligent. Preventable and complex problem failures may require a review of the individual doing the work (Didn't follow the rules? Didn't pay attention? Lacks training?) or of the processes involved in completing the work (Poor directions? Too difficult? Was there a design flaw? Did something unexpected happen?). Once a leader has identified the type of failure they are dealing with, they can analyze the situation, make note of lessons learned, and employ appropriate remedies. Therefore, an organization must engage in a cycle of "consistently reporting failures, small and large; systematically analyzing them; and proactively searching for opportunities to experiment."[31]

Comprehension Strategies

"They found that the only distinction between an innovative and a non-innovative team was psychological safety."[32]

Many of my students are not enthusiastic or confident readers. Presented with a technical text, they would rather not read it and fail than try to slog through it. In order to mitigate this fear, I often integrate comprehension strategies that have been successful at easing students into a reading and making them more comfortable with the comprehension process. Below are a few of my favorite strategies.

Text-to-Speech

Reading quietly, reading aloud, and being read to allow my students to access text by activating different senses. It is important that none of these happen alone. If a student prefers to read quietly to themselves, they should also repeat the reading aloud to themselves, read it to someone else, or listen to a text-to-speech generator while taking notes or annotating. Accessing a text several times, in several ways forces students to take the time to think about the content. My district pays for Snap & Read, but there are many free online resources. Snap & Read will read any text aloud, adjust readability, translate, and outline. If students need free resources, naturalreaders.com and ttsreader.com are free text-to-speech readers that will read simple copy-and-paste text.

Annotation

Annotation is my favorite way to help students understand text. This is not a passive teacher exercise! Tables 1 and 2 show two types of annotation, depending on the format of the reading. Once students have had the opportunity to access the text and annotate individually at least once, students can come together in small groups or as a whole class with the teacher to dissect their annotations. Start with the Main Idea of the text: What is this about? What's the point? Briefly discuss important points. The main part of this discussion should be about difficult to understand words and phrases. I have found that students really connect with this part of the annotation process because they are comforted by knowing that most other students don't understand the same things.

General Highlighting Annotation Guide

Main Idea	A sentence or two in each section which summarizes the main point of that section.
Key Term and Definition	Any time vocabulary is defined.
I don't understand/Unfamiliar word or phrase	Anything you don't understand.
Names/Dates/Useful facts	Important parts of the stories or research

Table 1: The general highlighting annotation guide is useful for stories and simple informational texts or articles.

Science and Engineering Annotation

Underline	Underline useful info about the problem

	Circle unfamiliar words and phrases
	Box useful information about the design
	Write notes in the left margin
	Write questions in the right margin

Table 2: The science and engineering annotation guide is useful for technical texts that describe experiments or engineering design.

Phonetic Spelling

My students really depend on this part of the reading process and ask for it when I don't include it. Reading technical texts can really be intimidating when students don't know how to say the words, so I include an informal phonetic spelling session with most readings. Any word that is difficult to pronounce, such as *prosthetic*, can be reduced to individual sounds such as *pros-theh-tick*. I always say "spell it like it sounds, not like it's spelled". I can say the word for the students and they can do their own phonetic spelling or I can guide them to Google search, Merriam-Webster, or other website that will "say" the words so that they can listen to the words several times at their own pace. I generally guide them away from traditional linguistic phonetic spelling because it contains many symbols that students are not familiar with and would be too time consuming to learn in this class.

Modeling

Learning does not have to be reduced to lecturing, reading, taking notes, and taking tests. Modeling is my favorite science instructional teaching strategy. Modeling is not just building models of solar systems, although that is a great activity. Modeling can be a demonstration, a drawing, or a prototype made of things students find around the house.

Demonstrations

Modeling can be demonstrations by teachers or students to the class or a group. I have demonstrated the exothermic reaction of the sugar in gummy bears and potassium chlorate. This results in a lot of fire and heat and is safer done as a demonstration. Demonstrations can also be done when supplies are hard to find or prohibitively expensive.

Experiments

Experiments are the ultimate modeling exercise for science teachers. Experiments can be used to prove a concept (measure blood drop angle vs. size of blood drop to find the established correlation in Forensics) or to explore a concept (which fertilizer will grow the best roses in our garden for Biology).

Engineering Projects

Engineering projects are great for exploring solutions to complex problems. These can be as simple as interactive posters for public awareness and as complicated as building a prosthetic limb for a surfer who lost her arm.

Graphing

Graphing and graph analysis are critical scientific tools. Graphing gives students an analytical tool that lets them visualize complex data sets. For example, they might graph the number of homeless in San Jose over the past 20 years and compare that to economic trends. Graph analysis helps students understand graphed data and, most important, recognize data manipulation. Table 3 shows various strategies to help students annotate and understand graphs.

Graph Annotation and Analysis Strategies

HLPA	High	The highest (y-axis label) is (value/category) at (value) (x-axis label).
	Low	The lowest (y-axis label) is (value/category) at (value) (x-axis label).
	Pattern	The trend is…
	Anomaly	The outlier is…
I^2	Identify	I see…
	Interpret	It might mean…
Captions and Headlines	Caption	Label (Figure x). Title Statement (descriptive title). Pattern (describe trends/patterns).
	Headline	Create a catchy headline for this graph that you might see in the news.

Table 3: Students can use these tools to annotate and analyze graphs.

Classroom Activities

The following activities (Empathy, Lean Country Analysis, Failure Analysis, Physiology Literature Review, and Building a Helping Hand) will take approximately three weeks to complete. Preparation for a symposium will take an additional six weeks, but this can be spread out over a long period of time (for example, dedicate one day each week during the first semester to symposium preparation).

Empathy

Empathy is an important first step in trying to design for a vulnerable population. This exercise allows students to research populations, such as homeless or geriatric, and then figure out what it's like to belong to that population. Once students have researched their population in small groups, they will make a poster about that population and present it to the class. This poster should have a roughly drawn person and room to add descriptions. Their drawing needs to have real or symbolic attributes which represent physical, mental, or emotional characteristics of a person from that population. For example, students might draw a brain on

their person and label that “PTSD” with a description “31% of homeless in San Jose suffer from PTSD”.[33] Students may need prompting such as “Your person needs eyes; what can you imagine a homeless person would see a lot?” Posters should be displayed around the room for reference as students are working on their projects and brainstorming ideas that will have the greatest impact in their chosen population.

Lean Country Analysis

“We cannot just look at a country by looking at charts, graphs, and modeling the economy. Behind the numbers there are people.”[34]

Students will work individually or in small groups to analyze various lean countries. They will use annotation techniques to find information about the culture of the country. Then they will use HDI data from UNDP to graph and analyze the country’s resources.[35] This information should also be presented and widely available to the class as students progress through the design process and consider global versus local technological impacts.

Failure Analysis

The pacemaker, a device that can regulate the rhythm of a misfiring heart, has come a long way from the huge machines of the 1950s. The breakthrough to small, implantable devices was actually the result of carelessness. Wilson Greatbatch was trying to build a heart rhythm recorder in 1956 and put the wrong resistor in a circuit. What he created did not record the heart rhythm; it *created* the heart rhythm. His device was the precursor to the modern pacemaker, a device that has saved millions of lives.[36] Students will work independently or in small groups to research, analyze, and report out about a famous failure in science.

Physiology Literature Review

Designing medical technology requires a detailed knowledge of anatomy and physiology. Students will conduct a literature review and write a report about the body system(s) directly affected by their technology. For example, if the students were to pursue a better pacemaker design, they would need to research and write about how the cardiovascular system works and the current pacemaker technology.

Building a Helping Hand

Students will practice the Engineering Design Process by building a working model of a hand with cheap materials found around the home that can perform a task of their choosing (such as hold on to a surfboard). The base project is originally from Science Buddies (Build a Helping Hand Science Project[37]), but uses The Adjacent Possible and Curb Cut Effect to help them come up with a solution to a new problem. They must document their progress, including opportunities to learn from the failure during the iterative process. They will then show their results to the class, assess their new technology, and describe their next steps. Table 4 shows an example technology assessment tool that students can use to organize their thoughts.

Technology Assessment Tool

Question	Notes
What problem are you trying to address?	
Who is your intended audience?	

Who else would find this technology valuable?	
Approximately how much did it cost to produce your prototype?	
Is this a durable product? Explain.	
Is this product user-friendly? Explain.	
Will this product be easy to maintain? Explain.	
Is this product environmentally friendly?	
Considering your answers to the above questions, what should you do next to improve your prototype?	

Table 4: Technology Assessment questions to help students think critically and honestly about their product.

Partners in Innovation

Once my students have a handle on how to analyze vulnerable populations, they will work with one or more of the following organizations to identify and prototype innovative medical technology. Students can work with mentors to design solutions, build prototypes, and test these with their chosen population. Students will then consider the global applications of their product by modifying it for use in another country with a similar need. Students must consider technical feasibility, economic viability, accessibility, and cultural appropriateness. Finally, students will present their project at the appropriate symposium.

City of San Jose

The City of San Jose works to promote community engagement in our schools and I hope to include them in the process of identifying and working with vulnerable populations in this area.

Synopsis sciencepalooza!

The Synopsys Silicon Valley Science & Technology Outreach Foundation funds a yearly science fair called sciencepalooza! for the students of East Side Union High School District. The official science fair symposium is typically held in February. Winners of this science fair can advance to county, state, and national science fairs.

Stanford University FAST (Future Advancers of Science and Technology)

Stanford pairs graduate student mentors with science fair participants to work on high level science projects. The students present their work at Sciencepalooza.

BioEHSC (Bioengineering Honor Society Competition)

The Bioengineering Honor Society at UC Berkeley hosts a competition in which high school students work with a mentor to find a bioengineering solution to a problem in medicine or biology. Students present their project at the BioEHSC Symposium. The symposium is typically held in April.

The Amgen Biotech Experience

Amgen Biotech works with UC Berkeley to bring authentic biotechnology into the classroom. They provide free training and loan out research-grade equipment in order to give students real world genetic engineering

experiences.

Appendix on Implementing District Standards

Students will focus on three main NGSS Engineering Performance Expectations. Students will be able to identify problems that require bioengineering solutions for a vulnerable population (Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. HS-ETS1-1). Students will be able to design one solution for that population (Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS-ETS1-2). Students will be able to assess the viability of their solution (Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. HS-ETS1-3).

Bibliography

"About Universal Design for Learning." CAST. April 20, 2021. https://www.cast.org/impact/universal-design-for-learning-udl. Description of the Universal Design for Learning model.

Baggett, Travis P., James J. O'Connell, Daniel E. Singer, and Nancy A. Rigotti. "The Unmet Health Care Needs of Homeless Adults: A National Study." American Journal of Public Health. July 2010. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2882397/. Study illustrating the challenges health care professionals have when caring for homeless adults.

"Behavioral Change Models." Diffusion of Innovation Theory. https://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories4.html.

Berwick, Donald M. “Lessons from Developing Nations on Improving Health Care.” *BMJ*, vol. 328, no. 7448, 2004, pp. 1124–1129., doi:10.1136/bmj.328.7448.1124. Description of the barriers to health care improvement as well as examples of successful health care systems in countries with limited resources.

Bureau, US Census. "Health Insurance Coverage in the United States: 2018." The United States Census Bureau. November 08, 2019. https://www.census.gov/library/publications/2019/demo/p60-267.html. Statistics on health care coverage in the United States in 2018.

Carmichael, Kevin. September 12, 2016. "Christine Lagarde on Slow Growth, Inequality and Fighting Cynicism." Macleans.ca. September 12, 2016. https://www.macleans.ca/economy/economicanalysis/christine-lagarde-on-slow-growth-inequality-and-fighting-cynicism/. Interview of the head of the International Monetary Fund.

City of San Jose Homeless Census & Survey: 2019 Executive Summary. Applied Survey Research, 2019, www.sanjoseca.gov/home/showpublisheddocument/38892/636987964892170000. Infographic of the results of a 2019 survey of homeless people in San Jose, CA.

Danielson, Caroline, Sarah Bohn, and Tess Thorman. "Poverty in California." Public Policy Institute of California. August 18, 2020. https://www.ppic.org/publication/poverty-in-california/. Discussion of the California Poverty Measure completed in 2018 by the Public Policy Institute of California.

Donnelly, Tim. "9 Brilliant Inventions Made by Mistake." Inc.com. August 15, 2012. https://www.inc.com/tim-donnelly/brilliant-failures/9-inventions-made-by-mistake.html.

East Side Union High School District, 2021, pp. 7–16, *James Lick High School Plan for Student Achievement (SPSA)*. School report of demographics, key areas for improvement, and targeted solutions.

"First Attempt in Learning: Why Failure Is Key to Innovation." Twenty One Toys. https://twentyonetoys.com/blogs/learning-from-failure/fail-first-attempt-in-learning-why-failure-key-innovation. A discussion of the role of failure in Silicon Valley technology companies.

"Five Challenges." Five Challenges | Engineering World Health. https://www.ewh.org/five-challenges.

"Gini Index (World Bank Estimate)." Data. https://data.worldbank.org/indicator/SI.POV.GINI?end=2019&start=1984&type=shaded&view=chart. Graphs and chart showing the Gini Index value for each country.

"Human Development Reports." Human Development Index (HDI) | Human Development Reports. http://hdr.undp.org/en/content/human-development-index-hdi. Description of the Human Development Index.

"Human Development Reports." Human Development Data Center | Human Development Reports. http://hdr.undp.org/en/data. Human Development Index values and breakdowns for each country.

Institute of Medicine (US) Committee on Health Care for Homeless People. "Health Care Services for Homeless People." Homelessness, Health, and Human Needs. January 01, 1988. https://www.ncbi.nlm.nih.gov/books/NBK218235/. Analysis of several different models of health care for homeless people.

Johnson, Steven. *Where Good Ideas Come From: The Natural History of Innovation*. Riverhead Books, 2011. Stories of innovation illustrating psychology and process.

Killion, CM. "Special Health Care Needs of Homeless Pregnant Women." ANS. Advances in Nursing Science. https://pubmed.ncbi.nlm.nih.gov/8585707/. Ethnographic study conducted in southern California which focuses on the health care needs of homeless pregnant women.

Lamb, Evelyn. "Ask Gini: How to Measure Inequality." Scientific American. November 12, 2012. https://www.scientificamerican.com/article/ask-gini/. Description of what the Gini coefficient is and how it is calculated.

Langlois, Shawn. "Norwegian University Urges Students to Return Home from the U.S., Cites 'poorly Developed Health Services'." MarketWatch. March 16, 2020. https://www.marketwatch.com/story/norwegian-university-urges-students-to-return-home-from-the-us-cites-po

orly-developed-health-services-2020-03-15. News article about Norwegian University.

"NFC Tags." Duratech. October 20, 2020. https://www.duratech.com/nfc-tags-a-mobile-solution-for-engaging-with-customers/. Description of NFC tags.

Olopade, Dayo. "Opinion: The End of the 'Developing World' (Published 2014)." Opinion | The End of the 'Developing World' - The New York Times. February 28, 2014. http://nyti.ms/NaZ8GK. Op-ed about the need to update the words we use to describe a country's socioeconomic status.

"Our History." Khushi Baby. https://www.khushibaby.org/history.html. Description of how the Kushi Baby vaccine record system was developed.

PBS LearningMedia. "Introduction to the Engineering Design Process: Engineering for Good." PBS LearningMedia. February 01, 2021. https://ca.pbslearningmedia.org/resource/introduction-engineering-design/introduction-to-the-engineering-design-process-engineering-for-good/. Description of the Engineering Design Process.

Prevention & Response to Infectious Diseases Within the Homeless Population. National Health Care for the Homeless Council, May 2016, nhchc.org/wp-content/uploads/2019/08/fact-sheet_infectious-diseases_hrsa-approved-final-version-1.pdf. Report on Infectious Disease incidence and prevalence in national homeless populations.

Science Buddies. "Build a Helping Hand: Science Project." Science Buddies. November 20, 2020. https://www.sciencebuddies.org/science-fair-projects/project-ideas/HumBio_p042/human-biology-health/build-prosthetic-hand. Classroom ready project for building a cheap and simple prosthetic hand.

Scholarly Teacher. "Purposefully Incorporating Technology into the Classroom Using the SAMR Model." December 12, 2019. https://www.scholarlyteacher.com/post/purposefully-incorporating-technology-into-the-classroom-using-the-samr-model.

"Section 14. SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats." Chapter 3. Assessing Community Needs and Resources | Section 14. SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats | Main Section | Community Tool Box. https://ctb.ku.edu/en/table-of-contents/assessment/assessing-community-needs-and-resources/swot-analysis/main.

Singh, Tanaya. "This Necklace Created by a Yale Grad & His Team Helps Kids in Rural India Get Vaccinated on Time." The Better India. July 13, 2016. https://www.thebetterindia.com/61540/khushi-baby-vaccination-immunization-history/. News article about Kushi Baby (vaccine record innovation).

Sprott, Ryan. "Curb Cuts and Texting Might Change the Way You Design Projects." PBLWorks. October 30, 2019. https://www.pblworks.org/blog/curb-cuts-and-texting-might-change-way-you-design-projects. Lessons learned from curb cuts and other technology initially intended just for those with disabilities.

Stanford Magazine. "Why Mindset Matters." Medium. September 20, 2017. https://medium.com/stanford-magazine/carol-dweck-mindset-research-eb80831095b5. Article in Stanford Magazine about Carol Dweck and her growth mindset research.

"Strategies for Learning from Failure." Harvard Business Review. August 01, 2014. https://hbr.org/2011/04/strategies-for-learning-from-failure. Harvard Business Review article about how to leverage failure to improve your business.

"What Are Wicked Problems?" The Interaction Design Foundation. https://www.interaction-design.org/literature/topics/wicked-problems. Description of how to approach problems with complex answers.

"What Is Design Thinking?" The Interaction Design Foundation. https://www.interaction-design.org/literature/topics/design-thinking. Description of the process of Design Thinking.

"What Is PBL?" PBLWorks. https://www.pblworks.org/what-is-pbl. Description of Project Based Learning.

Notes

---

[1] Shawn Langlois, “Norwegian University Urges Students to Return Home from the U.S., Cites ‘poorly Developed Health Services’” in MarketWatch.

[2] US Census Bureau, “Health Insurance Coverage in the United States: 2018”.

[3] Ryan Sprott, “Curb Cuts and Texting Might Change the Way You Design Projects” in PBL Works.

[4] United Nations Development Programme, “Human Development Reports”.

[5] United Nations Development Programme, “Human Development Data Center”.

[6] Evelyn Lamb, “Ask Gini: How to Measure Inequality” in Scientific American.

[7] The World Bank, “Gini Index”.

[8] Dayo Olopade, “Opinion: The End of the ‘Developing World’” in The New York Times.

[9] Ibid.

[10] Ibid.

[11] Engineering World Health, “Five Challenges”.

[12] Kushi Baby, “Our History”.

[13] Duratech, “NFC Tags”.

[14] Steven Johnson, “Where Good Ideas Come From: The Natural History of Innovation”, 30.

[15] Diffusion of Innovation Theory, “Behavioral Change Models”.

[16] National Health Care for the Homeless Council, “Prevention & Response to Infectious Diseases Within the Homeless Population”.

[17] East Side Union High School District, “James Lick High School Plan for Student Achievement (SPSA)”, 7-16.

[18] Caroline Danielson, et al, “Poverty in California”.

[19] Donald Berwick, “Lessons from Developing Nations on Improving Health Care” in BMJ.

[20] PBL Works, “What is PBL?”.

[21] CAST, “About Universal Design for Learning”.

[22] PBS Learning Media, “Introduction to the Engineering Design Process: Engineering for Good”.

[23] Donald Berwick, “Lessons from Developing Nations on Improving Health Care” in BMJ.

[24] The Interaction Design Foundation, “What Is Design Thinking?”.

[25] The Interaction Design Foundation, What Are Wicked Problems?”.

[26] Scholarly Teacher, “Purposefully Incorporating Technology into the Classroom Using the SAMR Model”.

[27] Community Tool Box, “Section 14. SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats”.

[28] Harvard Business Review, “Strategies for Learning from Failure”.

[29] Twenty One Toys, “First Attempt in Learning: Why Failure Is Key to Innovation”.

[30] Stanford Magazine, “Why Mindset Matters”.

[31] Harvard Business Review, “Strategies for Learning from Failure”.

[32] Twenty One Toys, “First Attempt in Learning: Why Failure Is Key to Innovation”.

[33] Applied Survey Research, City of San Jose Homeless Census & Survey: 2019 Executive Summary”.

[34] Kevin Carmichael, “Christine Legarde on Slow Growth, Inequality and Fighting Cynicism”.

[35] United Nations Development Programme, “Human Development Reports”.

[36] Tim Donnelly, “9 Brilliant Inventions Made by Mistake”.

[37] Science Buddies, “Build a Helping Hand: Science Project”.