CONNECTING STUDENTS TO COMPUTATIONAL THINKING

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FRAMEWORK FOR K-12 COMPUTER SCIENCE

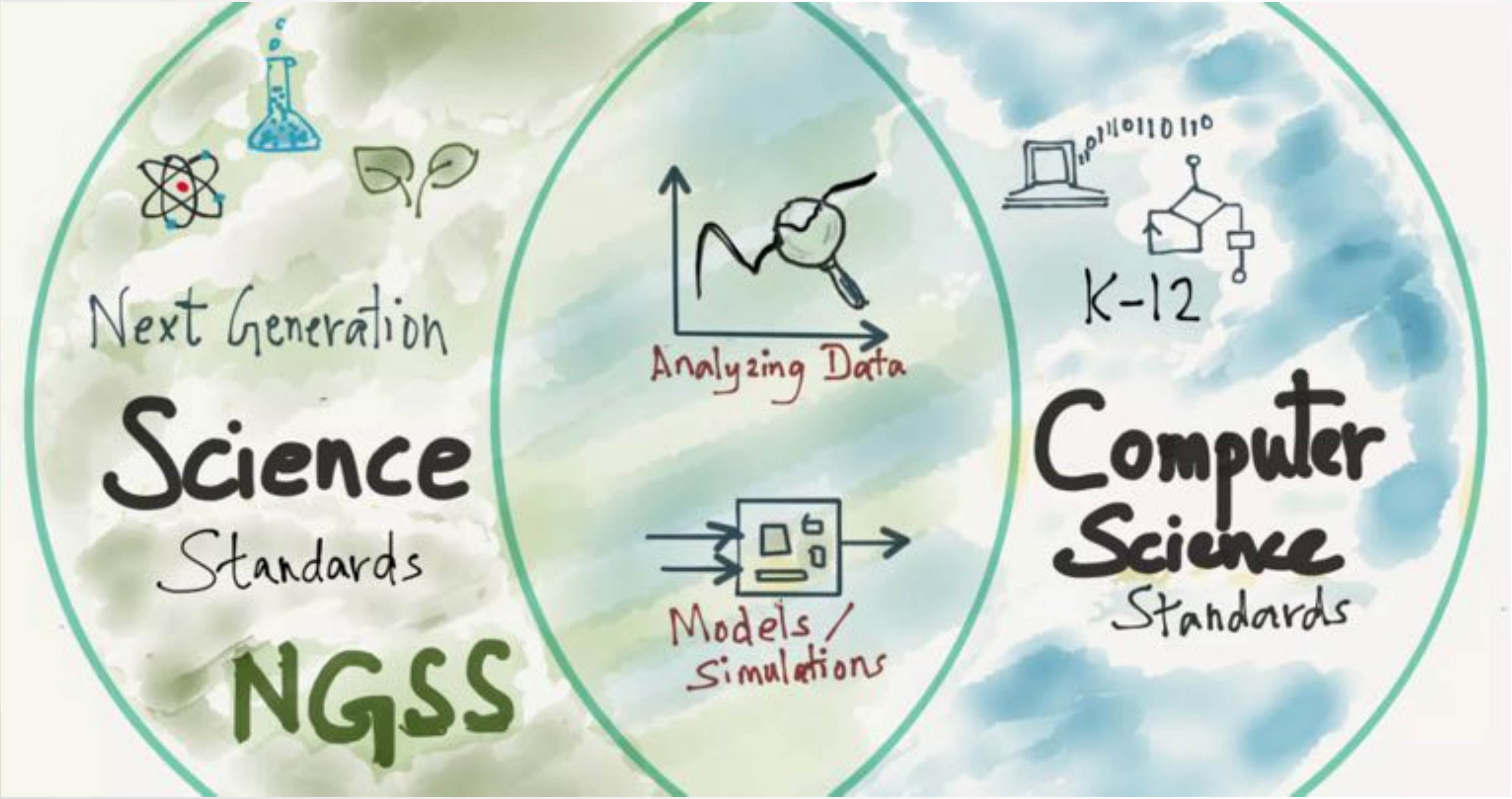
View the full set at https://k12cs.org/

Examples: By the end of grade 12 students should be able to

- Select, organize, and interpret large data sets from multiple sources to support a claim.
- Create **models** and develop points of interaction that can apply to multiple situations and reduce complexity.
- Create team norms, expectations, and equitable workloads to increase efficiency and effectiveness.
- Include the unique perspectives of others and reflect on one's own perspectives when designing and developing computational products.
- See also https://www.csteachers.org/page/standards

NEXT GENERATION SCIENCE STANDARDS (NGSS)

View more at https://www.edsurge.com/news/2017-11-16-why-computer-science-belongs-in-every-science-teacher-s-classroom

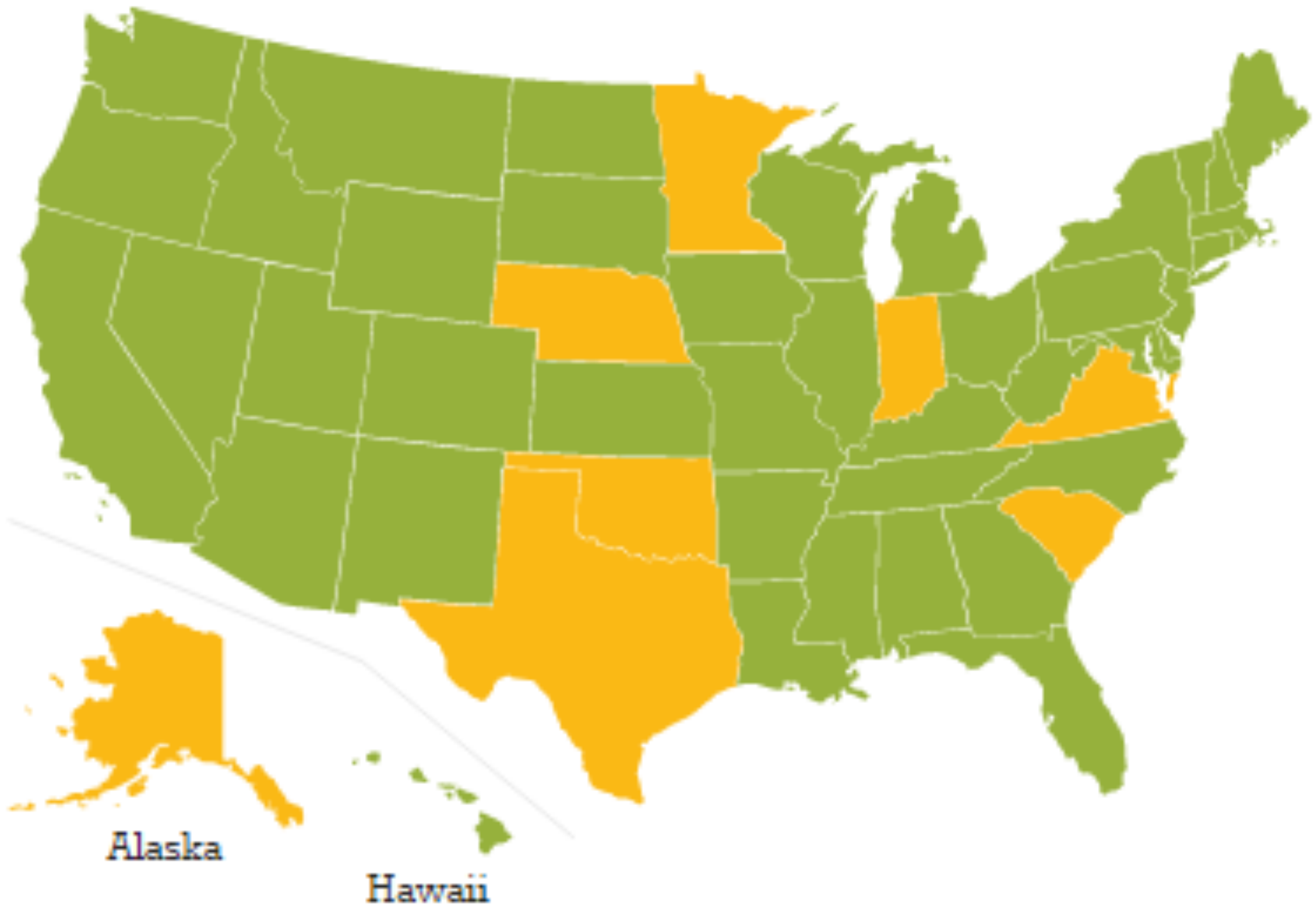


TECHNOLOGY STANDARDS (ISTE)

From Colleen's Presentation Yesterday: https://id.iste.org/my-profile/standardsdownload

- Create learning opportunities that challenge students to use a design process and computational thinking to innovate and solve problems.
- formulate problem definitions suited for technology- assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

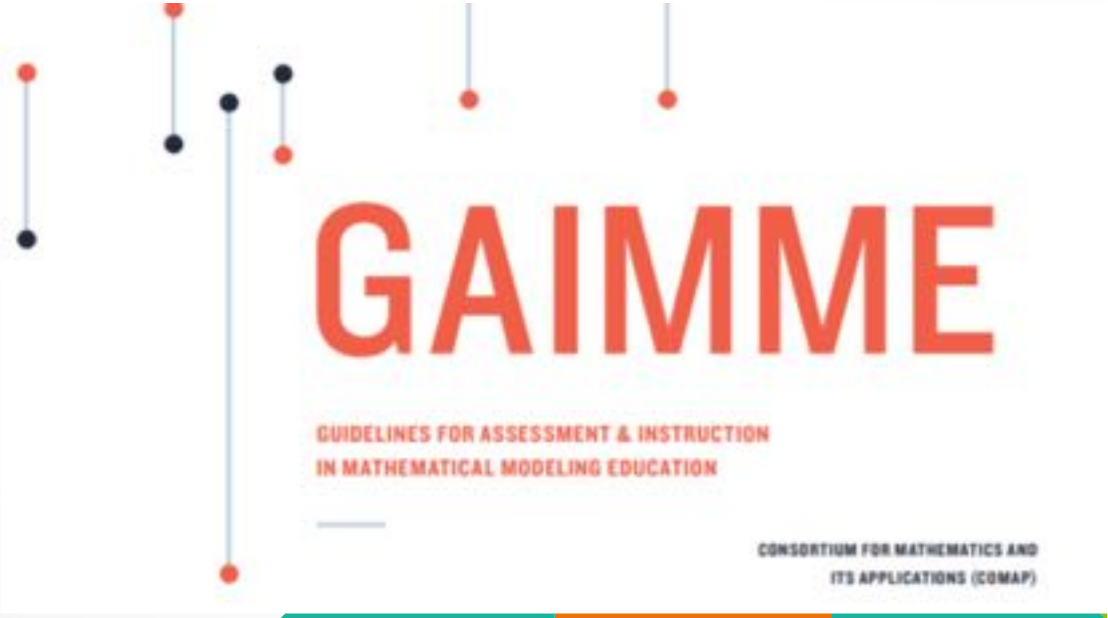
COMMON CORE STATE STANDARDS



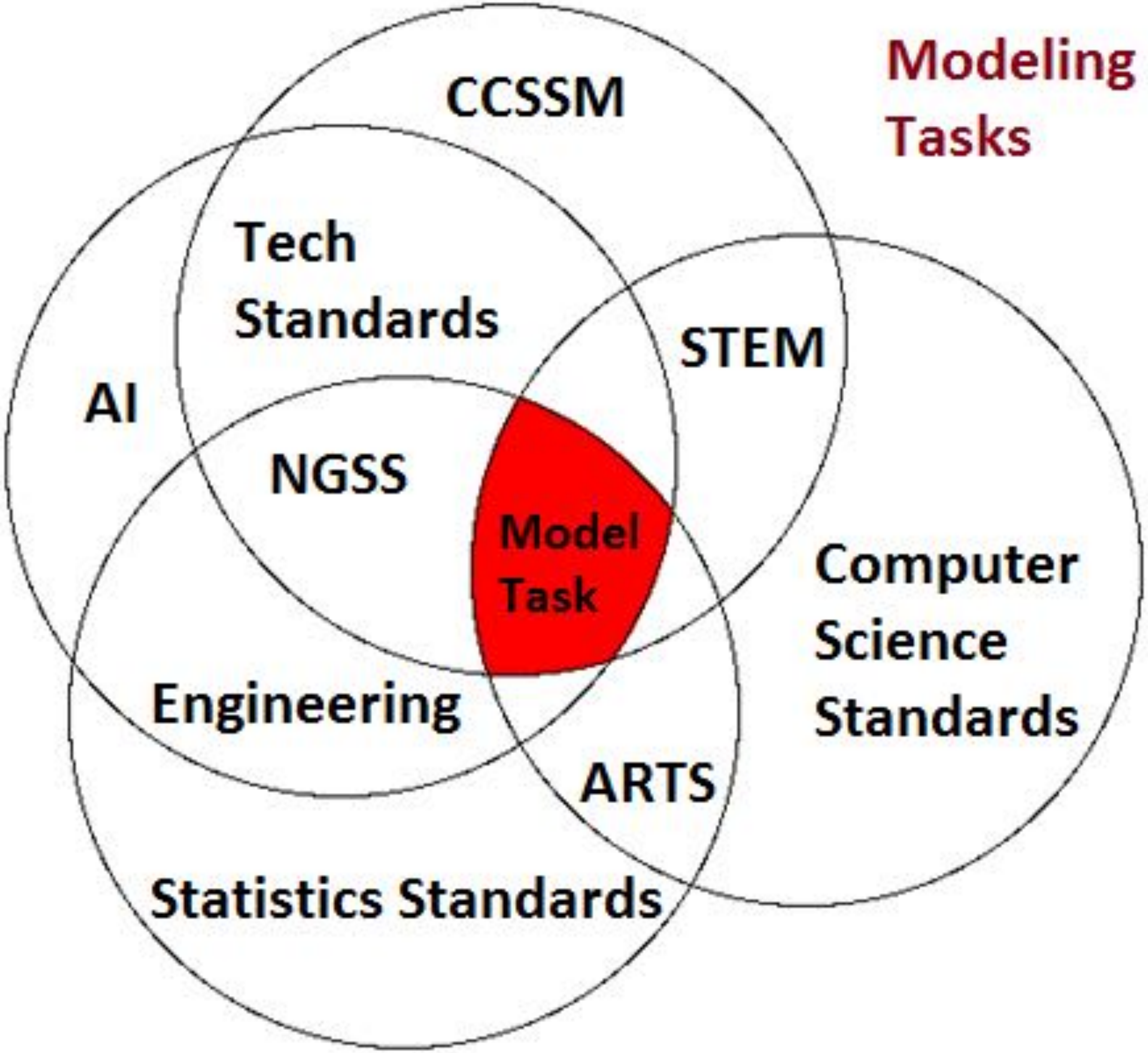
- Problem Solving and Data Analysis is built in throughout the content
- Modeling with Mathematics is at the heart of the standards urgency for teachers create spaces for students to meaningfully connect mathematics to the real world, everyday life, and the work place.

WHAT IS MATHEMATICAL MODELING?

- *Mathematical modeling is a process that uses mathematics to represent, analyze, make predictions or otherwise provide insight into real-world phenomena.*
  - GAIMME Report page 10



THE INTERSECTION OF ALL THESE USA INITIATIVES IS MATHEMATICAL MODELING



MODEL ELICITING ACTIVITY- SIX PRINCIPLES

1. Model Construction Principle
2. Reality Principle
3. Self-Assessment Principle
4. Model Documentation Principle
5. Model Sharability and Reusability Principle
6. Effective Prototype Principle

Lesh, R., Hoover, M., Hole, B., Kelly, A., & Post, T. (2000). Principles for developing thought-revealing activities for students and teachers. *The handbook of research design in mathematics and science education,* 591-646.

WIND ENERGY MEA TASK

Use the data to fairly distribute 260 prototype Windmills to at least 5 of the 8 interested countries: Chile, China, Indonesia, Mexico, New Zealand, Russia, Thailand, and the United States.

Borean Winds MEA Task is under review for publication. Please do not replicate without permission. Matney, G., Padmi, R. S., Wiemken, R., Porcella, J., & Lustgarten, A. (2018).

DATA SHEET

CO2 Emission Table – 2014	Total CO2 Emission[1] (kt-c)	Coal & Coal Products[1] (kt-c)	Crude Oil & Petroleum Products[1] (kt-c)	Gas[1] (kt-c)	Wind Power Capacity[2] (MW)	United Nations Population Estimate[3] (People)	United Nations GDP[4] (U.S. Dollars)
Chile	20748	6641	11949	2158	331	17,613,798	258,733,356,496
China	2444710	2011525	325220	107964	91,412	1,390,110,388	10,534,526,618,925
Indonesia	124815	48632	56491	19692	Unknown	25,513,116	890,487,074,874
Mexico	430798	47404	241382	142012	1,859	124,221,600	1,294,694,582,263
New Zealand	8553	1536	4946	2070	623	4,566,700	198,733,512,153
Russia	399464	87933	93508	218023	Unknown	143,761,378	2,030,972,934,892
Thailand	69302	18653	26286	24363	223	68,416,772	404,319,839,490
United States of America	1566861	465144	613400	391951	61,110	317,718,779	17,393,103,000,000

Conversion: 0.557918615 kt-c/gwh

Older wind turbines generate ~90,000 gwh/year

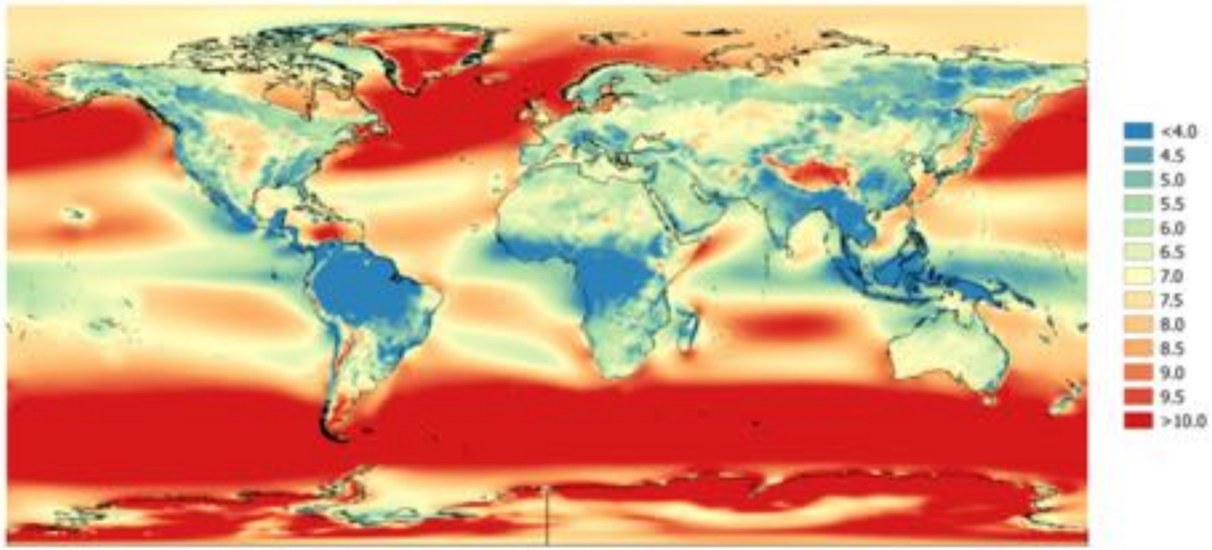


Figure 1
Mean wind speed at 100m from MERRA reanalysis. Period 1979-2013 [5]

SAMPLE STUDENT MODELS: US MODEL 1

Total number of turbines = ((0.4 * (% Total CO2 contributed per country)) + (0.3 * (%GDP contributed per country)) + (0.25 * (%Population contributed per country)) + (0.05 * % Wind Power Capacity contributed per country))) * 260

% represents the percent of data from one country between the eight available countries.

Chile	2
China	125
Indonesia	5
Mexico	16
New Zealand	1
Russia	18
Thailand	5
USA	88

SAMPLE STUDENT MODELS: US MODEL 2

$$\frac{9(A_1)+6.5(B_1)+5(C_1)}{\Sigma_1^8(9(A_n)+6.5(B_n)+5(C_n))}(260) = W_n$$

A= CO2 emissions

B= Wind capacity

C= GDP per person

Wn= # of windmills for each country

Chile	1
China	125
Indonesia	7
Mexico	22
New Zealand	1
Russia	20
Thailand	4
USA	80

SAMPLE STUDENT MODELS: INDONESIA MODEL 1

Step 1:	Step 2:
$N = \frac{E.P}{H}$	$X = \frac{N}{N_{total}} \times 260$

E = CO_2 emission from each country
P = population count of each country
H = GDP of each country
X = number of turbines received for each country

Chile	1
China	192
Indonesia	2
Mexico	25
New Zealand	1
Russia	17
Thailand	7

SAMPLE STUDENT MODELS: INDONESIA MODEL 2

$$X = \frac{\left(\frac{E}{P}\right) \times G \times W}{\Sigma\left(\left(\frac{E}{P}\right) \times G \times W\right)} \times 260$$

E = CO_2 emission from each country
P = population count of each country
G = GDP of each country
W = wind speed
X = number of turbines received for each country

Chile	0
China	24
Indonesia	9
Mexico	6
New Zealand	1
Russia	11
Thailand	0

STUDENT LEARING AND GLOBAL CONNECTIONS

- Students engaged in computational thinking appropriate for their level.
- Students learned and applied mathematical knowledge (Ratio thinking & Rational Multivariable Functions)
- Students connected with those living in a different country (Global Citizenship)
- Students better understand what it means to use mathematical ideas to justify their reasoning and how those reasons influence the design of model makers.
- Students understood that when we disagree about what is "fair" the applied mathematics is related to those beliefs and the model is not value-neutral.

QUESTIONS?

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NOTES

[1]Ma, L. (2010). *Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States*. New York, NY: Routledge.

[2]Schmidt, W. H., McKnight, C. C., & Raizen, S. A. (1997). A Splintered Vision: An Investigation of U.S. Science and Mathematics Education. Norwell, MA: Kluwer.

[3]Achieve (2010). Comparing the Common Core State Standards and Japan's Mathematics Curriculum Course of Study. Retrieved on February 9th, 2016 at: www.achieve.org

[4]National Governors Association Center for Best Practices (NGAC), Council of Chief State School Officers (CCSSO). (2010). *Common Core State Standards for Mathematics.* Washington, DC: Author. http://www.corestandards.org.

[5]Matney, G. (2014). Early Mathematics Fluency with the CCSSM. *Teaching Children Mathematics 21*(1), 26-35. Reston, VA: National Council of Teachers of Mathematics.

[6]Stigler, J. W. and Hiebert, J. (1999) *The Teaching Gap: Best Ideas from the World's Teachers for Improving Education in the Classroom. New York, NY:* Free Press.

Kullman, D. (1997). *Joseph Ray: The McGuffey of Mathematics.* Paper submitted to the Ohio Journal of Mathematics. Columbus, OH.

COMPUTATIONAL THINKING (ISTE)

View more at (https://www.iste.org/standards/for-students)

5. Computational Thinker (p.2)

- Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions. Students:
- formulate problem definitions suited for technology- assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
- collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
- break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
- understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.