Asia-Pacific Economic Cooperation

Computational Thinking Education in the U.S. as it relates to Mathematics Education

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UNT A green light to greatness.

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Gaming - Minecraft

Informatics in US Education

- Included as option in University coursework – for example UNT Health Informatics (https://informationscience.unt.edu/health-informatics)
- 20 states now allow computer science to count as a math or science credit towards high school graduation (Loewus, 2016)
  - In Texas Advanced Placement (AP) Computer Science may count as one mathematics credits for high school graduation beginning in 2012.
- The term Informatics not currently used in:
  - International Society for Technology in Education (ISTE) – Standards for students or Educators (https://www.iste.org/standards/for-students)
  - Common Core State Standards - Mathematics (CCSS-M) (http://www.corestandards.org/Math/)
  - Texas Essential Knowledge and Skills – Technology Applications (http://ritter.tea.state.tx.us/rules/tac/chapter126/index.html)

Issues with Offering Computer Science Courses

- Lack of qualified and certified teachers in Computer Science
  - Currently in Texas schools are able to be a **District of Innovation** and receive a 5 year waiver, which allows schools to hire **uncertified** teachers for computer science courses.
  - Private sector computer science jobs pay significantly more than a beginning teacher.

- Students are not required to choose Computer Science as one of their math or science courses

Computational Thinking in Education

International Society for Technology in Education (ISTE) - Standards for Educators

https://id.iste.org/my-profile/standards-download

6. Facilitator (p.2)

c. Create learning opportunities that challenge students to use a design process and **computational thinking** to innovate and solve problems.

International Society for Technology in Education (ISTE) - Standards for Students

(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:
- a. formulate problem definitions suited for technology- assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
- b. 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.
- c. break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
- d. understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

analysis of computational thinking in mathematics education

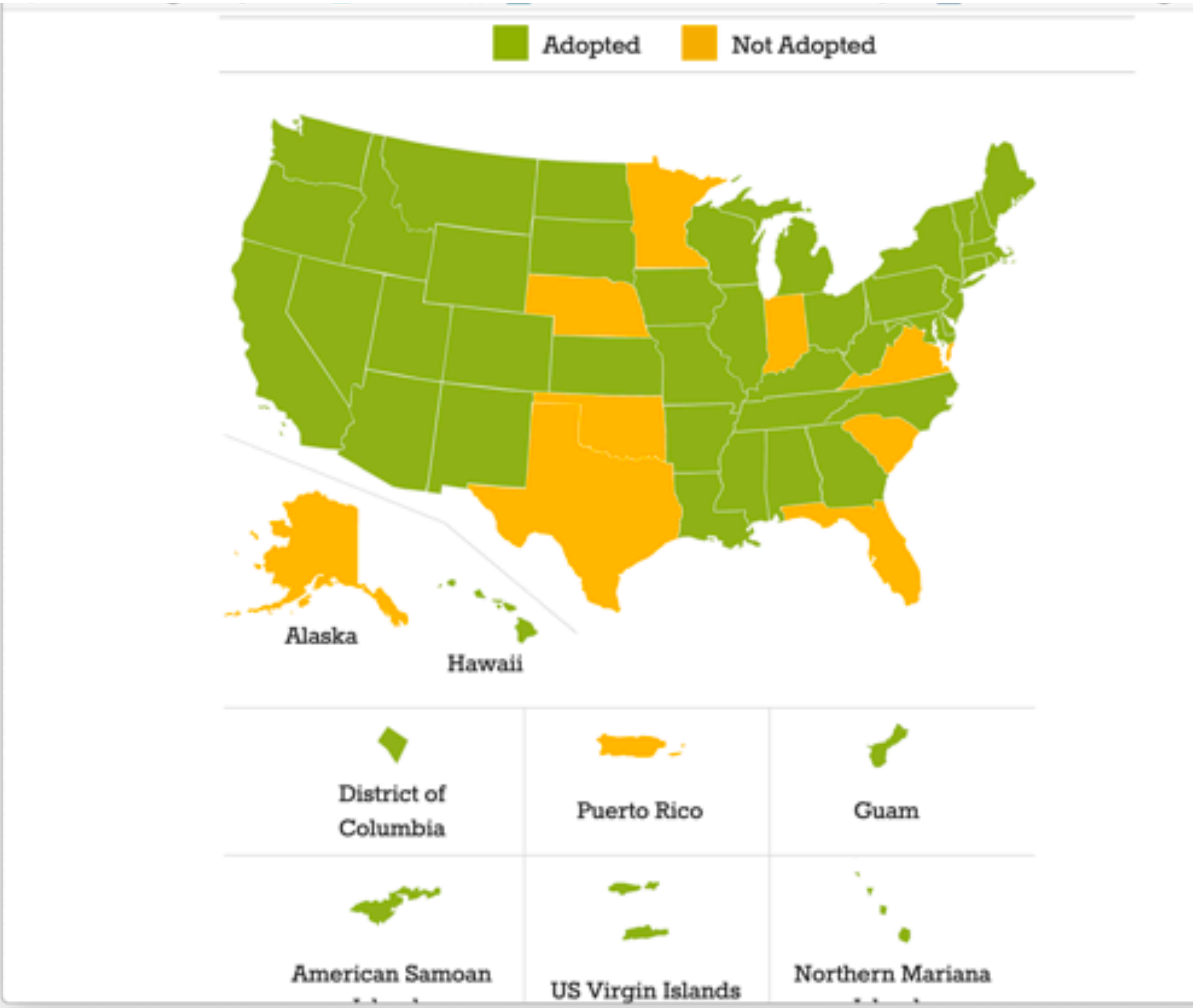
1. Journal for Research in Mathematics Education (JRME) – Highest ranked US journal in mathematics education
2. Search included 2008-2019 –
   - Why? Reauthorization of the Elementary and Secondary Education Act (ESEA) as Every Student Succeeds Act (ESSA).
3. Search term(s) – computation
4. Originally 11 articles
5. Reviewed each article for computational thinking in the text of each article
6. 1 article fit this criteria Perez (2018) and within this article another article was found, Weintrop and colleagues (2016)

RESULTS

- Pérez, A. (2018). A Framework for Computational Thinking Dispositions in Mathematics Education. *Journal for Research in Mathematics Education*, *49*(4), 424-461.

- Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology*, *25*(1), 127-147.

Note: Other US math education journals were searched for articles on computational thinking without success



Adoption of Common Core State Standards (2010)

Computational Thinking in US Education

Mathematical Teaching *Practices in Principles to Action* (NCTM, 2014)

Of the 8 practices Perez (2018) highlights 4 of them as relevant to CT.

- Implement tasks that promote reasoning and problem solving.
- Use and connect mathematical representations.
- Build procedural fluency from conceptual understanding.
- Support productive struggle in learning mathematics.

Common Core State Standards for Mathematics – Mathematical Practices (NGA & CCSSO, 2010)

Of the 8 practices Perez (2018) highlights 3 of them as relevant to CT.

- Make sense of problems and persevere in solving them.
- Model with mathematics.
- Look for and make use of structure.

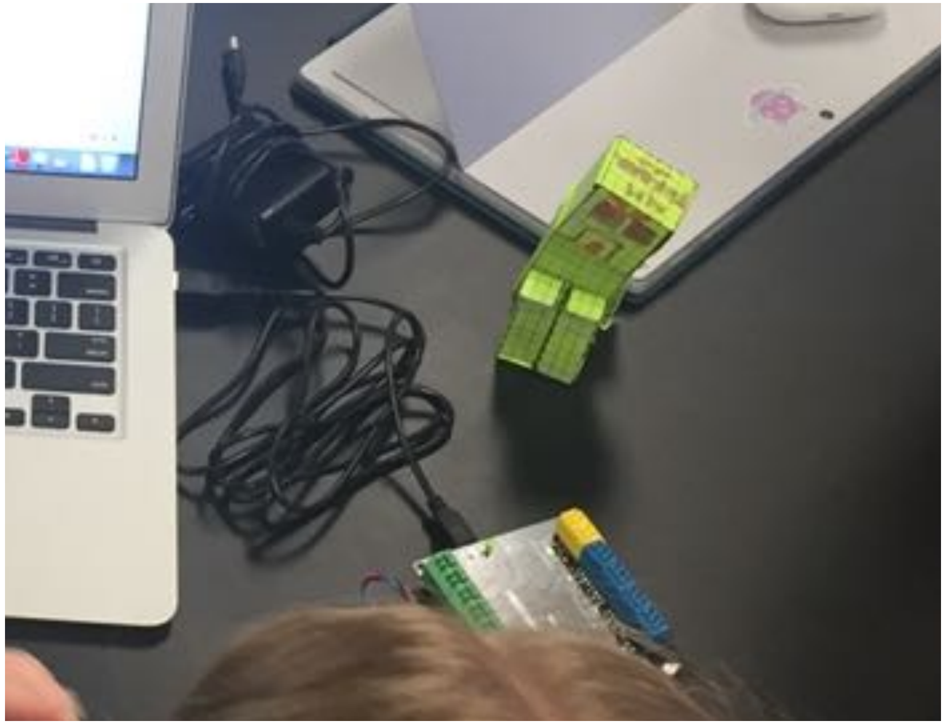
Computational Thinking in US Education

- Weintrop and colleagues (2016) created the taxonomy of practices for CT distinct from computer science

1. Data practices
2. Modeling and simulation practices
3. Computational problem solving practices
4. Systems thinking practices

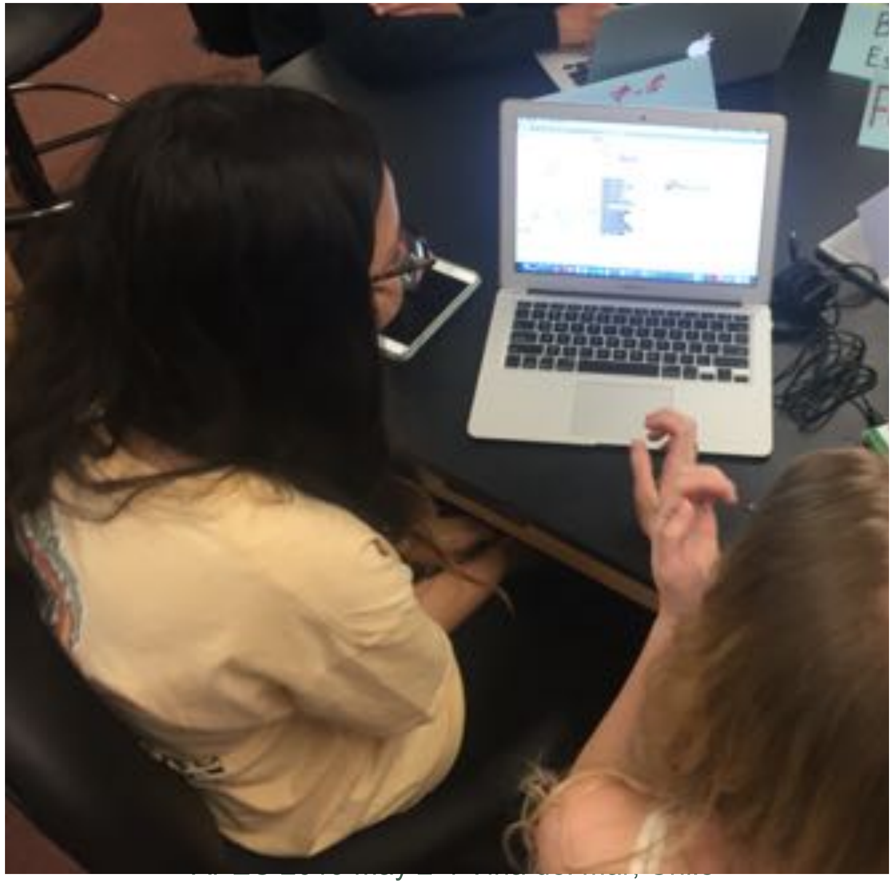
Surface Area and Volume of Rectangular Prisms

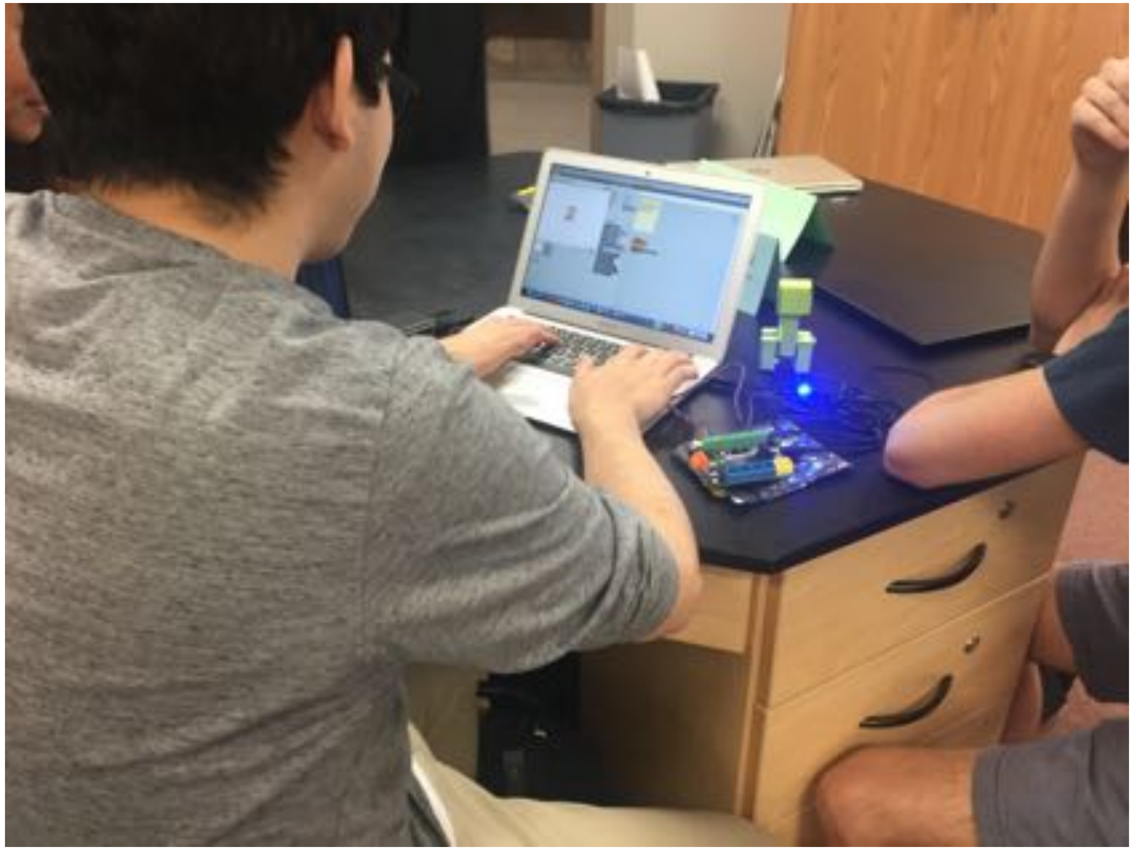
- Moore, K. (2018). Minecraft Comes to Math Class. *Mathematics Teaching in the Middle School, 23*(6), 334-341.



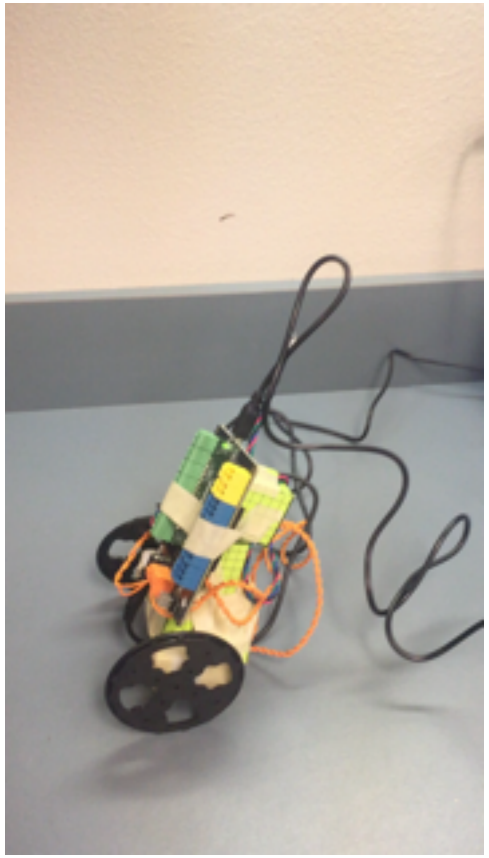
Extension with Robotics - Hummingbird Robotics

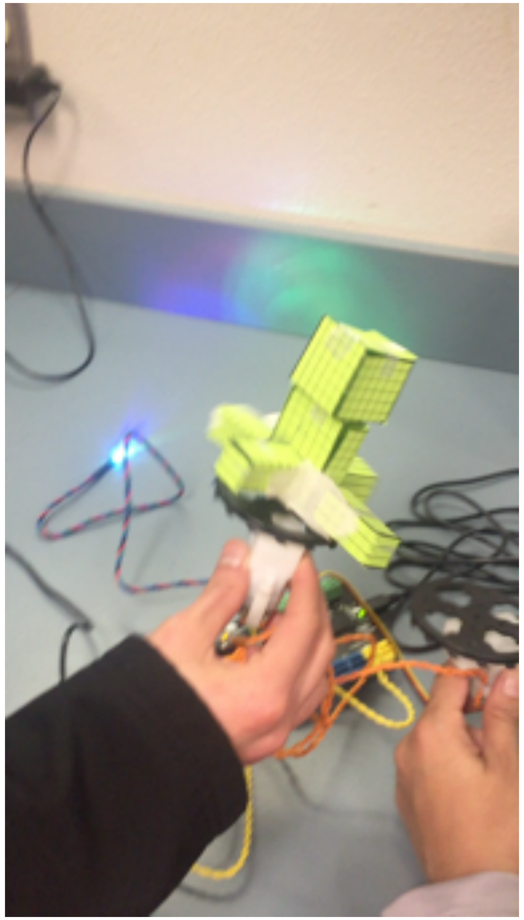
https://www.birdbraintechnologies.com/hummingbirdduo/





How many functions are these robots Performing?
How long do you think it took the candidates to have their creepers to have these functions?





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Statistics Education in the U.S. as it relates to Mathematics Education

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Possum Kingdom Lake

analysis of statistics education

1. Journal for Research in Mathematics Education (JRME) – Highest ranked US journal in mathematics education
2. Search included 2008-2019 –
   - Why? Common Core State Standards adopted by 42 states in 2010.
3. Search term(s) – statistics
4. Originally 149 articles
5. Reviewed each article for key words to see if exclusively statistics education
6. 149 articles reduced to 5 articles
7. 3 articles remained b/c: 1 article omitted for referring to statistical analysis used in mathematics education research and 1 omitted for focus on student interest

Results

- Lyn D. English, & Jane M. Watson. (2016). Development of Probabilistic Understanding in Fourth Grade. *Journal for Research in Mathematics Education, 47*(1), 28-62. doi:10.5951/jresematheduc.47.1.0028 (Australia study)
- Randall E. Groth. (2015). Working at the Boundaries of Mathematics Education and Statistics Education Communities of Practice. *Journal for Research in Mathematics Education, 46*(1), 4-16. doi:10.5951/jresematheduc.46.1.0004
- Jennifer Noll, & J. Michael Shaughnessy. (2012). Aspects of Students' Reasoning About Variation in Empirical Sampling Distributions. *Journal for Research in Mathematics Education,43*(5), 509-556. doi:10.5951/jresematheduc.43.5.0509

Groth (2015) – Shared spaces between mathematics and statistics education

Common Core State Standards-Mathematics – NGA & CCSSO, 2010

- Not until high school is there student choice to determine attributes to study for a situation (e.g. measuring highway safety)
- Grade 6 variability is introduced but lacks what types to be studied
- K-5 statistics content found in measurement and data focused on mathematics skills (e.g. producing specific types of graphs to solve specific math problems)

Note: US does not have national standards but the CCSS-M is close. See Eddy & Richardson (2011) for the historical development to accept the CCSS.

Guidelines for Assessment Instruction in Statistics Education Report – Franklin et al., 2007

- Early experiences in defining measures (e.g. define *word*)
- Learning trajectory for understanding variability (measurement, natural, and induced)

Note: GAISE uses levels A,B, & C versus grade levels and ages similar to van Hiele's levels of geometric thinking of experience over age

GAISE 2016 College Report

Recommendations updated from 2005 Report

1. Teach statistical thinking
   - Teach statistics as an investigative process of problem-solving and decision-making.
   - Give students experience with multivariable thinking.
2. Focus on conceptual understanding.
3. Integrate real data with a context and purpose.
4. Foster active learning.
5. Use technology to explore concepts and analyze data.
6. Use assessments to improve and evaluate student learning.

Note: Red is new

Why the Gaise 2016 College report Matters

Below is a highlight of some of the reasons.

- More students are studying statistics
- Students exposed to statistical thinking in grades 6-12 (Adoption of CCSS-M in 2010)
- **Availability of data** has made statistics more relevant
- **Data Science** includes statistics and computer science
- **Innovations** in statistical inference

CCSS-Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

CCSS-M - High school: modeling

Modeling links classroom mathematics and statistics to everyday life, work, and decision-making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. Quantities and their relationships in physical, economic, public policy, social, and everyday situations can be modeled using mathematical and statistical methods. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data. (NGA & CCSSO, 2010, p. 72)

Noll & Shaughnessy (2012) – Lattice as instructional tool

Lattice as an instructional tool teaching statistics (e.g. student reasoning for Sampling Distribution for understanding concept of variability) – originally included three levels of reasoning in the following progression:

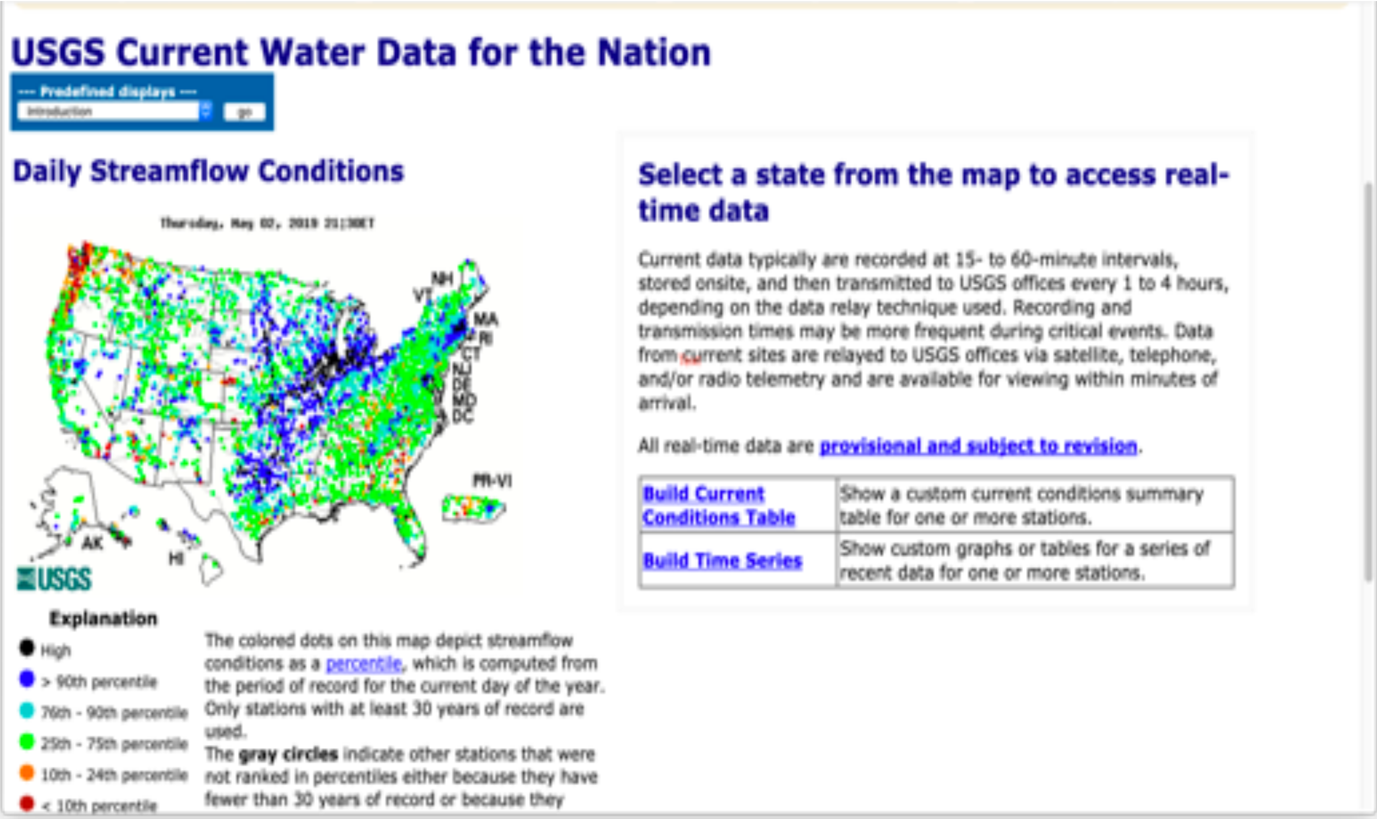
Additive-dependence on frequency information

Proportional - percentage and relative frequencies and flexibility between population and sample proportions

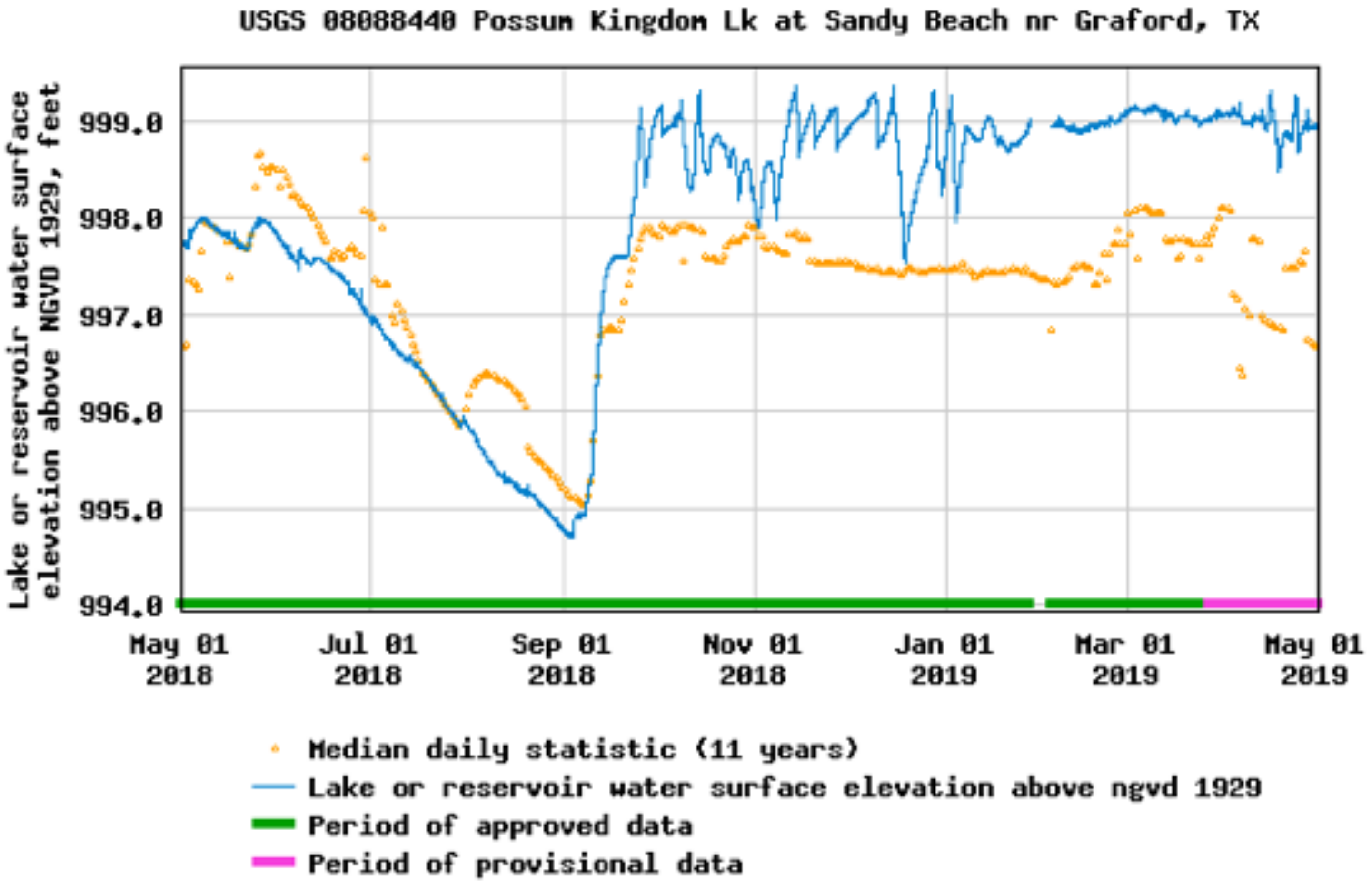
Distributional – "integrate multiple aspects of sampling distributions (e.g. center, shape, and variability) when making predictions about, or when estimating population proportions, from a sampling distribution

Possum Kingdom Lake

Lake Levels



- National Geodetic Vertical Datum (NGVD)
- Realtime data of lake levels: https://waterdata.usgs.gov/nwis/rt

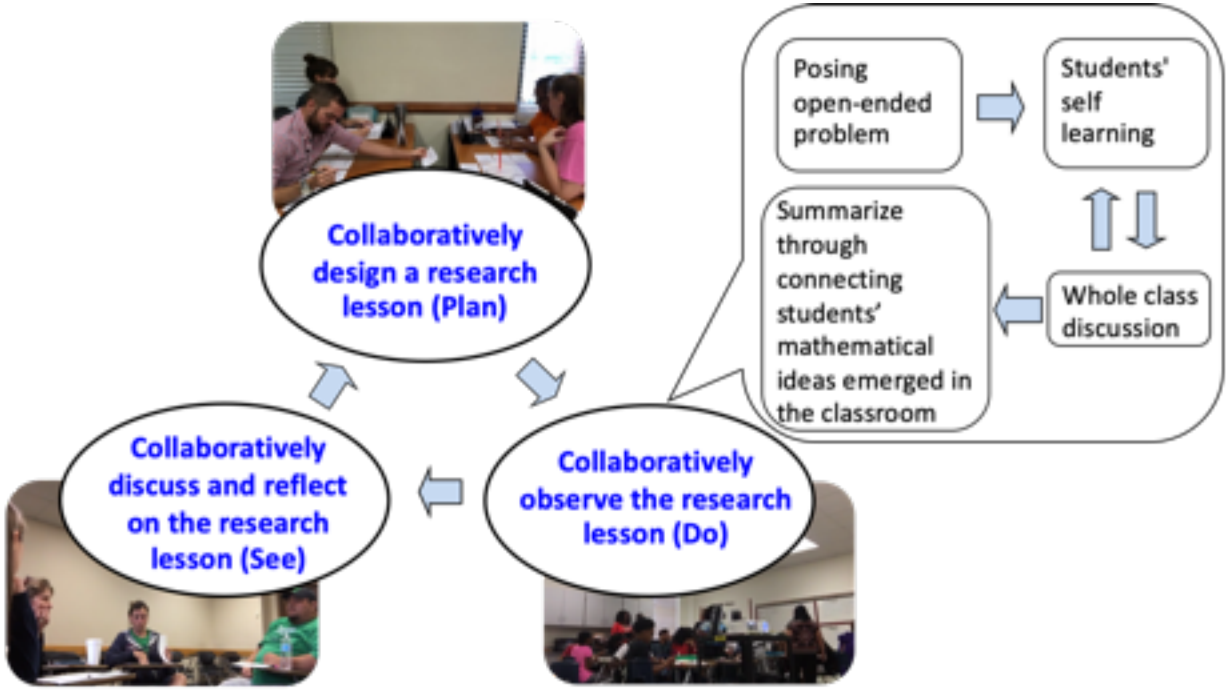


Why do lake levels matter?

- Describe why you chose the lake.
- What inferences can you make from this data?

Fidelity of Implementation

Lesson Study



(Eddy, Pratt, Kuehnert, & Wu, 2017; Inprasitha, 2010; 2015)

Thank you

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