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Integrating Statistical Analysis in CC-Math/NGSS Classrooms 9-12

NEXT GENERATION SCIENCE STANDARDS
For States, By States

COMMON CORE STATE STANDARDS INITIATIVE
PREPARING AMERICA'S STUDENTS FOR COLLEGE & CAREER

Today's Presenters

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STEM Coordinator

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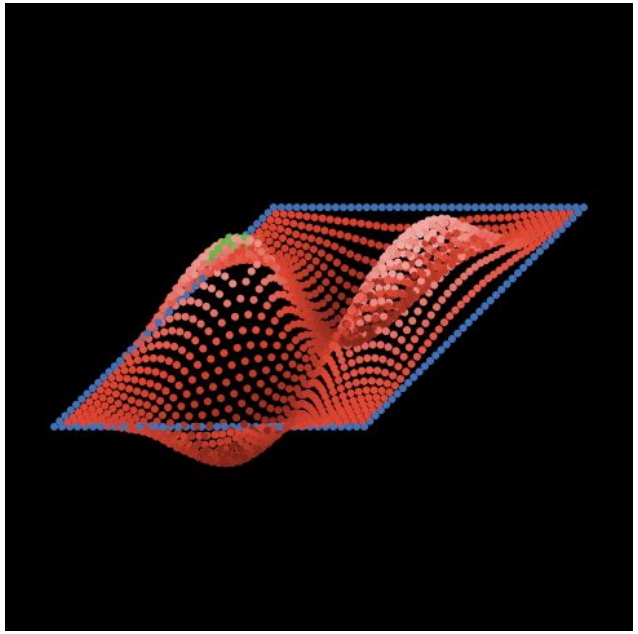
Introductions

- Name and site
- https://padlet.com/bstates/CCSSMathNGSSHighSchool
- What experience do you currently have with developing and using models and analyzing and interpreting data?

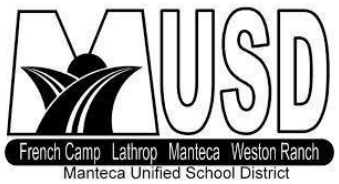


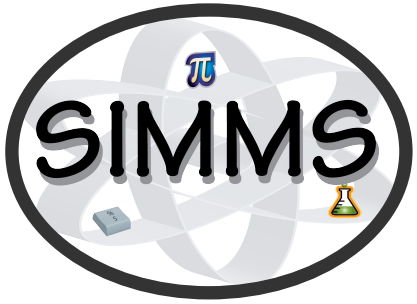
NetLogo simulation of wave action

Secondary Integration of Modeling in Math and Science

(SIMMS) Project

California Math and Science Partnership Grant





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Lawrence Livermore National Laboratory

University of the Pacific

Escalon Unified

Lincoln Unified

Manteca Unified

Ripon Unified

Stockton Unified

Tracy Unified

CaMSP Cohort 10, SIMMS

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- California Math and Science Partnership Grant
  - 3 years, $1.26 Million
  - Year 1: Train (2013-14)
  - Year 2: Implement (2014-15)
  - Year 3: Disseminate (2015-16)
- 54 High School Math and Science Teachers spend 84 hours per year integrating math, science and computer modeling and simulations.

NetLogo

SIMMS

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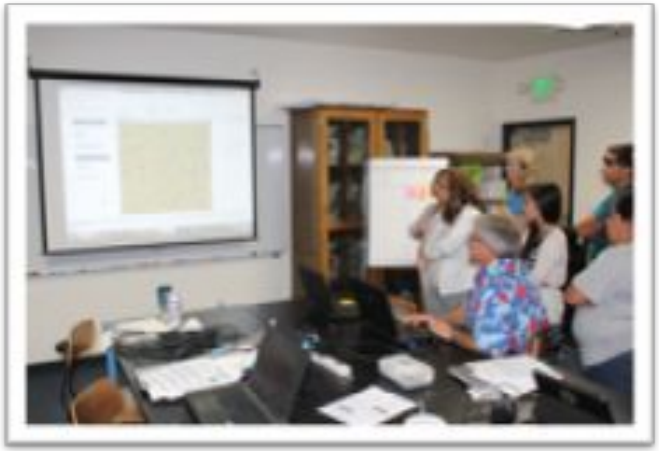
SIMMS in action



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Today's Resources:

Padlet:

www.padlet.com/bstates/CCSSMathNGSSHighSchool

www.STEMccm.com

www.desmos.com

NetLogo:

https://ccl.northwestern.edu/netlogo/

http://www.netlogoweb.org/

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Goals for Today

- **Overview of 3-D NGSS Structure**
  - Analyzing and Interpreting Data
  - Developing and Using Models
- **Overview of CCSS-M Statistics**
  - Statistics and Probability in first three years of high school, regardless of pathway
- **Experience the Bifocal Modeling Process**
  - Coupling real experiments with computational models

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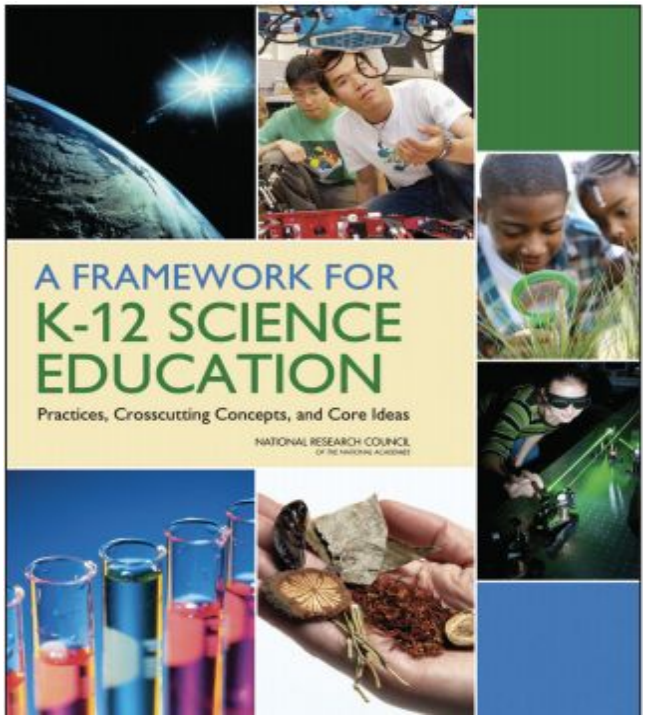
NGSS Overview



A New Vision for Teaching and Learning

- Science for ALL Students
- 3 Dimensional Coherent Learning across Grades

National Research Council
Board on Science Education

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Vision of Science Education

- All students' experiences over multiple years foster progressively deeper understanding of science.
- Students **actively engage** in scientific and engineering practices in order to deepen their understanding of crosscutting concepts and disciplinary core ideas.
- **All three dimensions should to be integrated** into the system of standards, curriculum, instruction, and assessment to best support student learning

NRC Framework Page 217

STEM Conceptual Shifts in NGSS

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1. K-12 science education should reflect the i**nterconnected** nature of science as it is practiced and experienced in the **real world**.

2. The NGSS are student **performance expectations** – **NOT curriculum**.

3. The science **concepts build coherently** from K-12.

4. The NGSS focus on **deeper understanding of content** as well as **application** of content.

5. **Science and engineering are Integrated** in the NGSS from K–12.

6. The NGSS are designed to prepare students for college, career, and citizenship.

7. The NGSS and **Common Core State Standards (Mathematics** and English Language Arts) are aligned.

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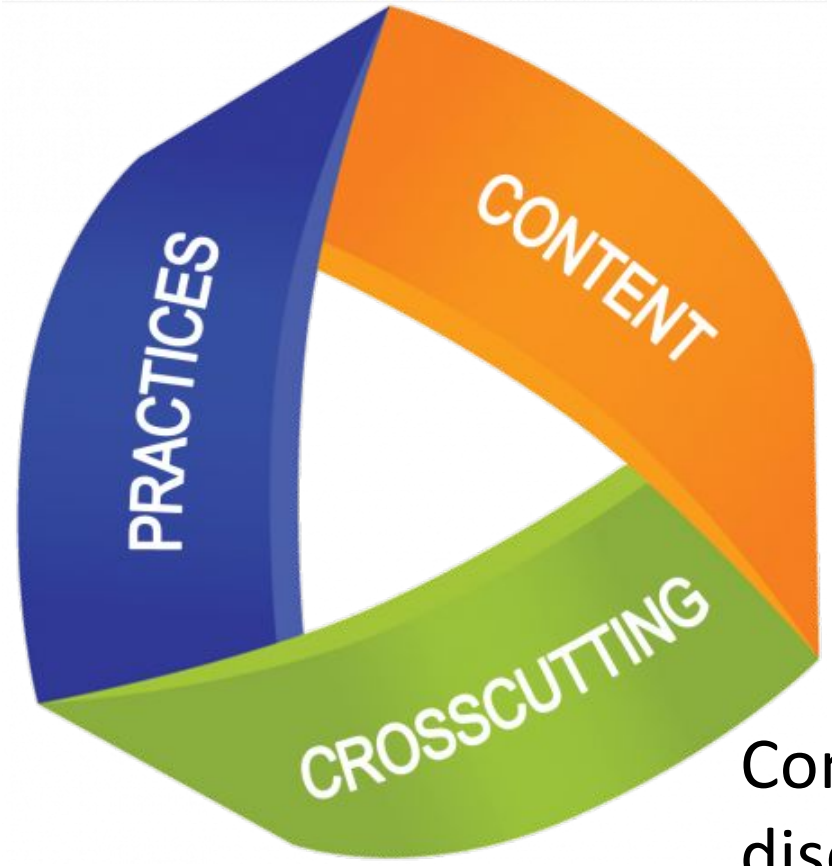
What's in a Logo?

Science and Engineering



Core ideas in the discipline

Concepts across disciplines

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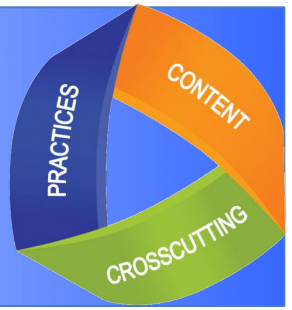
3 Dimensions



Students who demonstrate understanding can:

HS-PS2-1. **Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [*Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena.	**PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-level:
HS.PS3.C ; HS.ESS1.A ; HS.ESS1.C ; H.ESS2.C

Articulation of DCIs across grade-bands:
MS.PS2.A ; MS.PS3.C

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS2-1)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS2-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-PS2-1)
MP.4	Model with mathematics. (HS-PS2-1)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-PS2-1)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1)
HSA.SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1)
HSA.SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1)
HSA.CED.A.1	Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1)
HSA.CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. *(HS-PS2-1)*
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS2-1)*
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. *(HS-PS2-1)*
HSS-IS.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots). *(HS-PS2-1)*

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Dimension 1
Scientific and Engineering Practices

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

For each, the Framework includes a description of the practice, the culminating 12th grade learning goals, and what we know about progression over time.
Framework Pages 41-82

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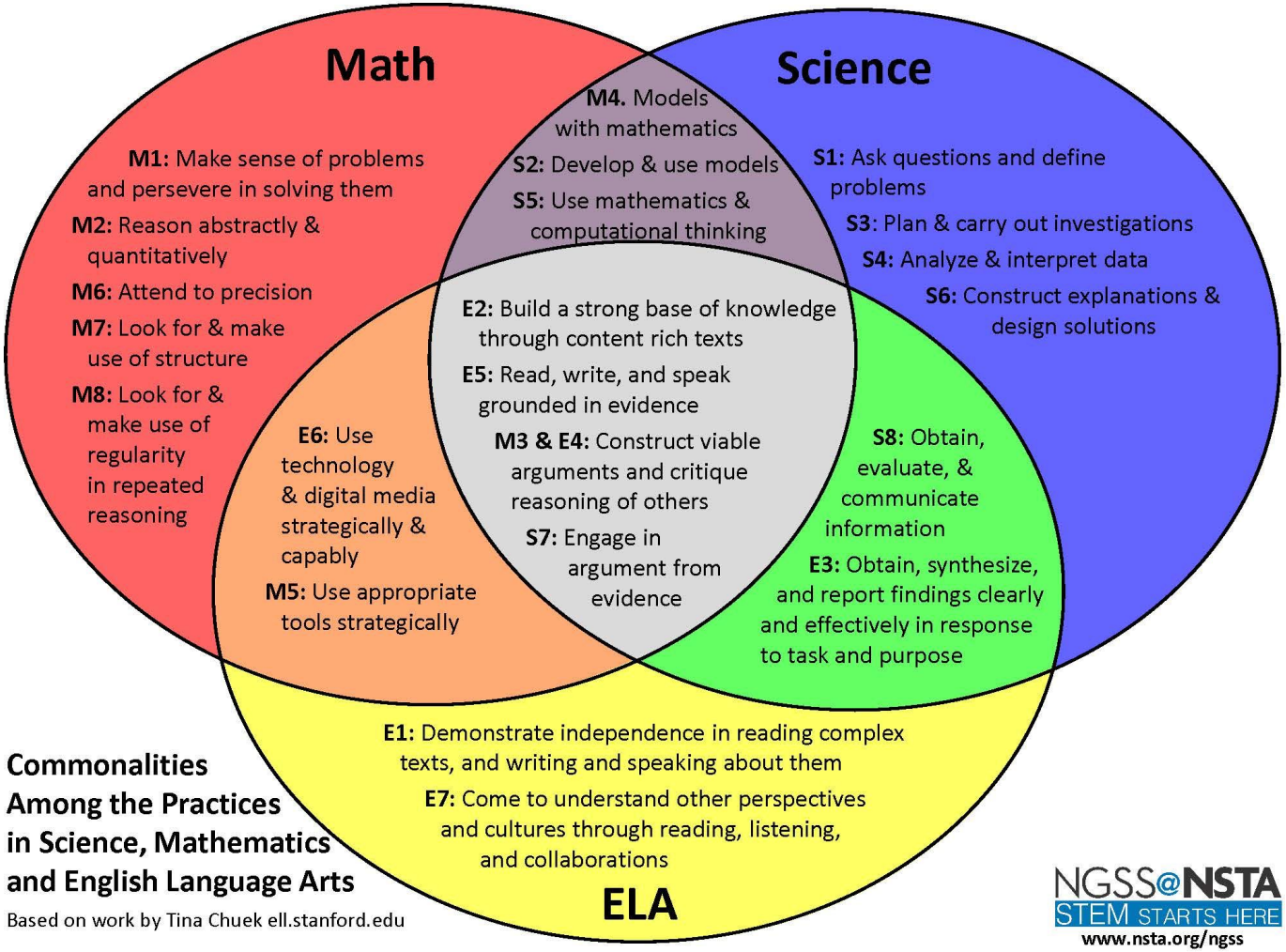
Interconnected and Aligned to CCSS



Commonalities Among the Practices in Science, Mathematics and English Language Arts

Based on work by Tina Chuek ell.stanford.edu

NGSS@NSTA
STEM STARTS HERE
www.nsta.org/ngss

Math is the Language of Science

Quotations by Galileo Galilei

[The universe] cannot be read until we have learnt the language and become familiar with the characters in which it is written. It is written in **mathematical language**, and the letters are triangles, circles and other geometrical figures, without which means it is **humanly impossible to comprehend a single word.**

Opere Il Saggiatore p. 171.

To **excite** in us tastes, odors, and sounds I believe that nothing is required in external bodies except shapes, **numbers, and slow or rapid movements**. ... if **ears, tongues, and noses were removed**, shapes and numbers and motions would **remain**, but **not odors or tastes or sounds**.

Dialogue on the Great World Systems

Bifocal Modeling

"Bifocal Modeling is a new framework to inquiry-driven science learning. It challenges students to experience a scientific phenomenon through two lenses in parallel – a real experiment and a model."

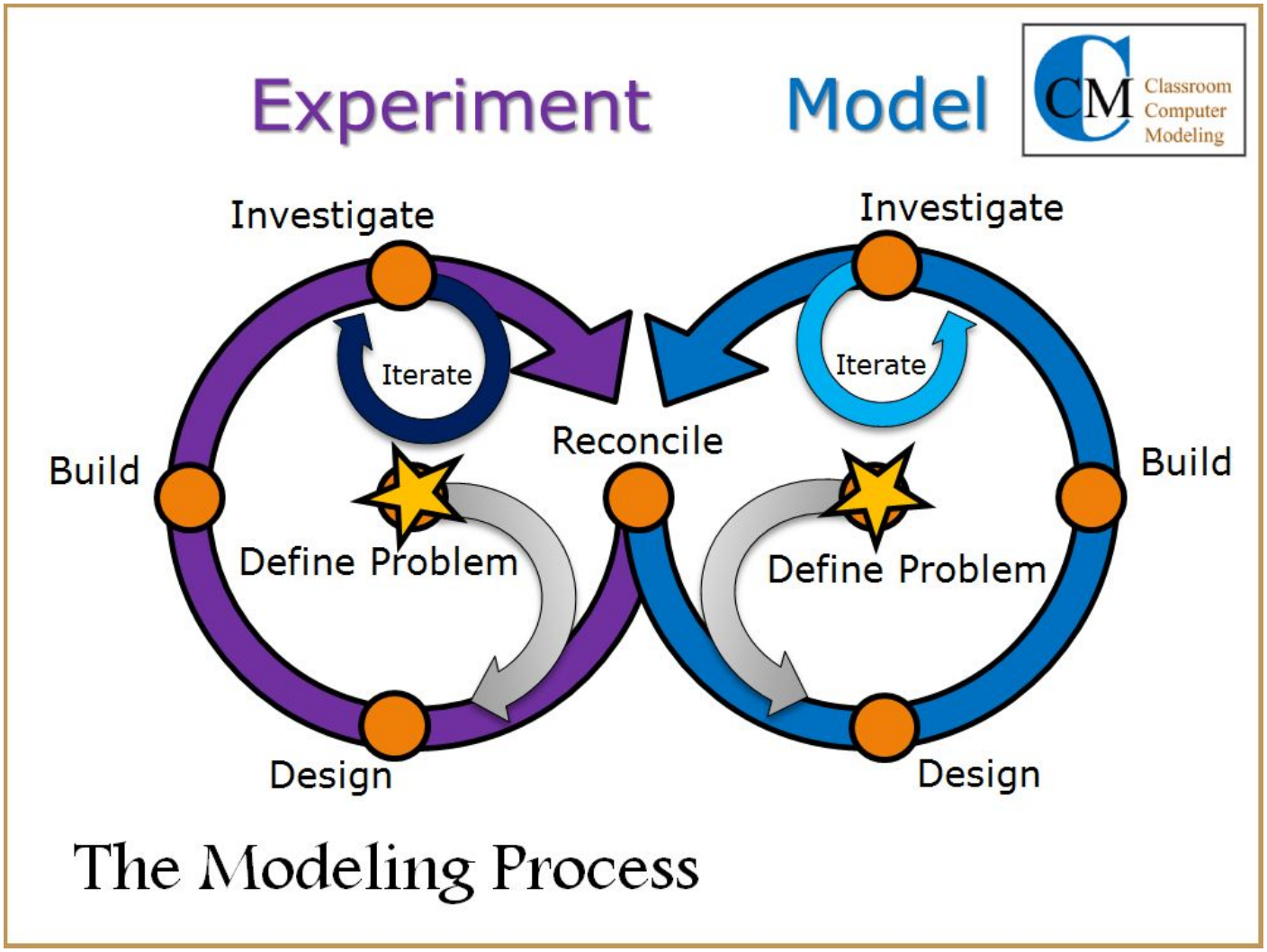
- *Transformative Learning Technologies Lab (TLTL)*
  Stanford Graduate School of Education

https://tltl.stanford.edu/project/bifocal-modeling

Figure 1. The bifocal modeling schematic

https://tltl.stanford.edu/project/bifocal-modeling

Bifocal Modeling



NGSS, Appendix F

Read Appendix F - Science and Engineering Practices 2-5 for your assigned SEP:

- Developing and Using Models, page 6
- Planning and Carrying Out Investigations, page 7
- Analyzing and Interpreting Data, page 9
- Using Mathematics and Computational Thinking, page 10

Science and Engineering Practices

- Why do you think your assigned SEP is particularly important in terms of bifocal modeling using real data and computer generated data?

- What about the integration of statistical analysis into NGSS?

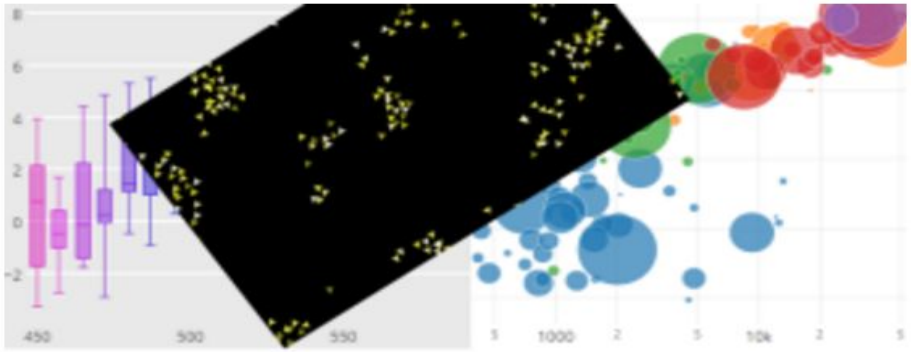
www.STEMccm.com

CM Classroom Computer Modeling

Statistical Tools

Modeling and Statistics

Computational modeling is a powerful tool for teaching statistics – from simple descriptive statistics to conducting inference tests.



What is statistics?

Data Collection

Data Summarization

Data Analysis

Data and Forestry

- **NGSS Performance Expectation**

  HS-ESS3 Earth and Human Activity

  4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

- **CCSS-M Performance Expectation**

  Statistics and Probability S.ID - Statistics, Interpreting Categorical and Quantitative Data

  1. Represent data with plots on the real number line (dot plots, histograms, and box plots). ★

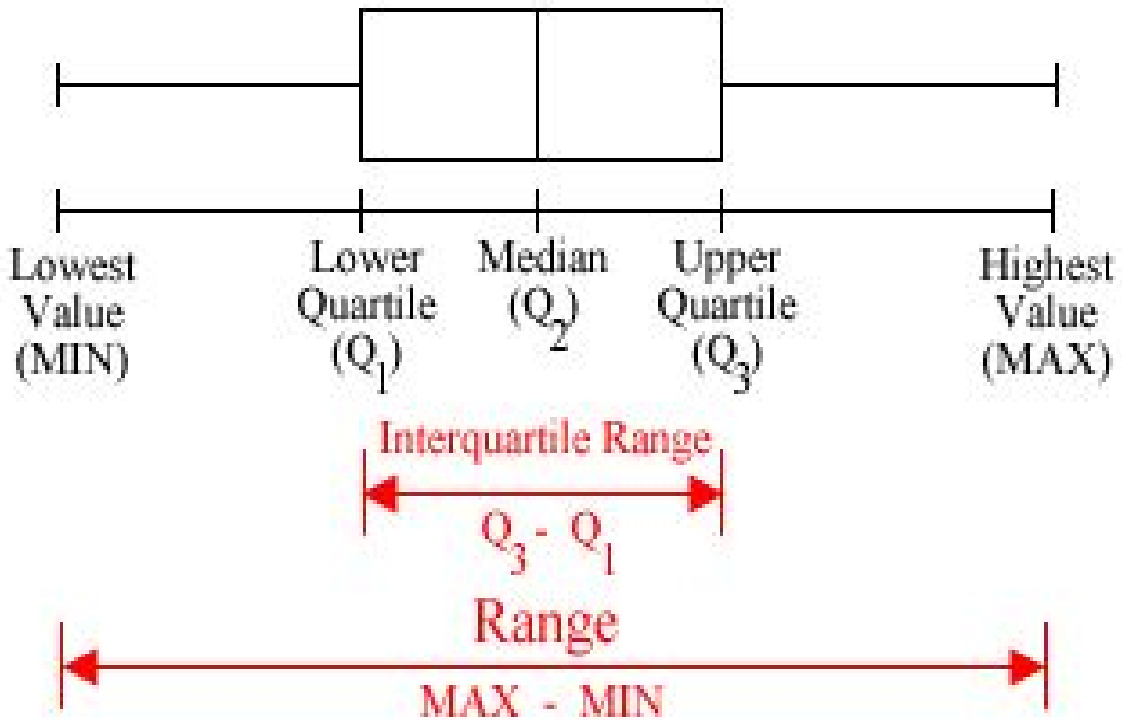
- **Skill Developed:**

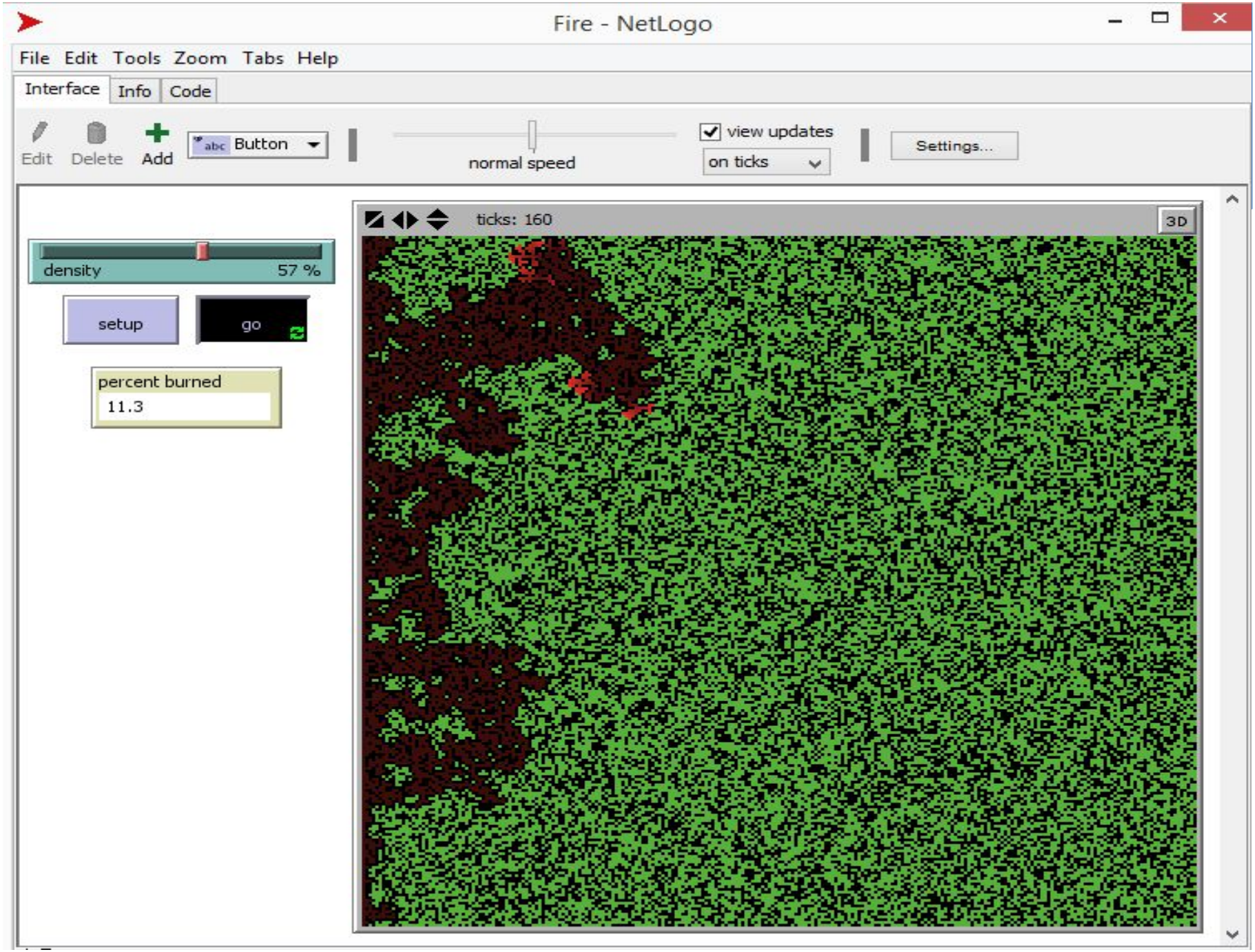
  Using a modeling in NetLogo to drive instruction

  Using the statistical Excel and/or Google Sheets

Data and Forestry

Activity 1


Lowest Value (MIN)
Lower Quartile (Q_1)
Median (Q_2)
Upper Quartile (Q_3)
Highest Value (MAX)
Interquartile Range
$Q_3 - Q_1$
Range
MAX - MIN


Fire - NetLogo
File Edit Tools Zoom Tabs Help
Interface Info Code
Edit Delete Add
Button
normal speed
view updates
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Settings...
density 57 %
setup
go
percent burned
11.3
ticks: 160
3D

New Fire Number of Trees Burned - Excel

File Home Insert Page Layout Formulas Data Review View ACROBAT Tell me what you want to do... Kevin Allred Share

Paste Clipboard Calibri 11 Font Wrap Text Merge & Center Alignment General Number Conditional Formatting Format as Table Cell Styles Styles Insert Delete Format Cells Sort & Filter Find & Select Editing

P99

	A	B	C	D
72	54	23	0	TRUE
73	55	19	0	TRUE
74	56	17	0	TRUE
75	57	16	0	TRUE
76	58	12	0	TRUE
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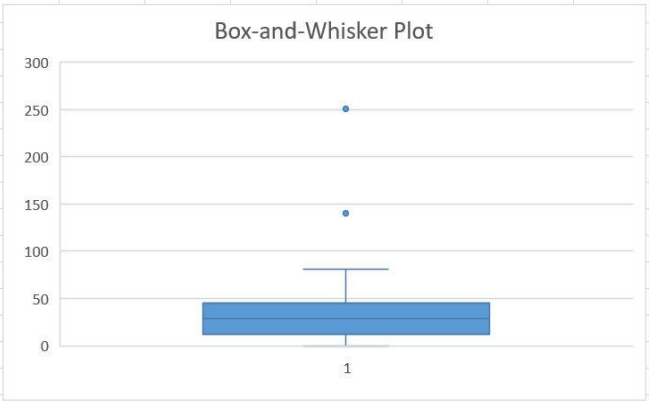
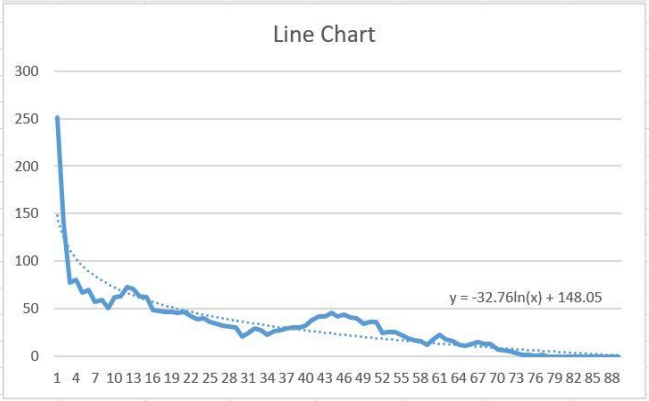
103	85	0	0	TRUE





New Fire Number of Trees Burned

Ready 100%

Revolutions

Daily news about using open source R for big data analysis, predictive modeling, data science and visualization, since 2008

« magrittr: Simplifying R code with pipes | Main | July 29: Applications in R Webinar »

July 24, 2014

Agent Based Models and RNetLogo

by Joseph Rickert

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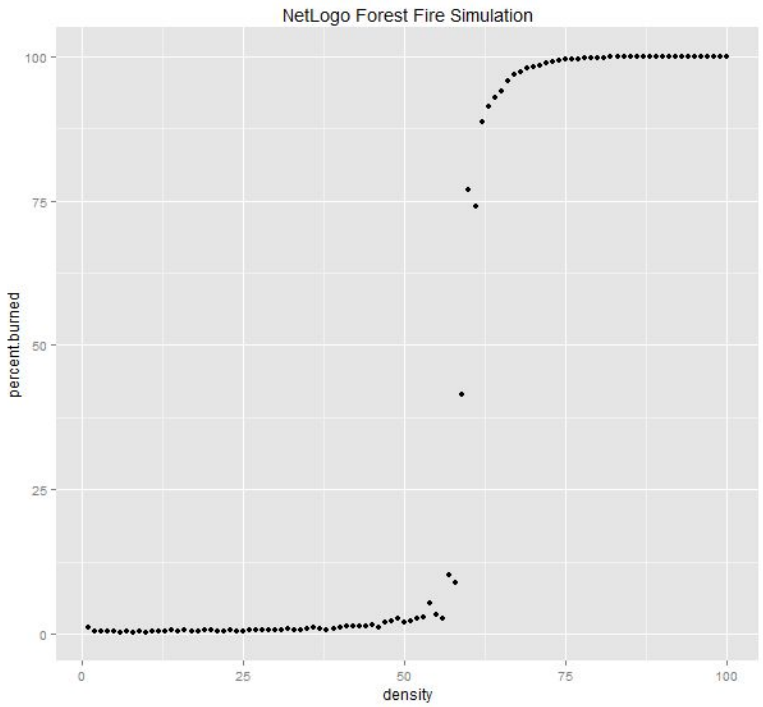
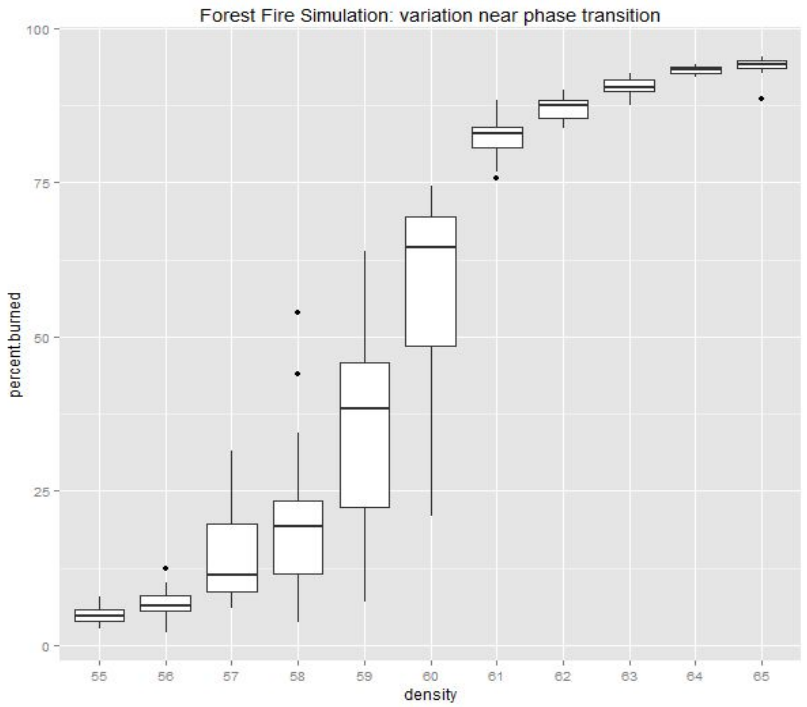




http://blog.revolutionanalytics.com/2014/07/agent-based-models-and-rnetlogo.html

Measurement and Distributions

- **CCSS-M Performance Expectation**
  Statistics and Probability S.ID
  Interpreting Categorical and Quantitative Data
  4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. ★

- **Skill Developed:**
  Data Collection and Summarization using Histograms
  Using the statistical software Desmos

Measurement and Distributions

Work with a partner to measure each other's height to the nearest ½ inch.
Go to: https://goo.gl/forms/sYtsRkAkJsateuMt1
and enter your individual data

Draggable Points

$a = [a_1, a_2, a_3, a_4, a_5, a_6, a_7, ...$

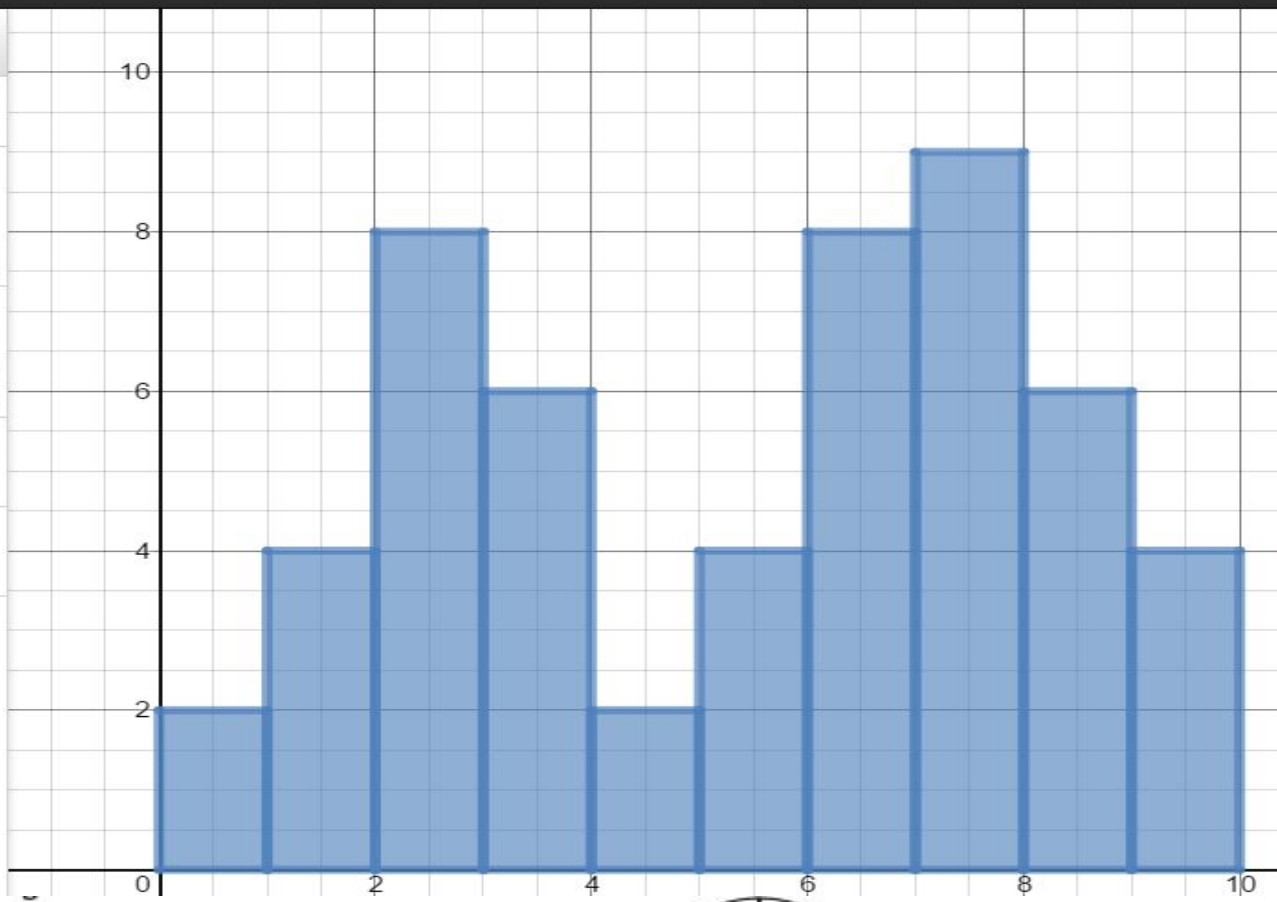
$a =$ 10 element list

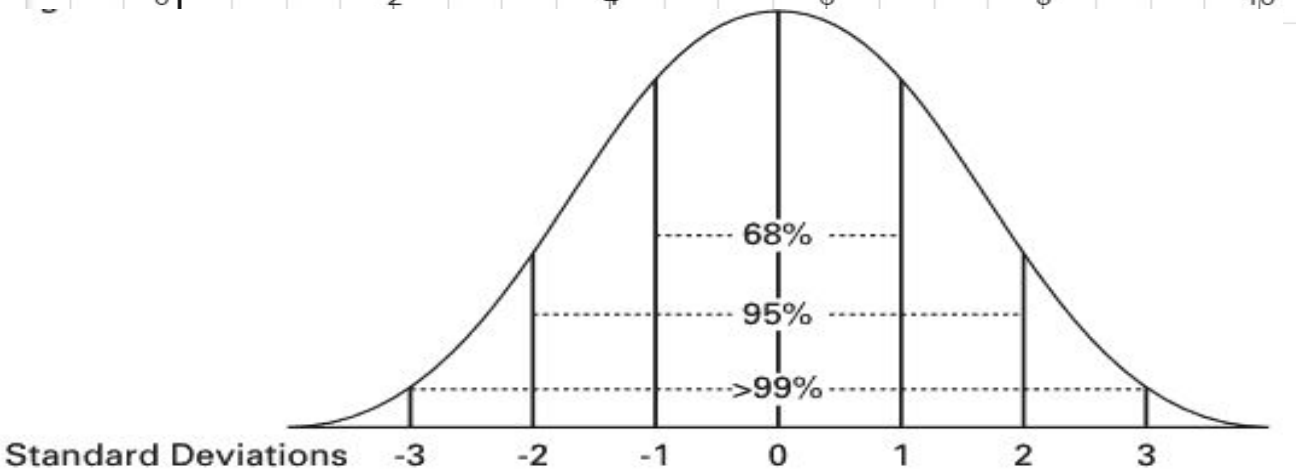
$b = [1...10]$

$b =$ 10 element list

$0 \le y \le a\{b - 1 \le x \le b$

$b - 1 \le x \le b\{0 \le y \le a$





Analyzing Trends in Time

- **NGSS Performance Expectation**

  HS-LS1 From Molecules to Organisms: Structures and Processes

  3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

- **CCSS-M Performance Expectation**

  Statistics and Probability S.ID

  Interpreting Categorical and Quantitative Data

  6. Represent data on two quantitative variables on a scatter plot and describe how the variables are related. ★

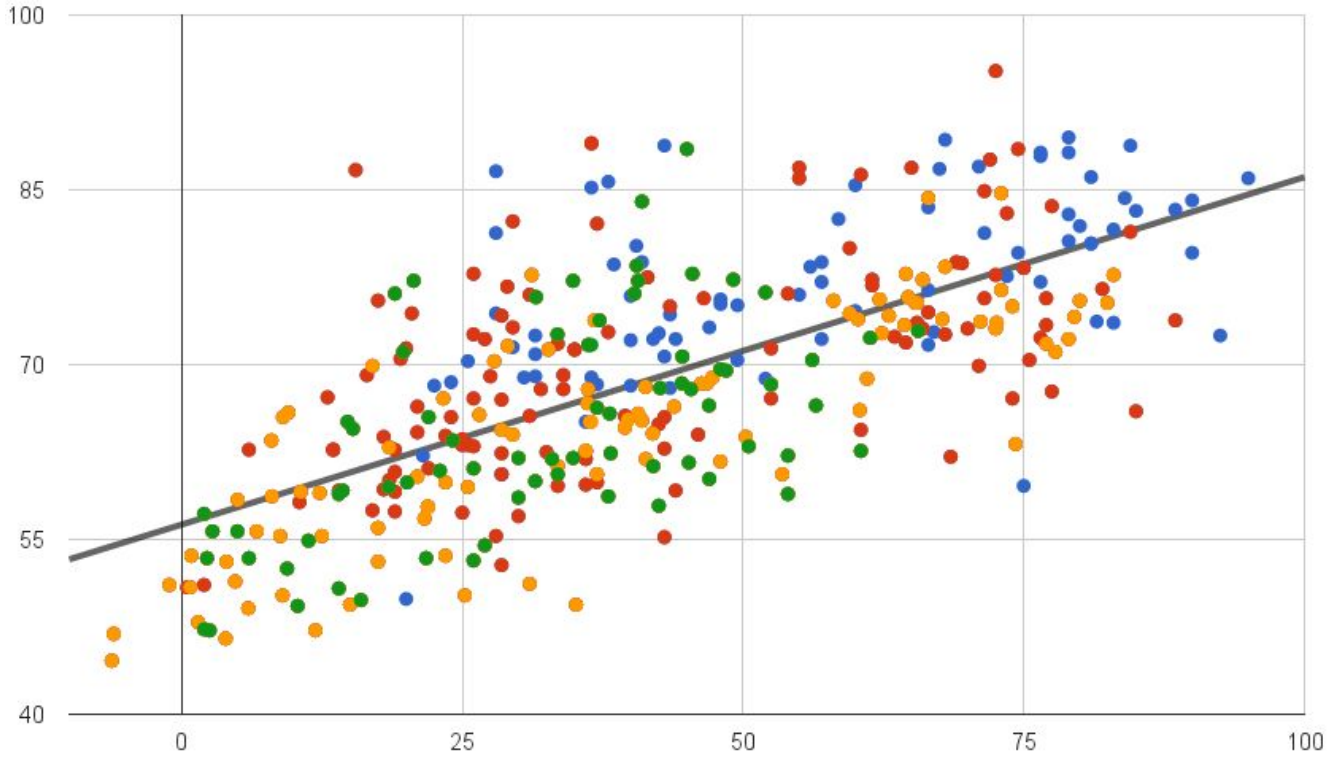
- **Skill Developed:**

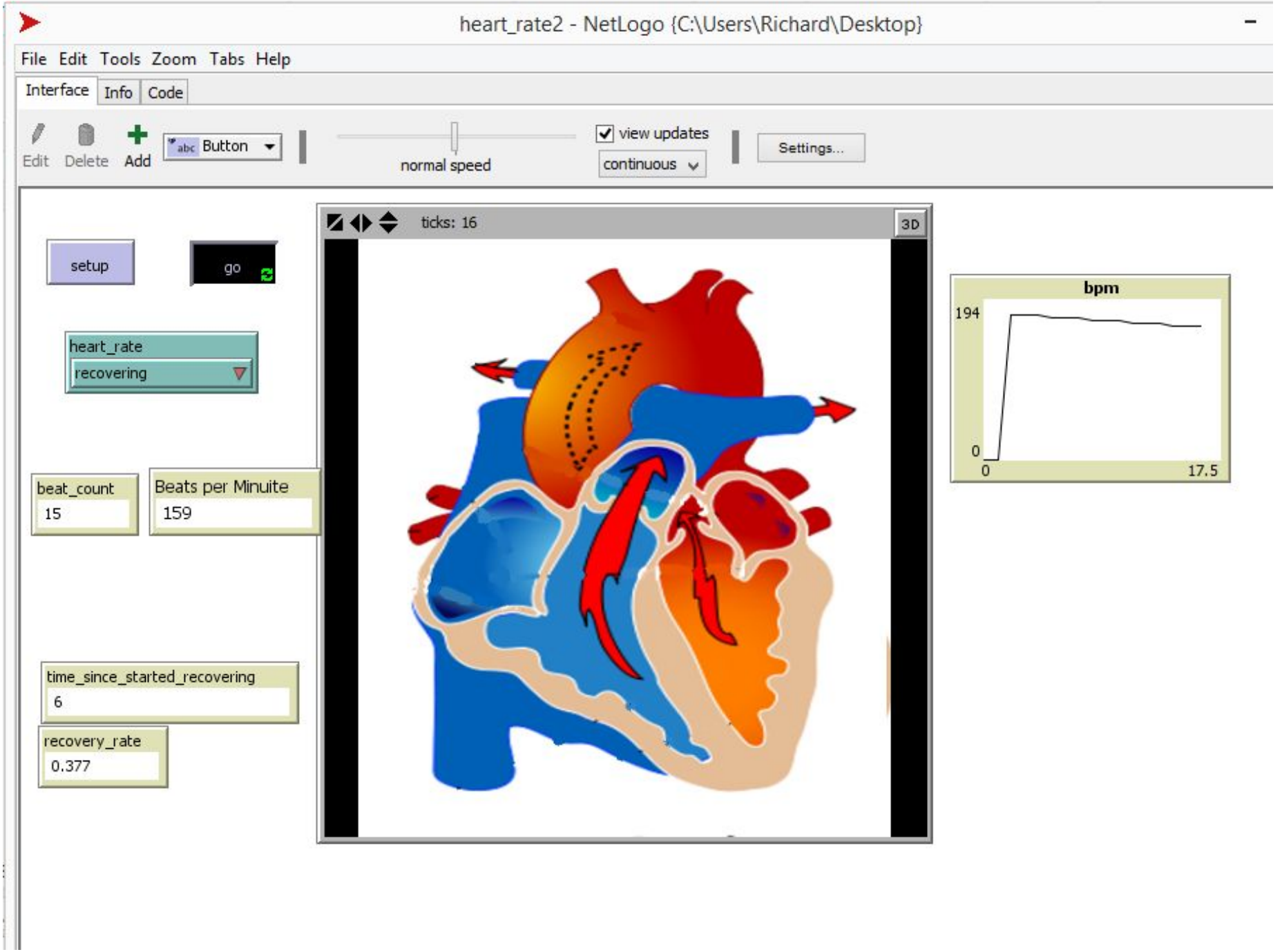
  Data collection using Cell Phones

  Using a modeling in NetLogo to drive instruction

  Using the statistical software Excel

Analyzing Trends in Time




heart_rate2 - NetLogo {C:\Users\Richard\Desktop}
File Edit Tools Zoom Tabs Help
Interface Info Code
Edit Delete Add
Button
normal speed
view updates
continuous
Settings...
setup
go
heart_rate
recovering
ticks: 16
3D
bpm
194
0
0
17.5
beat_count
15
Beats per Minuite
159
time_since_started_recovering
6
recovery_rate
0.377

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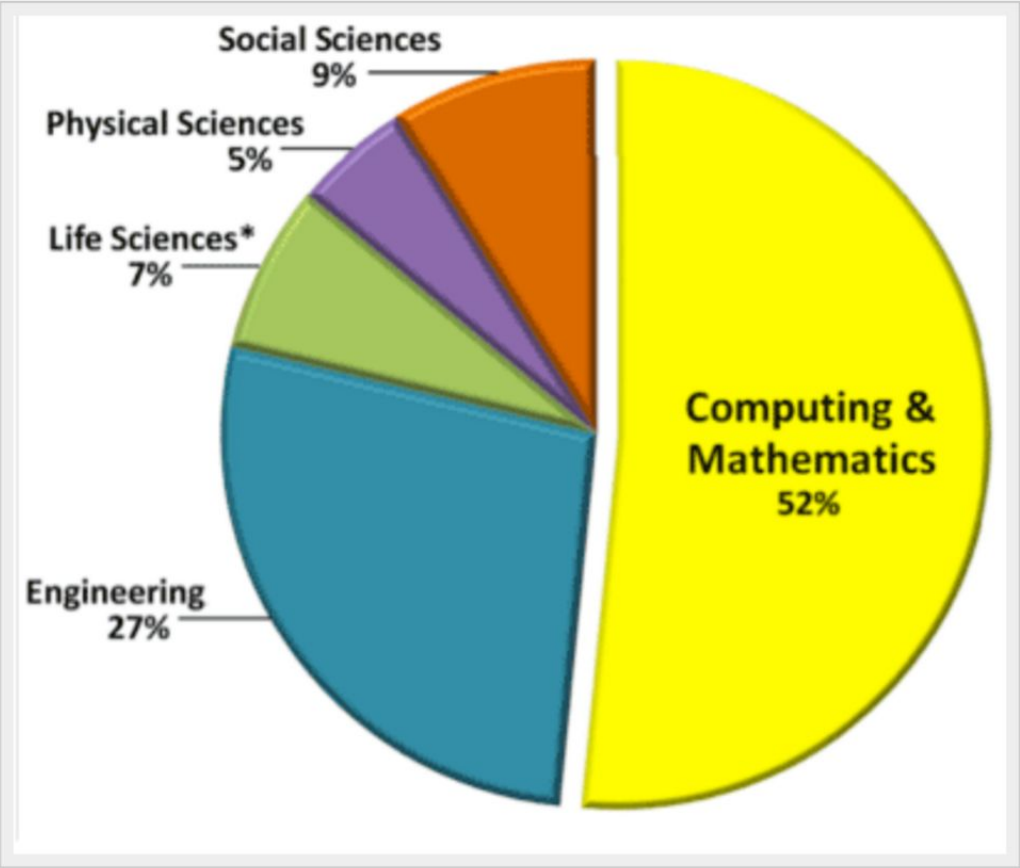
STEM Job Growth

Projected Annual Growth of STEM Job Openings 2010-2020



Source: Jobs data are calculated from the Bureau of Labor Statistics (BLS), Employment Projections 2010–2020

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AB 2329

Authored by Assemblymember Susan Bonilla, D-Concord, the bill, Assembly Bill 2329, requires State Superintendent of Public Instruction Tom Torlakson to create by September 2017 a 23-person advisory panel to be charged with developing a long-term plan to make computer science education a top priority in the state.

https://edsource.org/2016/gov-brown-signs-law-to-plan-expansion-of-computer-science-education/569895

https://goo.gl/MuwpUj

Debrief

- Turn to your neighbor and have a brief conversation of how you can implement more bifocal modeling and statistical analysis into your NGSS, 3D lessons

- Thank you for attending our session!

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Questions?

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