JAMES B. CONANT

Using GameSalad® Creator as a Mathematical Modeling Tool in Math and Science

***As you walk in, please go to www.gamesalad.com and download a free copy of GameSalad® Creator

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Downloads

- Please download:
  - GameSalad® Creator at:
    - www.gamesalad.com under “Download Creator”
  - “Two Planets” simulation at:
    - asteuser.x10.mx

Presenter Profile: Chris Bruce

- National Board Certified Physics Teacher
- Lead Developer for Nerd Island Studios, LLC
- Former US Naval officer
  - Submarines
  - Satellite Ground Control and Space Systems
  - Office of Naval Research / Naval Research Laboratories
- MIT B.S., Mechanical Engineering
- Ketchikan High School Graduate

Presenter Profile: Chris Bruce

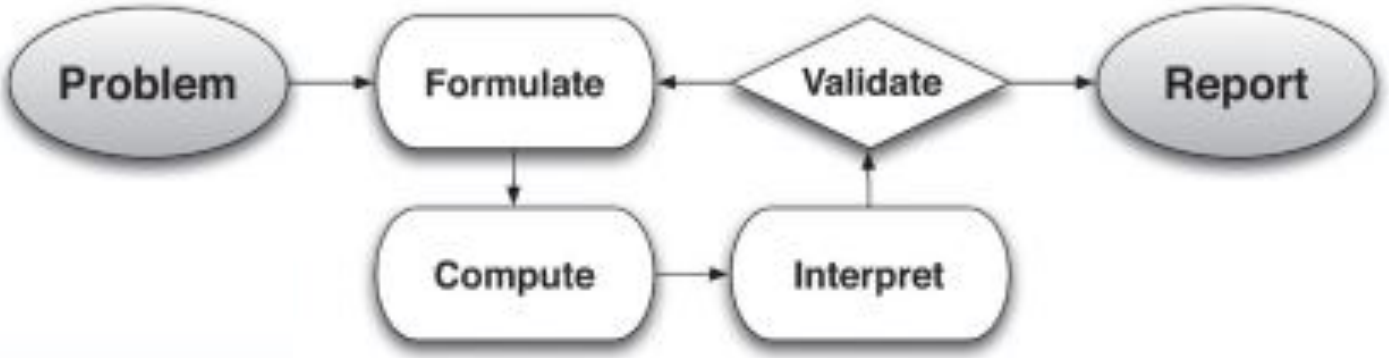
- Current Projects:
  - Participating in school's iPad 1:1 pilot
  - Developed/Developing:
    - iPad app for tutoring students in physics -"Step2Step Physics"
    - Instantaneous assessment/reinforcement system for formative quizzes - "Question Bank"
    - System for rapid assessment of student's drawing - "scratchQuiz"
    - Simulations and games for mobile devices and the web

Motivation

- Students are great at providing cookbook answers to problems.
  - Students are not great at tackling problems creatively using models.
- New standards require students to use models to develop ideas and solutions
- Technology enables students to do this in new ways

Making a Difference: Meeting the Common Core State Standards

- Mathematical Modeling
  - "***Real-world situations are not organized and labeled for analysis***; formulating tractable models, representing such models, and analyzing them ***is appropriately a creative process***."***



***Common Core State Standards for Mathematics, Page 72

Making a Difference:
Meeting the Next Generation Science Standards

- Next Generation Science Standards Video
- Practice 2 "Developing and Using Models"
- Excerpts from key ideas for grades 9-12:
  - "…***predict*** and explain relationships between systems in the natural and designed world."
  - "***Develop, revise, and use models*** to predict and support explanations…"
  - "Develop a complex model that allows for ***manipulation and testing*** of a proposed process or system."
  - "Evaluate merits and limitations of ***two different models***…"

Making a Difference: Meeting the Next Generation Science Standards

- Practice 5 "Using Mathematics and Computational Thinking"
- Excerpts from key ideas for grades 9-12:
  - "Use mathematical or algorithmic representations of phenomena or design solutions to ***describe and support claims and explanations***, and create computational models or simulations."
  - "Use simple limit cases … to ***see if a model 'makes sense'*** by comparing the outcomes with what is known about the real world."
  - "***Create a simple computational model or simulation*** of a designed device, process, or system."

Real Science is Messy! - A Summary of the New Standards

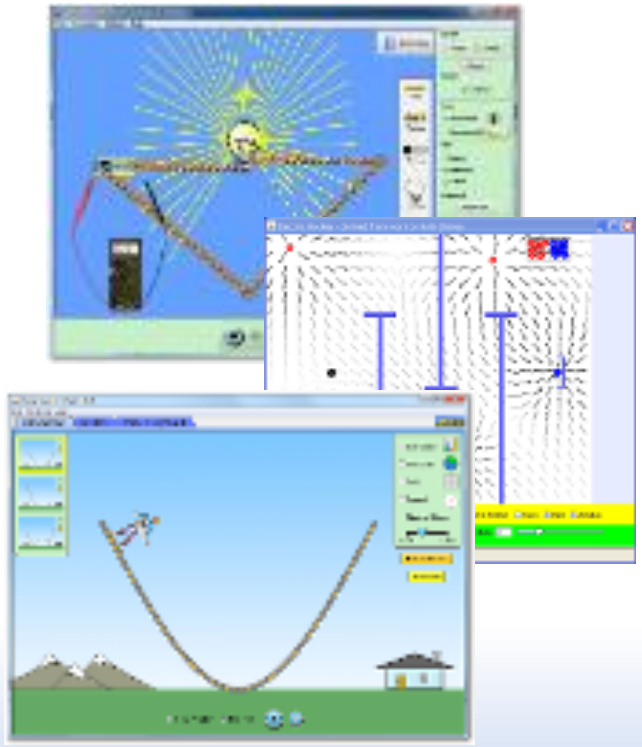
- To prepare for the real world, students must:
  - *"Develop, revise, and use models "*
  - *"Evaluate two different models"*
  - *"Describe and support claims and explanations"*
  - *"See if a model 'makes sense'"*

"Formulating tractable models, representing such models, and analyzing them is appropriately a creative process."

…so how will students learn to do this?

The Old Way: Prebuilt Simulations

- phet.colorado.edu
  - Energy Skate Park
  - Circuit Construction Kit
  - Electric Field Hockey
  - Wave on a String
  - My Solar System
- The rules of the universe are dictated by the programmer

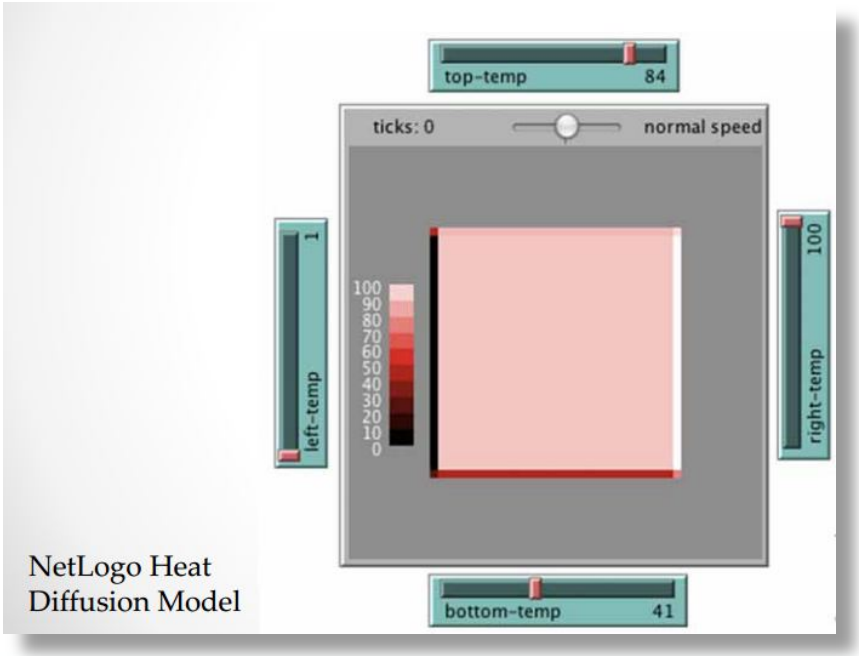


The New Way:
Build Your Own Universe!

- Students build simulations to discover the rules
- Students create new rules for the universe
- Two Great Tools:
  - NetLogo – Maintained at Northwestern University
  - GameSalad® Creator – Commercial Product

NetLogo:
A Simple Programming Language

- Simple syntax
- Text + Graphical User Interface
- Free at ccl.northwestern.edu/netlogo/
- Featured in National Science Teacher's Association (NSTA) web seminar on Mathematical Modeling and Computational Thinking***



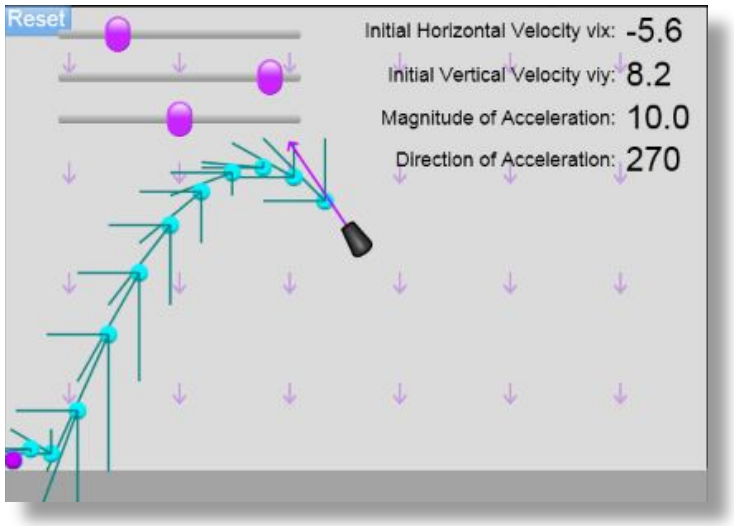
***NSTA Web Seminar: "Preparing for the Next Generation Science Standards—Using Mathematics and Computational Thinking", Robert Mayes and Bryan Shader, November 6, 2012

GameSalad®: Drag and Drop Programming

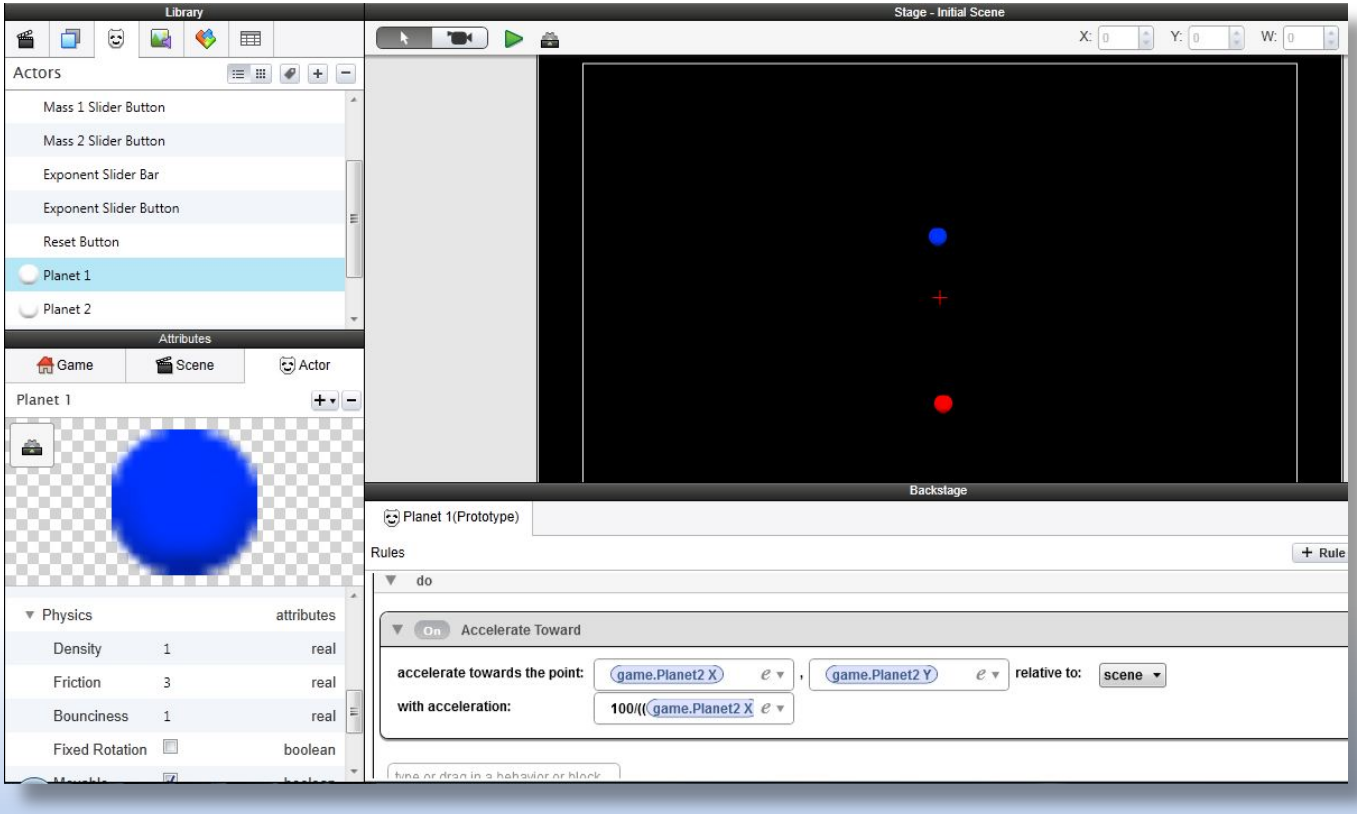
- Pulldown menus
- Simple mathematical statements
- Powerful physics engine
- Free at www.gamesalad.com
- Hundreds of professional published titles
- Publishing options for students and teachers:
  - Web: Free!
  - iOS: $99/year
  - Android: $149/year with teacher discount

Teacher-Built Example:
Projectile Simulator v 1.0

- Simulates Projectile Motion
- Built using GameSalad® Creator
- Published Online at:
  - arcade.gamesalad.com
    - "Community Games"
    - Search for "Projectile Simulator"
- Anyone can build something like this!



Playing with the Universe: "Two Planets" Simulation



Part I – Understanding the Simulation

1. Press the green "Play" button to run the simulation – You should see two planets.
   a. Are they in a stable orbit?

      Mostly – The simulation has rounding errors which causes the orbits to degenerate!

   b. What shape are the orbits?

      Almost circular, but slightly elliptical

Part I – Understanding the Simulation

2. Go “Back to Editor” and click through the following “Library” tabs:
   a) Scenes – What is the name of the only scene in this project?

      “Initial Scene”

   b) Layers – What is the name of the only layer in this project?

      “Background”

   c) Actors
      i. What are the names of the actors in this project?

         “Mass 1 Slider Bar”, “Mass 2 Slider Bar”, “Mass 1 Slider Button”, etc…

      ii. Which actors are “instantiated” in the scene?

         “Planet 1” and “Planet 2”

Part I – Understanding the Simulation

3. Click on the blue planet.
   a) Is this an instance of "Planet 1" or "Planet 2"?
   b) Describe all of the rules for both the prototype and the instance of Planet 1 in the table:

Planet 1 Prototype Rules:	Instance Rules for This Scene:
1. "Constrain x…" 2. "Constrain y…" 3. "Accelerate Toward…"	1. "Constrain x…" 2. "Constrain y…" 3. "Accelerate Toward…" 4. "Spawn Tracer Dot…"

Part II – Tweaking the Simulation

4. Under "Attributes", choose the "Game" tab. Change the "Gravitational Constant" value and run the simulation.
    4. What happens when Gravitational Constant is smaller than 1,000,000?

       Smaller acceleration, big ellipses!

    5. What happens when it is larger than 1,000,000?

       Larger acceleration, small ellipses!

Part II – Tweaking the Simulation

5. Click on one of the planets on the scene and find its instance behavior that controls its acceleration.
   a) What equation is the planet following to control its acceleration? Write the equation in words or in variables:

$$acceleration = (Gravitational\ Constant)/(Planet\ 1\text{'}s\ X - Planet\ 2\text{'}s\ X)\uparrow 2 + (Planet\ 1\text{'}s\ Y - Planet\ 2\text{'}s\ Y)\uparrow 2$$

…with a little rearranging, this is also known as: $Gravitational\ Force = Gm\downarrow 1\ m\downarrow 2\ /d\uparrow 2$

Part II – Tweaking the Simulation

6. Add a new Game Attribute called "Power".
   - Modify the equation for both planets so that they no longer follow a $1/r^2$ law, but instead follow a $1/r^{power}$ law. (Hint: This can be done without deleting anything.)

acceleration= (Gravitational Constant)/***sqrt***((*Planet* 1↑ *s X* − *Planet* 2↑ *s X*)↑2 + (*Planet* 1↑ *s Y* − *Planet* 2↑ *s Y*)↑2)^***power***

Part II – Tweaking the Simulation

7. Adjust the value of the "Power" game attribute.
   a) What happens to the orbits when Power = 2?

      The simulation is the same as the original

   b) What happens to the orbits when Power < 2?

      Gravity is too strong when far away – Orbits are unstable!

   c) What happens to the orbits when Power > 2?

      Gravity is too weak when far away – Planets don't orbit!

   d) Could we exist if our universe did not obey a $1/r^2$ law for gravity?

Part II – Tweaking the Simulation

8. You can also modify the starting attributes of the planets themselves. Set "Power" back to 2 and adjust the starting velocities and positions to achieve:
   a) Elliptical orbits
   b) Circular orbits
   c) Larger circular orbits
   d) Parabolic trajectories

Resources

- ASTE website with this presentation at www.aste.org
- PhET website at phet.colorado.edu
- NetLogo at ccl.northwestern.edu/netlogo/
- GameSalad Cookbook at cookbook.gamesalad.com
- Next Generation Science Standards at www.nextgenscience.org/next-generation-science-standards
- Common Core State Standards for Mathematics at www.corestandards.org/Math

Student Projects

Question Bank

Start: 2013-02-14 22:23:01
Stop: 2013-02-15 07:53:21
Duration: 570 minutes and 20 seconds

Objective	Score	Description	Reinforcement	Reinforcement Required
7.1	4 / 4	Define, distinguish, and discuss the following terms: conductor, insulator, ground, electroscope, electric field, electric potential energy, test charge, electric potential/voltage and equipotential	• See Teacher • Reading: Static Electricity Lessons 1a,b,c,d,e	
7.10	2 / 4	Define, distinguish, and discuss the following terms: conductor, insulator, ground, electroscope, electric field, electric potential energy, test charge, electric potential/voltage and equipotential	• See Teacher • Reading: Static Electricity Lessons 1a,b,c,d,e	X
7.2	3 / 4	Discuss the charge and mass on a proton, neutron, and electron and relate the elementary charges to coulombs.	• MOPs: S1 • Reading: Static Electricity Lesson 1c	
7.3	3 / 4	Discuss and demonstrate how certain charges interact with each other.	• MOPs: SE2 • Reading: Static Electricity Lessons 1c	