Simplexity

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Apprenticeship pitch at the beginning of the semester:

- Did you come across something behavbing in a "complex" or "intelligent" way, and wanted to find out how difficult it would be tor build this kind of behavior?
- Do you think that you can create on the computer something that looks complex/intelligent, but is actually very simple?

Show Boids:

- Who is the leader in Boids?
- How difficult (how many rules) is it to create a flock behavior like in Boids?

THE PITCH (AT THE FAIR) – SIMPLEXITY

Show Boids – set it up for one flock with a leader:

- Does it look like the birds are smart/intelligent?
- Who is the leader in the flock, and how did they become a leader?
- How difficult (how many rules) is it to create a flock behavior like in Boids?

KEY SKILLS AND OUTCOMES FOR STUDENT LEARNING

State/Common Core Standards	21st Century Skill(s)
- **Data gathering** - **Analysis** - **Modeling** - **Hypothesizing** - **Simulating**	**Oral Presentation** – prepare and present a project and its findings using appropriate Math and Computer Programming concepts. **Technology** – use the NetLogo software to develop and present the project **Advanced Literacy** – acquire and properly use Math and Computer Programming vocabulary relevant to the subject

GUIDING QUESTIONS

These are the questions you want students to be thinking about in every lesson to ensure they get to WOW! and learn the objectives listed above. Here is where you build the connection between the skills students will learn and the content they need to cover. The guiding questions translate that connection into everyday thinking for your planning purposes.

1.) Is complex behavior always a result of complex systems/organisms and rules?
2.) Is complex behavior always a result of "central" leadership, planning, and "global" forces?
3.) When, why, and how can computational tools help in understanding complexity?

WOW! DESCRIPTION

For the WOW! the kids will

BASIC WOW! PROJECT PLAN	
Week	What will students need to do each week to finish their WOW! product, performance or presentation?
1	Intro: simplicity leading to complexity, tools for analysis, visualization, simulation Example: Mandelbrot fractals (http://benojt.sourceforge.net/)
2	1D Cellular Automata (1D CA)
3	The Game of Life (GoL = 2D CA)
4	Wildfires
5	Boids
6	Prisoner's Dillema
7	Predator and Prey
8	Termite piles
9	Work on the preso (posters, demos, games) for the WOW!
10	Dry-run the WOW!

21ST CENTURY SKILLS AND LEARNING OBJECTIVES THAT MEET THEM.

21st century skills	Your learning objectives
Oral Presentation: The ability to speak to an audience with confidence using eye contact and body language, developing coherent and well-organized content	• Students are able to develop a well organized, written presentation in preparation for their oral presentation. • Students are able to speak loudly, slowly and clearly enough for the audience to understand. • Students are able to present information using eye contact and good body posture. • Students are able to effectively use visual aids in a presentation.
Teamwork: The ability to work effectively and solve problems in a diverse team by working in groups, encouraging others, and giving and receiving feedback	• Students are able to build on other apprentices' ideas in discussion and participation. • Students are able to contribute to group work or discussions while sharing the spotlight. • Students are able to ask questions that deepen understanding of other people's perspective. • Students are able to give and receive constructive feedback.
Leadership: The ability to make decisions, establish goals, volunteer to help other students, and be a role model	• Students are able to speak more confidently in front of an audience. • Students are able to take initiative to get information and resources needed to accomplish tasks or solve a problem. • Students are able to articulate in writing or speaking how what they

	learned is connected to the larger community. • Students are able to set achievable goals.
Data Analysis: The ability to solve problems using data (qualitative and quantitative), test hypotheses, draw conclusions, and interpret and communicate data	• Students are able to analyze data and create a bar graph and/or pie chart accurately. • Students are able to ask a clear question and form a hypothesis that connects to it. • Students are able to draw concrete conclusions from data sets. • Students are able to identify and use data in their everyday life. • Students are able to develop and utilize survey questions to collect valid data.
Advanced Literacy: The ability to use new vocabulary, communicate effectively in writing, use critical reading skills, and make inferences from what is read	• Students are able to develop and think through the main idea for a written piece independently. • Students are able to write paragraphs with topic sentences and supporting ideas repeatedly. • Students are able to identify the main idea of something they've read. • Students are able to apply terms and vocabulary associated with their apprenticeship correctly.
Technology: The ability to identify and use technology as a tool	• Students are able to identify the uses of specific technological instruments and tools correctly. • Students are able to identify specific roles of technology in society. • Students are able to use technology as part of problem-solving.

WEEKLY BREAKDOWN OF APPRENTICESHIP TIPS

Week of Apprenticeship	What should I be doing as a Citizen Teacher?
Apprenticeship Fair	• Set up Communication Contract with your Team Leader • 10 Week WOW! plan should be completed and turned into your campus • Explore CTnation, check out the "Getting Started" page and fill out your profile (don't forget to upload a photo!) • Lesson #1 should be completed on CTnation

Week 1	• Intro to simplexity:
	  ○ Show videos that shows non-random applications of rules – leading to chaos/complexity
	  ▪ The Game of Life (GoL)
	  ▪ Boids/Birds – 3D
	  ▪ http://www.youtube.com/watch?v=eakKfY5aHmY
	  ▪ School of fish
	  ▪ http://www.youtube.com/watch?v=-Udq_41X6Xs&NR=1
	  ▪ http://www.youtube.com/watch?v=K0LABzJxCg8&NR=1
	  ▪ http://www.youtube.com/watch?v=xrEzkwXAUYM&NR=1
	  ▪ Weather as a complex/chaotic system?
	  ○ **Use NetLogo CA 1D - all rules 1.nlogo** to show the behavior of Wolfram's rules – to generate simple AND complex patterns
	  ▪ **Hands-on**: have the kids try out different rules and classify them
	  ▪ Each pair discover/classify interesting patters in a range of rules (e.g. pair 1 – rules 1-20, pair 2 – rules 21-41, etc.)
	  ▪ Disappearing, static, oscilating/repeating, dynamic (interesting)
	• Mandelbrot fractals
	  ○ Using Mandelbrot applet: benojt.jar (http://benojt.sourceforge.net/) or xMandelbrot.jar
	  ▪ Show UI capabilities: zoom, restart, etc.
	  ▪ Explain how a Mandelbrot shape is created
	  ▪ Ask students to explore and screen-capture "interesting" behavior
	  ▪ Repeating patters
	  ▪ Converging behaviors/shapes
	  ▪ Diverging behaviors/shapes
	• Computational Thinking
	  ○ Intro to Computational tools – what, why, when
	  ▪ Visualization (relevant to Simplexity)
	  ▪ How to visualize complexity/interesting-ness?
	  ▪ Disappearing, static, oscilating/repeating, dynamic
	  ▪ Simulation (relevant to Simplexity)
	  ▪ Simulation is the only way to explore this, since there are no formulea/functions for CAs
	  ○ Concepts
	  ▪ Simple rules MAY lead to complex behavior
	  ▪ Sometimes, calculations may be too hard or impossible, and other

	techniques may be better (e.g. simulation)

Week 2	• 1D Cellular Automata
	  ○ Explain CA, rules
	  ○ Ask kids to model on the board an application of a few rules
	  ○ Explain binary counting/naming for rules
	  ▪ Ask kids to count in binary on their fingers
	  ○ **Hands-on:** Use NetLogo **CA 1D - manual 1.nlogo** – apply rules manually
	  ▪ Ask kids to apply a few generations of a rule **and check**

Week 3	• The Game of Life (GoL)
	  ○ Demo using the **Java program**
	  ▪ http://www.math.com/students/wonders/life/life.html
	  ▪ show some impressive patterns – big picture
	  ○ Explain the rule of GoL
	  ○ Difference from Wolfram's rules (from week 2)
	  ▪ **In CA 1D "world" – the rules change, but the initial condition is fixed**
	  ▪ **In GoL – the rules are fixed, but the initial condition/colony changes**
	  ○ Manually show an example of an evolving patten
	  ○ Ask kid to volunteer and show another example
	• Using the NetLogo applet **GameOfLife1.nlogo**
	  ○ Explain/Show the "butterfly effect"
	  ▪ A small change can result in a drastically different evolution
	  ○ Hands-on: have the kids **use the GameOfLife1.nlogo applet**
	  ▪ Create a pattern that "lives" for at least 5 generations
	  ▪ Create an oscillating pattern
	• Show a few elaborate patterns in the **Java program**
	  ○ Gliders, guns, puffers, etc.
	• Computational Thinking
	  ○ Power of simulation
	  ▪ Can we determine/predict the outcome/behavior ahead of time?
	  ▪ There is no way to "calculate" it, so simulation is critical!
	  ○ Visualization tool
	  ▪ density fluctuation – prep for Predator/Prey
	  ▪ What is density? Ratio!
	  ▪ is the numeric display "good enough"? is a graph better? Why?
	  ▪ Could a similar visualization have helped us classify 1D CA into types (Disappearing, static, oscilating/repeating, dynamic)?

Week 4	• Wildfires
	  ○ Implications/similarities to social/group cliques, and
	  ○ a discussion of
	  ○ Use NetLogo applet (Random Fire)
	  ▪ Show/discuss a fire starting at the edge (Original Wilensky version)
	  ▪ Show/discuss a fire starting at the center (hmark modified version)
	  ○ Explain density
	  ○ Explain probability

	• Hands-on: have students use NetLogo
	  ○ have students find "tipping points" in density and probability Computational Thinking
	  ○ Use Excel to tabulate and average student results over several runs/trials/experiments

Week 5	• Boids
	  ○ Implications/similarities to social/group cliques, and
	  ○ a discussion of traffic behavior, and walking down a crowded sidewalk without bumping into people. This is so intuitive that students immediate grasp it. This is also the principle behind **Adam Smith's "invisible hand",** sometimes restated as private virtue (each individual doing what is best for themselves) leads to public virtue (wealth in the society increases).
	  ○ Use C:\Program Files (x86)\Cool School\CoolSchool.exe – 3D fish sim
	  ○ Use NetLogo applet
	  ▪ Show a flock, and ask kids to explain how/why they behave this way
	  ▪ Choose to follow/watch a "leader" in the flock – ask kids to predict future behavior
	  ○ Explain the simple behavior rules
	  ○ Activity: have kids demonstrate the rules
	• Hands-on: have kids use NetLogo
	  ○ Choose parameters that will create random, non-flock behavior
	• Computational Thinking
	  ○ Find a tool to visualize the flock behavior over time?

Week 6	• Prisoner's Dillema (PD)
	  ○ A Dilbert video on PD: http://www.youtube.com/watch?v=ED9gaAb2BEw
	  ○ This is another example (like CA, GoL, Boids) where simulation enables deeper understanding of phenomena/behavior, and in this case can influence decision making on the personal, country, and global levels. For example:
	  ▪ individual cooperation
	  ▪ pair country response/retaliation – Cold War scenarios
	  ▪ multi-country response/collaboration – Global Warming
	  ○ Explain difrerent scenarios: snitching at school (or to parents), prisoners and police, countries at war (cold war), global warming
	  ○ **Use NetLogo "PD Person-Person Iterated simple 1.nlogo"**
	  ▪ Explain the rules for compensation/punishment
	  ▪ 1 time game, multiple iterations
	  ▪ Ask 2 kids to demonstrate a few rounds
	  ○ Hands-on: have kids use **NetLogo "PD Person-Person Iterated simple 1.nlogo"**
	  ○ Play in pairs, and try to win the most points possible (**not** more than their partner!)
	  ○ Ask kids if they found any strategy that works best
	• Summarize strategies
	  ○ Use GeoGebra ? to show the decision tree for cooperation/defection
	• Demo with **NetLogo "PD Person-Computer Iterated simple 1.nlogo"**with various strategies
	• Show/visualize the best strategy – by switching between human + computer strategies

	as the simulation is continually run – to show ups/downs in average scores
Week 7	• Predator-Prey (PP)
Week 8	• Termite piles
Week 9	• Mandelbrot fractals in depth ○ Show step-by-step how fractals are/can be created (repeating an application of same function)

Week 10	• Amazing Mazes WOW! your authentic audience, friends, family, and community
	• Things we learned in the apprenticeship:
	  ○ Sometimes simple rules can cause complex behavior
	  ▪ 1D CA, GoL, Boids, Predator-Prey
	  ○ Complex behavior can be created by
	  ▪ Starting with fixed initial conditions and dhanging the rules (1D CA)
	  ▪ Starting with different initial conditions and fixing the rules (GoL, PP)
	  ○ No central control is needed to create orderly, intelligent behavior
	  ▪ Boids, Termites

Reflection Week	• Appreciate and celebrate apprentices and Citizen Schools staff through an interactive activity • Discuss apprenticeship highlights and challenges
Post Apprenticeship	• Sign up to teach next semester!

SIMPLEXITY

Week #	Phenomenon/Tool	Question	Analysis/Tool
1	Intro - Boids		Similarity to social behavior in schools – leaders and followers?
2	1D Cellular Automata		NetLogo
3	The game of life		http://www.math.com/students/wonders/life/life.html http://ccl.northwestern.edu/netlogo/models/Life - create a pattern that lives the longest - modify a pattern to live forever (ping-pong? Glider gun?)
4	Predator-Prey		Fine-tune the parameters to reach - the longest time of oscillations - the longest time between oscillations - the shallowest oscillations
5	Prisoner's Dilemma		Start with 2 person PD, multiple manual games (PD Two Person Iterated) Ask if the kids can think of a good strategy to win End with person against PC, multiple games – to verify strategy
6	Traffic jam		
7	Termites		
8			
9	Chaos – logistic map		-
9			
10	Prep		

COMPUTATIONAL THINKING/ LITERACY SKILLS

Activity #	Skill type	Activities	
1	Observe, gather data	Watch video – youtube, vimeo, etc.	
2	Define questions	Capture/document – GoogleDocs,	
3	Hypothesize		
4	Identify elements (modeling, knowledge, tools, etc.)		
5	simulate		
6	Analyze, visualize		
7	Visualize, present		
8			

IDEAS FOR THE APPRENTICESHIP

- Exploring Complexity – Melanie Mitchel
  - http://web.cecs.pdx.edu/~mm/ExploringComplexityFall2009/
  -
- Demo/simulate Resnick's "guiding ideas"
  - **Positive Feedback Isn't Always Negative**
  - **Randomness Can Help Create Order**
  - **A Flock Isn't a Big Bird**
  - **A Traffic Jam Isn't Just a Collection of Cars**
  - **The Hills are Alive**
- Gleick, J. (1987). ***Chaos****: Making a New Science*. New York: Viking Penguin Inc.
- Life – Conway
- Complexity and agent simulations - http://www2.econ.iastate.edu/tesfatsi/abmread.htm
- List of agent and simulation resources http://www.csd.uwo.ca/courses/CS2080b/
- Traffic gridlock – basic (no need for NetHub) http://beyondbitsandatomsblog.stanford.edu/spring2012/assignments/assignment-3-modifying-netlogo-models/traffic-gridlock/
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