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INTEGRATING COMPUTATIONAL THINKING

into Elementary Mathematics and Science Curriculum Materials and Instruction

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Education Development Center

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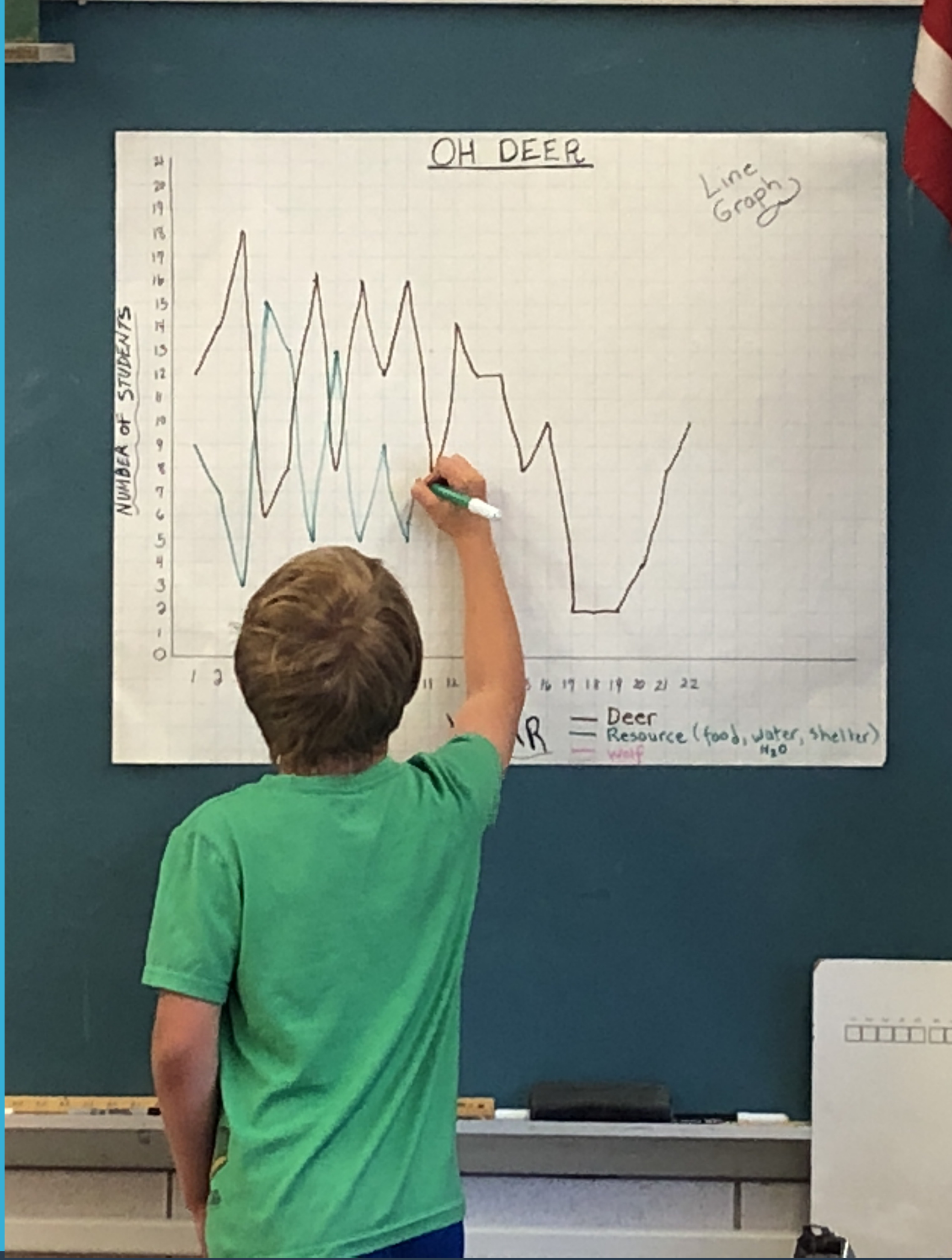

Our Project

- Broadening Participation of Elementary Students and Teachers in Computer Science
  - Funded by the US National Science Foundation
  - Addresses challenge of providing computer science in schools, starting with foundational computational thinking (CT) in elementary
  - Integrates CT into existing math and science units/lessons
  - Works with teachers in 16 districts across the state

EDC at a Glance

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1958

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REGIONS

» Africa
» Asia
» Europe
» Latin America and the Caribbean
» Middle East
» United States

What Is Computational Thinking (CT) ?

A way of thinking that involves:

- Formulating problems
- Decomposing problems
- Structuring problems
- Communicating solutions
    - For human understanding
    - For machine processing

Why Integrate?
Fitting It All into the Elementary School Day

- Less overwhelming
- More likely to find instructional time
- Exploit overlaps between CT and skills/practices in core subjects
- Mutually beneficial: develop students' CT concepts and skills while deepening students' disciplinary understanding

CT Strand Topics
From the Massachusetts Digital Literacy/CS Framework

- **Abstraction:** Create a new representation through generalization and decomposition
- **Algorithms:** Write and debug efficient, clear, reusable, and accurate algorithms
- **Data:** Create, modify, and manipulate data structures, data sets, and data visualizations
- **Programming and Development:** Use an iterative design process to create an artifact or solve a problem
- **Modeling and Simulation:** Create models and simulations to formulate, test, analyze, and refine a hypothesis

Next Generation Science Standards Science 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

Next Generation Science Standards
Computational Thinking as a Practice

Digital tools can enhance the power of mathematics by

- automating calculations
- approximating solutions to problems that cannot be calculated precisely
- analyzing large data sets available to identify meaningful patterns

Next Generation Science Standards
Computational Thinking as a Practice

Computational thinking involves strategies for

- organizing and searching data
- creating sequences of steps called algorithms
- using and developing new simulations of natural and designed systems

Levels of Integration

- Concepts, skills, and practices that already **exist** in the lessons and can simply be called out or elaborated upon with examples of how they can also relate to computers or other technology
- Additional tasks or lessons that **enhance** the disciplinary concept and provide clear connection to computing concepts, skills, and practices
- New lessons or sequences of lessons that **extend** the disciplinary concept as a basis for CS exploration, often involving programming activities

Levels of Integration: Exist

Concepts, skills, and practices that already **exist** in the lessons and can simply be called out or elaborated upon with examples of how they can also relate to computers or other technology.

- Consists primarily of background connections for teachers, with talking points for presentations to students
- Describes how existing hands-on activities can reinforce thinking and concepts that could be supported by technology

Levels of Integration: Exist

The Oh Deer! activity already **existed** within a larger life science unit on the survival of organisms.

We made CT connections more explicit by focusing on the game as a **model** of an actual system:

- How does the game represent an actual habitat?
- What critical elements are included in the game? What is simplified?
- What is not included in the game that is in the habitat?

Levels of Integration: Enhance

Additional tasks or lessons that **enhance** the disciplinary concept and provide clear connection to computing concepts, skills, and practices.

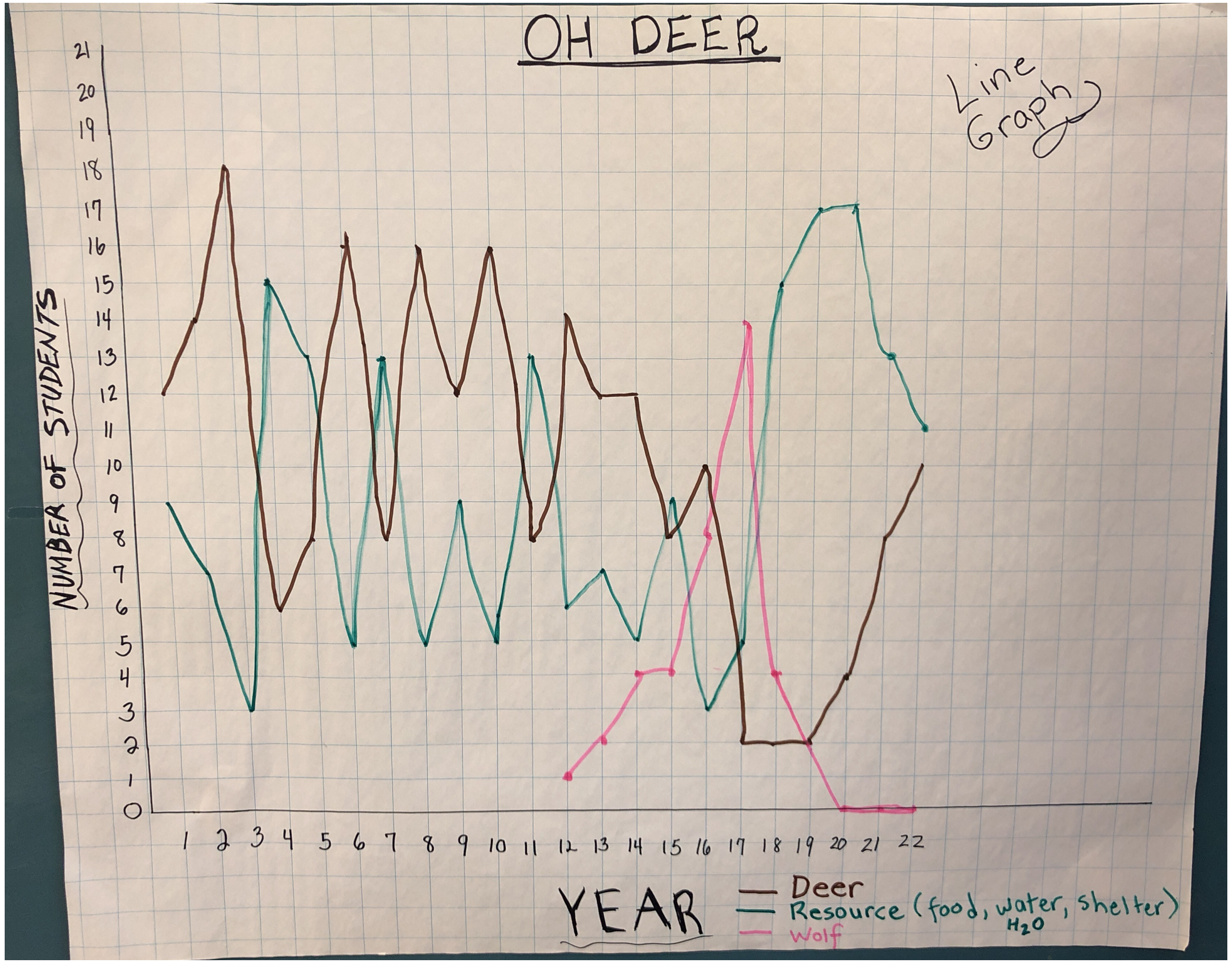
- Embedded tasks within an existing lesson that complement the activity with CT concepts
- Can also include tasks that use technology to perform a task or further a concept

Levels of Integration: Enhance

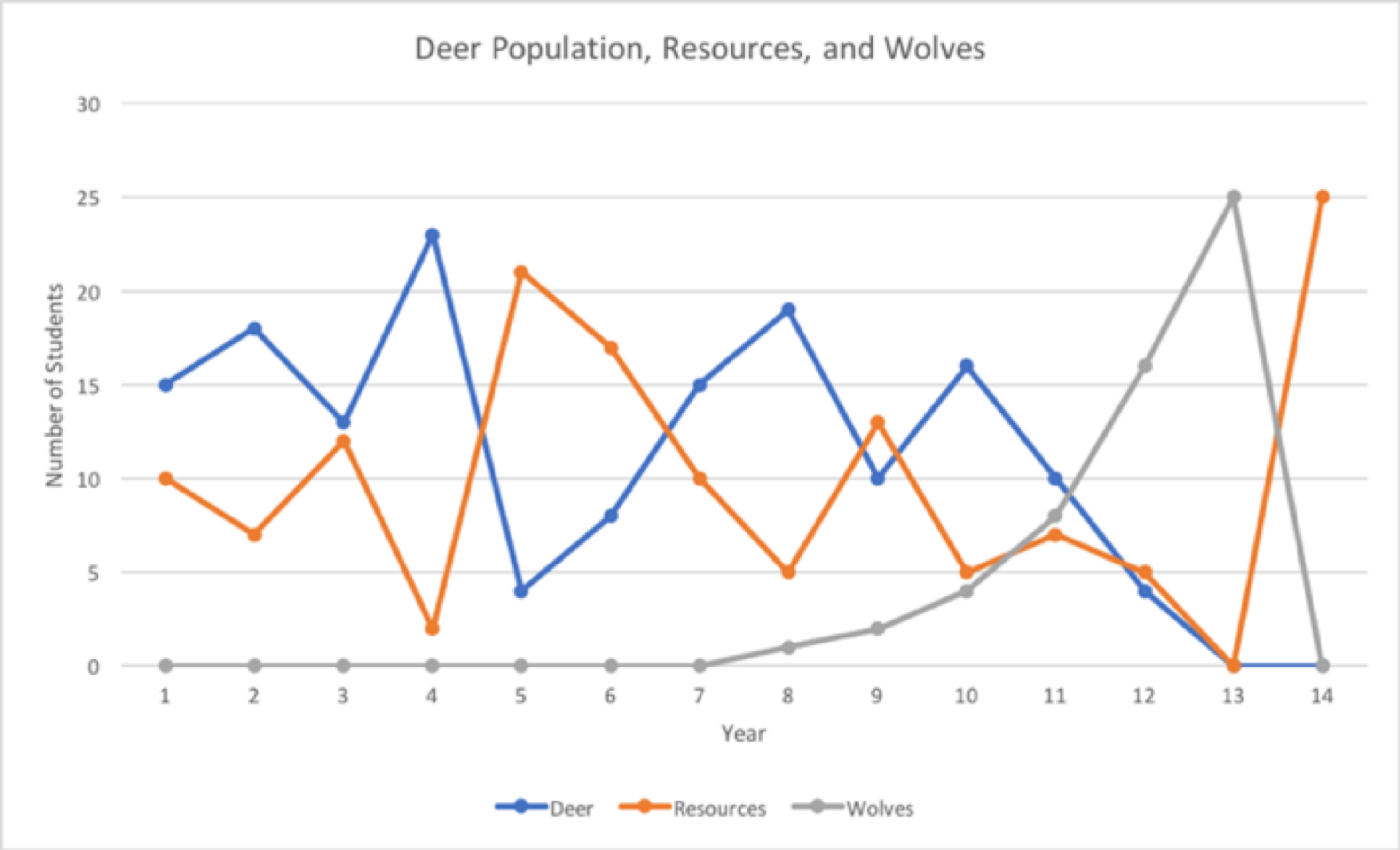
We **enhanced** the part of the lesson to include a broader study of the data they collected during the activity.

- Students first create graphs by hand, then recreate using a spreadsheet.
- Line graphs of multiple sets of data gave students the chance to see and discuss more broadly interactions between populations in the game.
- Students can connect the graph and the data to the game they played, and see how observations made from the game are represented.

Levels of Integration: Enhance



Levels of Integration: Enhance

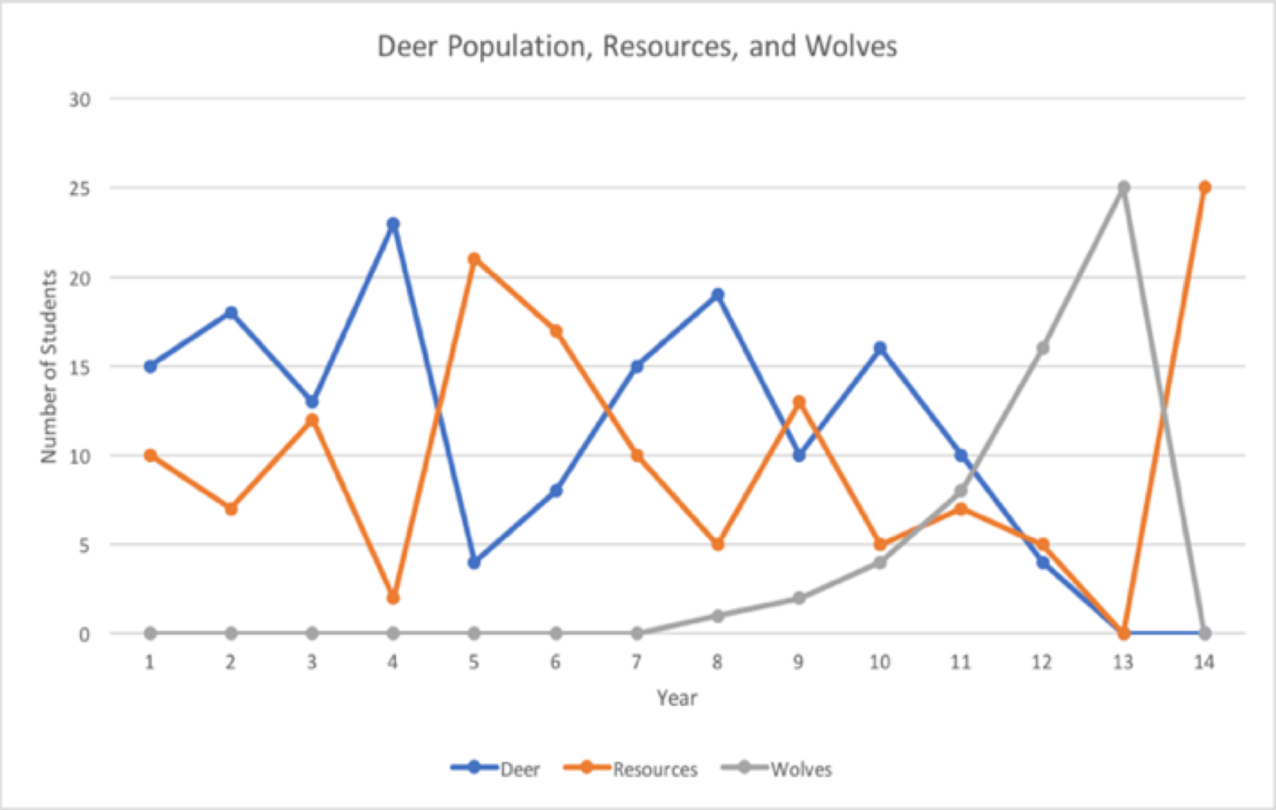


Graph of student data from one simulation of Oh Deer!

Levels of Integration: Enhance

Some initial observations made by students:

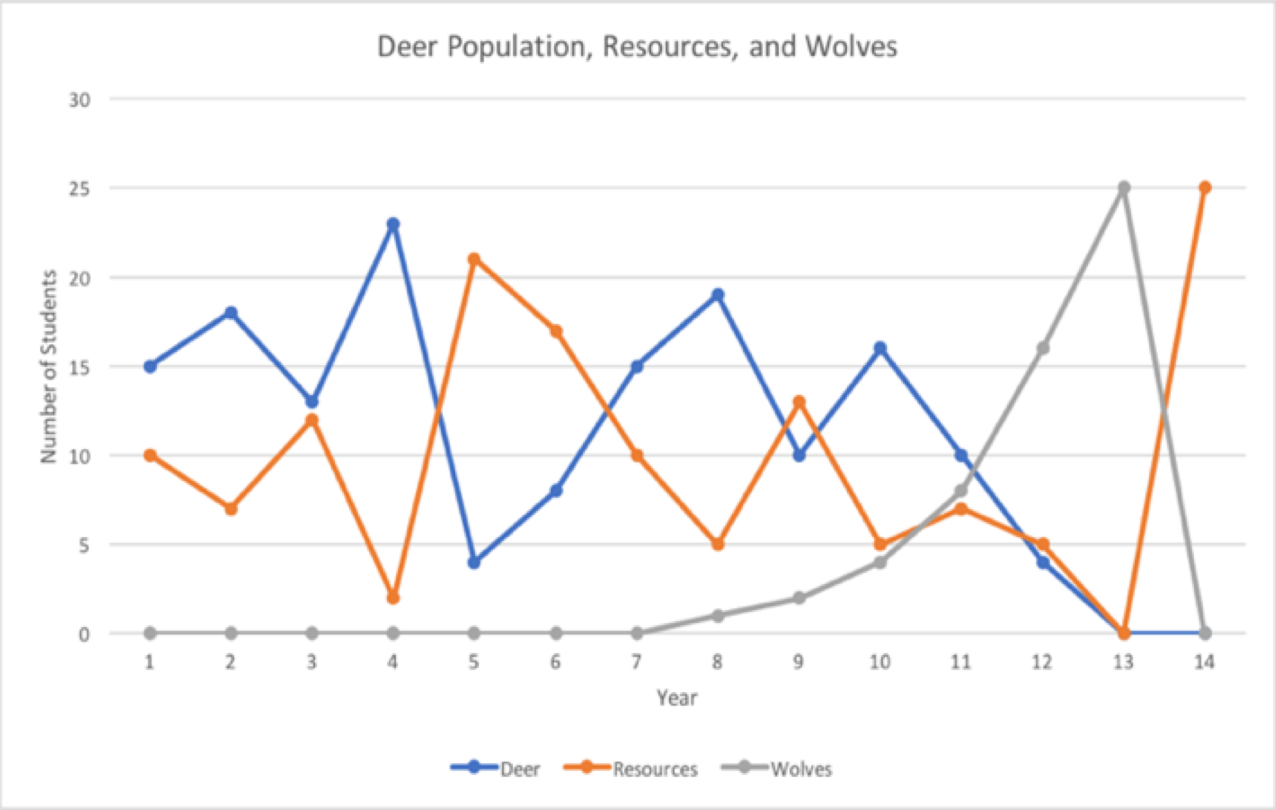
- both the blue line and the orange line go up and down
- the blue is like the orange line, only upside down, at least at first



Levels of Integration: Enhance

With prompting, students discussed patterns such as:

- when resources were low one year, the deer population would go down the following year
- when the deer population was low one year, resources would go up the following year



Levels of Integration: Enhance

The data discussion reinforced science concepts in the lesson:

- Deer die off the year after resources are low because they don’t have enough resources to survive
- Resources rise the year after the deer population is low because there are fewer deer around to consume the resources
- The interaction between the wolves and the deer is similar to the interaction between the deer and the resources

Levels of Integration: Extend

New lessons or sequences of lessons that **extend** the disciplinary concept as a basis for CS exploration, often involving programming activities.

- Added lessons to make explicit links between the discipline and CS
- Often use technology, including programming in later grades
- Can be delivered by technology teachers or specialists

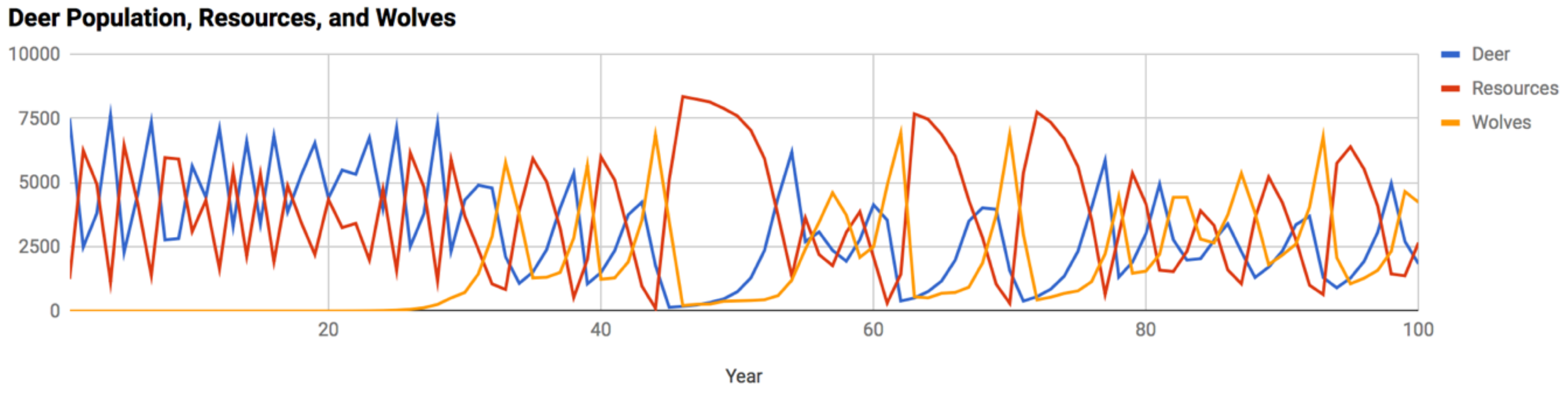
Levels of Integration: Extend

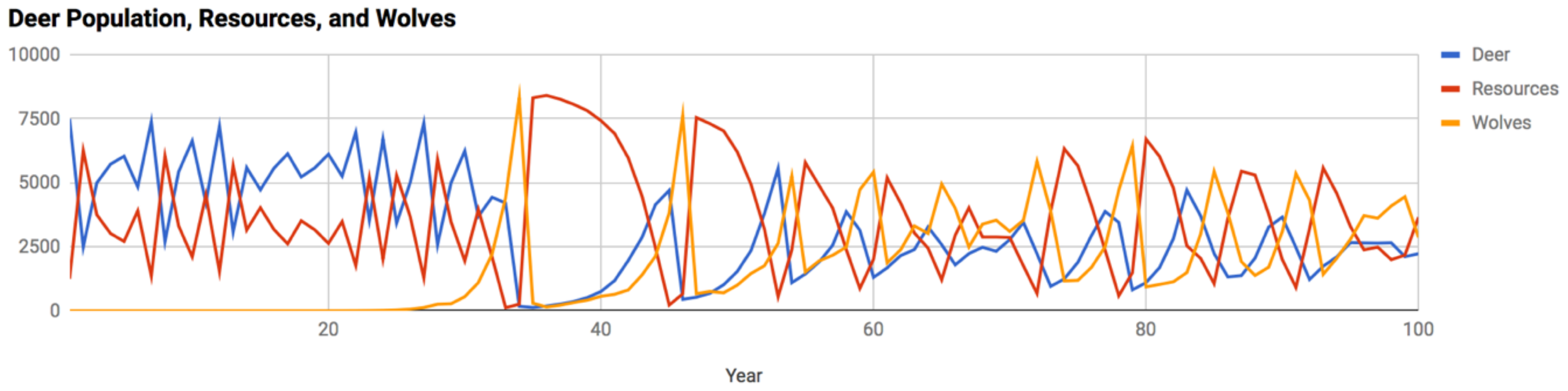
We **extended** the unit to view a more complex spreadsheet-based model built to reflect the same rules from *Oh Deer!*

- simulate data and produce charts for large numbers and time periods
- provides an example of simulating a game they physically acted out
- can be run many times with different outcomes

Levels of Integration: Extend

Students compared simulated data from 2 different runs of the model





Levels of Integration: Extend

Spreadsheet model is available at

http://go.edc.org/oh-deer-simulation

Levels of Integration: Extend

Some discussion points that emerge from the model:

- questions and curiosity over how the model “plays the game”
- example of how a computer model can play the game on a much larger scale than possible in school (more players and years)
- seeing why depleted populations come back slowly
- connections between local extinction and global extinction

THANK YOU

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