# Day 1

## Introduction to Complex Adaptive Systems and Computer Modeling and Simulation

### PACING GUIDE

**Getting Started**
(Assessment)

Pre-test / Assessment
Optional **10 min**

**Activity 1**
(New Learning)

Turn & Walk: Participatory Simulation, Computer Model (Teacher-led demo), Correspondence between the real world and the virtual world, and Parts of a StarLogo Nova model. **25 min**

**Activity 2**
(New Learning)

Complex Adaptive Systems: Video introduction, Characteristics of Complex Adaptive Systems. **10 min**

**Wrap-Up**
(Reflection)

What are computer models good for? **5 min**

### LEARNING OBJECTIVES: Students will. . .

**Complex Adaptive Systems**
Experience being part of a complex adaptive system. [LO 1]
Learn characteristics of complex adaptive systems. [LO 6]
Learn that complex adaptive systems are 1) made of many interacting parts or agents, 2) each agent follows its own rules, 3) emergent patterns can result from the interaction of agents.

**Modeling and Simulation**
Compare and contrast a computer simulation vs. a real-world phenomenon. [LO 2]
See a demo of using a computer model to run experiments. [LO 3]
Speculate as to why computer models can be valuable scientific tools. [LO 5]
Learn that models are representations of reality. Not all features of the real world are incorporated in to models. Models contain assumptions.
Learn how to setup and run an experiment using a model as a test bed.

**Computer Science**
Investigate the parts of a StarLogo Nova user interface and paradigm. [LO 4]
Learn that programs consist of simple instructions that are executed in a sequence. Each time the instructions are repeated in a loop. Each time through the loop is called an iteration.

### ASSESSMENTS OF UNDERSTANDING:

**Complex Adaptive Systems**
What are four necessary characteristics of complex adaptive systems? [They are 1) made of many interacting parts or agents, 2) each agent follows its own rules, 3) emergent patterns can result from the interaction of agents and 4) hard to predict.]

**Modeling and Simulation**
Why are models useful? How can computer models be used to learn about the real world? What can be different about a model vs. the world?

**Computer Science**
What is an instruction? What is a loop? What is an iteration? What are the parts of the StarLogo Nova user interface?

# Day 2

## Introduction to StarLogo Nova and Building Flower Turtles

### PACING GUIDE

**Getting Started**
(Review)

Review of the previous day's lesson and concepts; connection to today's lesson. **5 min**

**Activity 1**
(Guided Practice)

Guided Tour of StarLogo Nova: Guided Tour and Observations and Ethical considerations concerning remixing and sharing. **20 min**

**Activity 2**
(Discovery/Creative)

Flower Turtles Challenge: Pair programming; new StarLogo Nova commands, and Flower Turtles Challenge with extension. **20 min**

**Wrap-Up**
(Reflection)

What does Flower Turtles have to do with Modeling and Simulation? **5 min**

### LEARNING OBJECTIVES: Students will. . .

**Complex Adaptive Systems**
Learn that in complex adaptive systems one type of interaction is that agents impact their environment. [LO7]

**Modeling and Simulation**
Create a model in which agents impact their environment. [LO8]

**Computer Science**
Get comfortable with the StarLogo Nova programming environment. [LO9]
Create a program containing simple instructions that are executed in a loop. [LO10]
Trace a program's execution. [LO11]
Change variables to alter turtle movement. Use randomness. [LO12]

**Mathematics**
Turn angles, random function, relative vs. absolute position, and heading. [LO13]

### ASSESSMENTS OF UNDERSTANDING:

**Complex Adaptive Systems**
Which characteristics of a complex adaptive system are seen in Flower Turtles? Is Flower Turtles a model of a complex adaptive system? Why or why not?

**Modeling and Simulation**
Is the pattern made by turtles repeatable? If I run the program again, will it produce the same drawing? Why or why not?

**Computer Science**
What variables were used in Flower Turtles? What is the difference between right turn 90 degrees vs. right turn random 90 degrees?

**Other**
Math: turn angles, random function, relative vs. absolute.

# Day 3

## Conditionals with Trailblazer and Bumper Turtles

### PACING GUIDE

**Getting Started**
(Review)

Review of the previous day's lesson and concepts; connection to today's lesson. **5 min**

**Activity 1**
(Guided Practice)

Trailblazer: Blazing a Trail and Comparing Solutions; and New CS Concepts: conditionals and Boolean. **20 min**

**Activity 2**
(Discovery/Creative)

Bumper Turtles Challenge: Introduce new StarLogo Nova commands and the Challenge. **20 min**

**Wrap-Up**
(Reflection)

What does Bumper Turtles have to do with Modeling and Simulation?
Is Bumper Turtles a model of a complex adaptive system? Why or why not? **5 min**

### LEARNING OBJECTIVES: Students will. . .

**Complex Adaptive Systems**
Learn that in complex adaptive systems one type of common interaction is that agents react to their environment. (LO14)

**Modeling and Simulation**
Create a simple model in which agents react to their environment. (LO15)

**Computer Science**
Learn CS concepts of booleans, logic, and conditionals. (LO18)
Use Boolean logic and conditional branching to implement agents that can react to their environment. (LO17)
Trace a program's execution. (LO16)
Compare solutions to Trailblazer using number of steps or number of instructions as a metric. (LO20)

**Other**
Practice Pair Programming and Iterative design, implement, and test cycle (LO19)

### ASSESSMENTS OF UNDERSTANDING:

**Complex Adaptive Systems**
Which characteristics of complex adaptive systems do you see in Bumper Turtles?

**Modeling and Simulation**
Give an example of how agents reacting to their environment may be used to represent a behavior in the real-world. In your own words, how can if/then logic be used in a computer model?

**Computer Science**
How would you assess which Trailblazer solution is the best?

**Other**
Logic: What is the difference between a series of if/then statements and nested if/then/else statements?

# Day 4

## Probability with Dice and Data and Colliding Turtles

### PACING GUIDE

**Getting Started**
(Review)

Review of the previous day's lesson and concepts; connection to today's lesson. **5 min**

**Activity 1**
(Guided Practice)

Probability with Dice and Data: "Chances Are" and "Wiggle Walk."**20 min**

**Activity 2**
(Discovery/Creative)

Colliding Turtles: New concepts and the Challenge (adding a behavior that takes place upon collision).**20 min**

**Wrap-Up**
(Reflection)

What could collisions represent in the real world? How does probability play a role in modeling and simulation? **5 min**

### LEARNING OBJECTIVES: Students will. . .

**Complex Adaptive Systems**
Learn that in complex adaptive systems one type of common interaction is of agents interacting with other agents. (LO21)

**Modeling and Simulation**
Create a simple model in which agents interact with other agents upon collision. (LO22)
Use a random function to implement probabilistic outcomes/ behaviors. (LO23)
Learn the concept of random numbers. (LO24)

**Computer Science**
Understand the concept of collisions and bounding boxes around objects. (LO25)

**Other**
Learn mathematical concepts: probability; distributions resulting from 1 die and 2 dice throws. (LO26)

### ASSESSMENTS OF UNDERSTANDING:

**Complex Adaptive Systems**
Which characteristics of complex adaptive systems can you identify in Colliding turtles?

**Modeling and Simulation**
Give an example of how agents interacting with other agents may be used to represent something in the real world. How does using probability impact the outcome when running simulations?

**Computer Science**
Identify variables used in Colliding Turtles.

**Other**
What is the difference in the outcome between "right turn random 90 degrees" and "right turn random 90 degrees followed by a left turn random 90 degrees"?

# Day 5

## Modeling the Spread of Disease

### PACING GUIDE

**Getting Started**
(Review)

Review of the previous day's lesson and concepts; connection to today's lesson. **5 min**

**Activity 1**
(New Learning)

Introduction to Epidemiology: Methicillin resistant Staphylococcus Aureus and modeling the spread of disease as a complex adaptive system phenomenon. 1**0 min**

**Activity 2**
(Guided Practice / Discovery)

Modeling the Spread of Disease: Altering colliding turtles to make an epidemic model; adding a slider for transmission rate; customizing the model by adding another factor (such as recovery rate). **30 min**

**Wrap-Up**
(Reflection)

What can this model tell you? Can it be trusted to tell us anything about the real world? What other things move through a population like a disease? **5 min**

### LEARNING OBJECTIVES: Students will. . .

**Complex Adaptive Systems**
Learn about epidemiology and how epidemics can be modeled as complex adaptive systems. (LO27)

**Modeling and Simulation**
Create the contagion model then use the contagion model as an experimental test bed. Conduct experiments, collect and analyze data. (LO28)

**Computer Science**
Learn new CS concepts: procedures and variables. (LO29)
Create and use sliders to set variables and initial conditions. (LO30)
Create procedures and call procedures. (LO31)

**Other**
Use the random function to simulate probabilistic outcomes. (LO32)

### ASSESSMENTS OF UNDERSTANDING:

**Complex Adaptive Systems**
Which characteristics of complex adaptive systems can you identify in the contagion model?

**Modeling and Simulation**
What are other things that spread through a population like a disease? How does using probability impact the outcome when running simulations? What assumptions are made in this contagion model?

**Computer Science**
How would you change the model to one in which sick agents get healthy again after colliding with a healthy agent?

**Other**
If time allows, discuss how model might be modified to reflect real world.

# Day 6

## Adding Instrumentation to Your Model and Running Experiments

### PACING GUIDE

**Getting Started**
(Review)

Review of the previous day's lesson and concepts; connection to today's lesson. **5 min**

**Activity 1**
(Guided Practice)

Add instrumentation to your model: review qualitative vs. quantitative data, and add a line graph. Then test your model.."**10 min**

**Activity 2**
(Guided Practice / Discovery)

Running experiments: designing experiments, running experiments, and collecting and analyzing data output from models. Introduce the concept of parameter sweeps. **30 min**

**Wrap-Up**
(Reflection)

What patterns did you uncover?
What conditions led to each pattern?
Is the result of a simulation always the same? **5 min**

### LEARNING OBJECTIVES: Students will. . .

**Complex Adaptive Systems**
Students will understand that computer models are used by scientists to study and understand real-world problems. (LO38)

**Modeling and Simulation**
Learn how to instrument a model with a line graph. (LO34)
Learn experimental design using a computer model. (LO35)
Conduct experiments using a model as an experimental testbed. (LO36)
Record and analyze results. (LO37)

**Computer Science**
Learn how computer science is integrated into science through scientific inquiry using computer models and simulation.

**Other**
Learn the difference between qualitative vs. quantitative results. (LO33)
Ask questions that arise from observations of your model's behavior. (SEP)

### ASSESSMENTS OF UNDERSTANDING:

**Complex Adaptive Systems**
Which characteristics of complex adaptive systems can you identify in your epidemic model?

**Modeling and Simulation**
What is included and what is missing from your model? Name two things that happen in real life that are not part of this model.

**Computer Science**
How might you use computer science to investigate whether a new fad will spread through your school?

**Other**
If time allows, discuss how the model might be modified to help you study a real world disease.