Bug Dynamics: The Logistic Map; Learning Objectives & Goals

Learning goal: Students will experience some key properties of nonlinear systems, discrete mappings and displaying data, in particular, how to identify bifurcations and chaos.

Learning objective
Science content objective:

- Students will understand how the time dependence of a population is affected by the population's interactions with its environment, in particular the interdependence of living organisms and their interactions with the components of a biosphere.

Science model/computation objectives:

- Students will learn how to develop a simple model of a system that can then be computed and used to create simulated bug population data. Characteristics in the simulated data can then be compared to observed phenomena.
- Students will develop computational scientific thinking skills by developing a model with successively higher levels of complexity, and by using visualization to uncover simplicity within the complex behaviors found in the model's output.
- Students will learn how mathematical models can be used to describe the relationships among data points.
- Students will understand that computer models can be used to explore and develop scientific concepts.

Scientific skills objective:

- Students will practice the following scientific skills:
    - Graphing (visualizing) data
    - Describing trends revealed by data
    - Proportional and nonproportional (nonlinear) reasoning
    - Understanding discrete, in contrast to continuous, processes
    - Test (confirm, modify or reject) hypothesis using analyzed data

Products
At the end of this module students will produce and evaluate 1) a list of system statements presented, 2) concept maps, 3) mathematical equations and 4) a mathematical model implemented in one of three software applications. Each product is a different view of the data and phenomenon.

Where's Computational Scientific Thinking

Students will learn how to develop abstract representations of growth properties of a population rather than focusing on individual members.

In this lesson, students will devise and explore a model for which there is no obvious algebraic solution, yet be able to determine its predictions via computation of a recursion relation.

Students will learn that the computer can be used as an experimental lab to see what happens in nature, i.e., when the growth rate is increased.

Students will discover that mathematical models can provide understanding of various types of periodic and chaotic behaviors that are not at all obvious from the start.

Intuition Development

Students should be able to develop an understanding that the model will produce oscillations, and thus build intuition and insight. Understanding that simple mathematics can underlie some very complicated behavior is insightful. Bifurcation diagrams of a similar sort as developed in the module occur for many nonlinear systems.

Chaos itself occurs in many natural systems, with turbulence in water being a common example. In all cases of chaos, the mathematical description of the system must be nonlinear (a quadratic relation between present and future populations) and there must be three or more variable or parameters (Poincare'–Bendixson theorem).