ATTACK of the APHIDS!

Honors Pre-Calculus
Ms. Jasmine Frantz

Description

This lesson/project explores exponential and logistic models by investigating population growth (both uninhibited and inhibited) of Aphids, a common plant pest.

Packet Contents

Introduction

Why is it important to study aphids? Our world is a hungry world with an increasing population and a limited amount of farmland. Some statistics even estimate that our world population will by 9.6 billion by 2050! This is ton of people who will need to eat. Despite the use of modern crop protection, 20-40% (dependent on crop type) of potential food production is lost every year due to pests, aphids being one of these many pests. Can we control them? Can we increase crop yields to feed an ever growing population? Can we ensure food safety?

This lesson/project allows students to work in groups of 2-3 to play the role of a soybean grower in order to examine the population growth of Aphids, a common plant pest. Aphids feed on many different plants including both ornamental plants and crop plants (potatoes, cereals, sugar beets, citrus plants, and soybeans). As they feed, they transmit a virus to the plants which often results in lowering the plant yield as well as often killing the plant. Many aphids reproduce asexually resulting in rapid population growth on a single plant. In this lesson/project, we will look at both uninhibited population growth (exponential) and inhibited population growth (logistic).

Curriculum Alignment

Pre-Calculus North Carolina Course of Study Objectives:

2.01 Use functions (polynomial, power, rational, **exponential, logarithmic, logistic**, piecewise-defined, and greatest integer) to model and solve problems; justify results.

a) Solve using graphs and algebraic properties.

b) Interpret the constants, coefficients, and bases in the context of the problem.

2.03 For sets of data, create and use calculator-generated models of linear, polynomial, **exponential**, trigonometric, power, **logistic**, and logarithmic functions.

a) Interpret the constants, coefficients, and bases in the context of the data.

b) Check models for goodness-of-fit; use the most appropriate model to draw conclusions or make predictions.

Objectives

Student will be able to:

- Make a scatterplot of data.
- Build exponential and logistic models from data using computer technologies.
- Interpret values of the models (initial value, growth rate, capacity value) in context.
- Describe the importance of controlling pests like aphids.
- Describe the concept of carrying capacity and explain possible factors that influence a population's carrying capacity.
- Extrapolate future population numbers from given data using mathematical models.
- Explain why a particular mathematical model fits a given data set best.

Time & Location

This lesson/project can be completed in 2-3 class periods (90 minutes each period) depending on the time you want to allow students to work on the project inside and outside of class time. The project can be done in either a computer lab or classroom that has laptops available for use.

Teacher Materials

- Aphid Project Worksheet
- Project Introduction Slideshow
- Aphid Project Worksheet Suggested Answers
- Aphid Project Rubric
- Fake Leaf template for data collection
- Resource Padlet
- Computer and projector

Student Materials

- Aphid Project Worksheet
- Aphid Project Rubric
- Fake Leaves for data collection
- Graphing calculator, excel, or other data regression capable technology
- Computer/laptop (internet access) - at least one per group
- Paper and pencil

- Materials for final product (depends on choice of group)

Safety
Ensure that students are aware of rules for safe computer use.

Student Prior Knowledge
Students need to have prior knowledge of:
- Exponential Functions (the basics: how to graph and how to solve exponential equations)
- Exponent and logarithm properties
- How to create scatterplots using computer technology (graphing calculator, excel, etc)
- How to model data using graphing calculator or computer technology

This project is designed to review and build on topics from Math 1 and Math 3 (including exponential models, solving exponential functions with logarithms, and basic data regression techniques). In the day (or days depending on the teacher's time allotment) prior to this project, the teacher should have reviewed properties of logarithms, expanding/condensing logarithms, and how to solve exponential functions using logarithms. The majority of the time should be spent introducing Euler's number (e) and the natural logarithm. In addition to reviewing and building on these topics, this project is meant to introduce and develop the logistic growth model.

Teacher Preparations
In preparation for this lesson, the teacher needs to
- Make copies of the Aphid Project Worksheet (1 per student), Aphid Project Rubric (1 per student), and Fake Leaves (1 per group)
- Decide whether to allow students to choose groups or construct the groups yourself
- Review information on aphids
- Review resource links on the Resource Page
- Review and familiarize self with the Aphid Project Worksheet, the suggested answers, and the Aphid Project Rubric

Activities
Day 1 (Introduction and Student Work Day)
Warm-up - 10 minutes
Before students walk into class, the teacher will display the warm up for the students to complete (included in the Project Introduction Slideshow). After about 5 minutes, hold a class discussion to discuss student answers. Be sure students remember how to solve exponential functions using logarithms. Ask students if they have ever heard of an aphid before and be sure to discuss what aphids are in general.

Introduction to Project - 30 minutes
The teacher continues with the Project Introduction Slideshow. Explain to students that they will be examining an aphid population on a single soybean plant. Be sure to discuss the statistics regarding crop safety and the growing world population. Possible discussion questions include, but are not limited to the following:

- What is food safety? (in regards to defending against pests, funguses, weather, weeds, etc)
- What sort of things threaten crops?
- Why is important to ensure food safety?
- What does 9 billion people by 2050 mean? How will this impact their lives?
- How do growers keep food safe?

After discussing the motivation behind studying aphids, the teacher will tell the students that in groups of 2-3 they are going to take on the role of a soybean grower. Pass out the Aphid Project Worksheet and walk through the project description either reading or having volunteers read each part. Be sure to stop and ask if students have any questions. Then pass out the rubric and read over it with the students as well. After clearing up any remaining questions instruct the students to get in groups of 2-3 (or assign student groups).

Work Time - 50 minutes

After introducing the project, the teacher will instruct students to begin working. While students are working, the teacher will monitor and assist students as necessary. If a common problem or question arises, pause the work time and bring the class together to address it. Before students leave assign the video on Logistic Growth for students to watch for homework. In addition to watching the video, students should take notes and prepare questions for the next class period. This video will prepare them for Part 3 of the project.

Day 2 (Group Conferences and Student Work Time)

While students are working on the project, the teacher will continue to monitor and assist students as needed. During this class period, the teacher will conference with each group. The following should be addressed with each group:

- What have you completed?
- What is your goal to finish by the end of class today?
- What questions do you have?
- Do you have any questions on the Logistic Growth Model?

Day 3 (Optional Student Work Day)

If time permits in the course pacing guide, the teacher may elect to allow students to have a third work day.

It is up to the teacher's discretion as to the amount of time the groups have to work on their project outside of class. A week of outside class time is recommended.

Assessment

The teacher will collect the final product (form of the product has been left open for students to be creative) and grade according to rubric. The final product must contain all four parts and include answers/responses to each question/prompt. Special attention should be made to Parts 1-3 in order to identify mathematical errors or misconceptions. See the materials below for assistance.

- Aphid Project Suggested Answers
- Aphid Project Rubric

Critical Vocabulary

- The **uninhibited growth model** describes situations such that an amount *A* varies with time *t* according to the model $A(t) = A_0 e^{kt}$ where A_0 is the initial amount and k is the growth rate (*k > 0)*.
- The **logistic model** describes situations where the growth or decay of the dependent variable is limited. In a logistic model, the population *P* after time *t* is given by the function $P(t) = \frac{c}{1+Ae^{-kt}}$, where *A*, *k,* and *c* are constants with *A > 0* and *c > 0*. The model is a growth model if *K > 0*; the model is decay if *K < 0*. A is defined by $A = \frac{(c-A_0)}{A_0}$.
- The **carrying capacity (c)** is the amount that a population approaches over time.
- The **inflection point** is the point on the graph where the graph changes from being curved upward to curved downward for growth functions and the point where the graph changes from being curved downward to curved upward for decay functions.

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