5E STEM Modeling Using Logistic Growth

(2 to 3 days)

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SUBJECT/GRADE LEVEL

Subject Area: Pre-Calculus, AP Biology, Environmental Science

Grade Level: 11th and 12th grade

Materials

- Computer
- DESMOS interactive activity
- Calculator (graphing preferred) IT-30 will work
- Plan for a class of 30 students
- 5 printed images of mold on various surfaces
- Tape or magnets to display images
- Gallery Walk Recording Sheet

STANDARDS

Next Generation Science Standards

- HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Mathematics Standards | Common Core State Standards

- MP.4: Model with mathematics. Students will apply mathematical models to solve problems arising in everyday life, society, and the workplace.
- F-IF.B.4: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. (Focus on increasing/decreasing intervals, asymptotes, and maximums/minimums in the context of population).
- HSS.ID.B.6: Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
    - HSS.ID.B.6.a: Fit a function to the data; use functions fitted to data to solve problems in

the context of the data. Use given functions or choose a function suggested by the context. (Specifically, students will consider the logistic function as a fit).

LESSON OBJECTIVE(S)

Students will be able to:

- Explain the difference between logistic growth and exponential growth functions
- Identify and interpret key parameters of logistic growth (carrying capacity, c; growth rate, k; initial condition, B) within the context of a problem
- Evaluate logistic growth functions
- Create logistic growth equations (models) from word problems and data
- Apply logistic growth models to explain real-world scenarios

CAREER CONNECTION(S)

Mentor Background: Mark Ginsberg is the ERDC mentor. He has a bachelors in physics, masters in mathematics and doctorate in mechanical engineering. His past research includes enhanced biological contaminant protection for critical infrastructure. His work on air contamination has inspired this lesson plan on logistic growth using real-world examples.

STEM Careers: This should link to possible careers associated with mechanical engineering, medical research, chemistry, structural engineering can be linked with modeling data using logistic growth.

ENGAGEMENT

Brief Description: Students will participate in a Mold Growth Gallery Walk. They will observe visual examples of mold growing on different surfaces in order to identify patterns, generate questions, and build curiosity about how mold grows under different conditions. This will help students prepare to model mold growth using a logistic function.

Procedures:

This part should take approximately 8 - 10 minutes to complete.

Five printed images showing mold growing on various surfaces will be displayed around the classroom. Students will work in groups of three or four and walk around the room to examine each image carefully. They will spend one minute at each station, writing down one observation about what they see and one question that makes them wonder. Observations and questions will be recorded on the Mold Gallery Walk Recording Sheet.

After all groups have finished viewing the images, the class will gather for a short discussion to share their thoughts. Students will discuss the patterns they observed, identify which surface had the most mold and explore possible reasons for it, and consider whether mold can grow without limits.

This discussion will lead into introducing the concept that mold growth follows a predictable S-shaped pattern instead of growing endlessly at an exponential rate. Since mold depends on available surface area and resources, it eventually reaches a point where its growth slows and levels off.

EXPLORATION

Brief Description: Students will use DESMOS to create a logistic model for mold growth on different substrates. The data was pulled from Mold Growth Modeling of Building Structures Using Sensitivity Classes of Materials by Tuomo Ojanen. Students will use sliders to adjust the parameters of the equation to create a curve of best fit. Through this activity Students should be able to see how the three different parameters affect the model.

Procedures:
This activity should take approximately 40 minutes to complete.

What students will need: mold growth on different building materials worksheet and a computer for the interactive DESMOS graph.

This activity guides students through modeling mold growth using logistic functions within a DESMOS environment. The process is broken down into structured parts, encouraging collaboration, modeling, and external research.

Activity Overview and Implementation

Preparation and Background

1. **Reading and Discussion:** Students will begin by reading the provided activity instructions, which include a linked article from the EPA regarding mold.
2. **Teacher-Led Discussion:** Following the reading of the first page, the teacher should facilitate a brief discussion. This discussion should focus on the key concepts presented in the article, the provided data, and the importance of the mold growth index as background information for the modeling activity.

Part A: Data Selection and Group Setup

- **Group Work:** Students should work in groups of 2-4.
- **Data Selection:** Using the DESMOS activity, groups will select four distinct data sets from the 10 provided. These data sets illustrate mold growth on different building materials under controlled conditions (22°C and 97% relative humidity).

- **Teacher Guidance:** The teacher should monitor groups to ensure they select four different building materials for their analysis.

Part B: Logistic Modeling in DESMOS

- **Modeling with Sliders:** Students will use pre-programmed sliders within DESMOS to manipulate and graph a logistic growth function. The goal is to manually adjust the sliders until the function accurately models the selected data sets.
- **Equation Recording:** For each of the four data sets modeled, students must record the resulting logistic growth equation.
- **Teacher Guidance:** Teachers should ensure students are proficient in navigating the DESMOS interface (opening folders, toggling data visibility, and adjusting sliders). **It is highly recommended that the teacher completes the activity beforehand.**

Part C: Prediction and Interpretation

- **Model Application:** Students will use their created models to predict specific values.
- **Contextual Explanation:** Students must explain the meaning of these predicted values within the context of the mold growth data.
- **Class Discussion:** Teachers can facilitate a discussion where groups share and compare their equations and predicted values. This provides an opportunity for students to analyze why different groups might have slight variations in their modeling results.

Part D: External Factors and Research

- **Research Task:** Students will research how factors such as relative humidity and temperature influence mold growth.
- **Model Analysis:** Students will discuss how these external factors might affect the specific models they created.
- **Teacher Guidance:**
    - Reinforce the importance of using reliable sources for research.
    - The teacher may provide a list of recommended resources.
    - If necessary, reliable articles can be modified using AI tools (such as Flint's AI text leveler) to match the appropriate reading level for students.

Optional Extension: Function Comparison

- Students will compare and contrast the characteristics of logistic and exponential functions.
- Students will then explain why exponential growth models are generally unrealistic for representing most real-world data scenarios.

EXPLANATION

Brief Description: This guided lesson introduces students to the logistic growth model, focusing on its application in real-world scenarios.

Lesson Flow and Activities

1. Video Analysis and Guided Notes (Warm-up and Introduction) Students will watch a 3Blue1Brown video that analyzes how the spread of COVID-19 in 2020 could be modeled using logistic growth. The video has been integrated into an Edpuzzle format, where students will respond to embedded questions. Students will also answer similar questions on their corresponding guided notes worksheet.

2. Prior Knowledge Review Before delving into the main lesson, students will complete a review of prerequisite skills from Algebra 1 and Algebra 2. This review is designed to activate prior knowledge necessary for understanding the logistic growth concepts presented in the notes.

3. Direct Instruction: Logistic Growth Formula The lesson transitions into structured note-taking. Students will examine the logistic growth formula and learn the meaning and significance of its various parameters.

4. Practice Problems The lesson concludes with four practice questions that require students to apply the logistic growth equation and model provided data.

Procedures:

This phase should take approximately 35-45 minutes, depending on how structured you need to be with the examples.

What students will need: guided note worksheet

For teachers: guided notes KEY

This lesson introduces students to logistic growth functions, building upon their prior knowledge of exponential equations. The lesson incorporates a video warm-up, a review of prerequisite skills, a direct instruction segment on logistic growth parameters, and guided practice problems.

Lesson Components:

1. Warm-up: Edpuzzle Video Analysis

- **Activity:** The lesson begins with a warm-up featuring a 3Blue1Brown video, adapted into an Edpuzzle activity with four embedded questions. Two questions are open-ended, and two are multiple-choice.
- **Teacher Role:** During this time, the teacher should actively circulate to ensure students are engaged with the Edpuzzle video. Special attention should be given to reviewing student responses to the open-ended questions.

- **Alternative (Non-1:1 Environments):** If students do not have individual device access, the video can be shown to the entire class. Following each embedded question, facilitate a "Think-Pair-Share" activity to discuss student responses.

2. Prior Skills Review & Video Discussion

- **Activity:** Following the warm-up, students will complete a review of prior skills, specifically focusing on evaluating and solving exponential equations. These skills are foundational for understanding and constructing logistic growth models.
- **Teacher Role:** While students are working on the prior skills review, the teacher should quickly review the Edpuzzle responses. After the review activity, lead a brief class discussion to address any misconceptions that arose from the video.
- **Key Takeaways:** The discussion should emphasize two critical points:
    - The general algebraic equation for logistic growth.
    - The fundamental differences between logistic growth and exponential growth functions.

3. Introduction to Logistic Growth Equation Parameters

- **Activity:** The teacher will then formally introduce the logistic growth equation.
- **Teacher Role:** The teacher will explain each parameter within the equation (commonly denoted as c, B, and k) and clarify what each parameter represents in the context of real-world problems.

4. Guided Practice Problems

- **Activity:** The final segment of the lesson consists of four practice problems designed to apply the concepts learned. These problems are structured in an "I Do, You Do" format. The teacher will demonstrate the first example, and students will then work independently on a similar problem.
- **Alternative:** Alternatively, students can work on all four problems in small groups of 2-4, checking their answers with the teacher or a provided answer key.
- **Teacher Role:** As students work through the practice problems, the teacher should continue to circulate, providing support, addressing individual questions, and identifying any lingering misconceptions.

ELABORATE

Brief Description: This worksheet is designed to reinforce concepts covered during the "Explain Phase" guided notes. Students will apply their understanding of data visualization and modeling to a new data set.

Procedures:
This piece should take approximately 20-30 minutes to complete.

Students will need: modeling worksheet and graphing calculator

For teacher: elaborate KEY

This activity involves students independently completing two distinct problems, with the option to consult peers for assistance. The goal is to develop and analyze mathematical models based on provided data sets.

Student Tasks

For each problem, students will follow a structured process:

1. **Data Visualization and Analysis:**
    - Plot the provided data on a scatter plot.
    - Analyze the plot and describe the overall shape or trend of the data.
2. **Manual Model Creation:**
    - Based on the observed data shape, construct a mathematical model (by hand) that fits the data.
    - Explain the meaning of each parameter in the model within the context of the problem.
3. **Model Justification and Error Analysis:**
    - Compare the manually created model against the actual data points.
    - Justify the model's validity and discuss the potential sources of error.
4. **Logistic Regression Comparison:**
    - Perform a logistic regression analysis on the data.
    - Compare the results of the logistic regression to the student's manually created model, explaining any differences observed.

Implementation Guidelines

This activity can be utilized flexibly, either as a take-home practice assignment or an in-class activity.

In-Class Implementation: If conducted in class, the teacher should actively circulate among students. The teacher's role is to provide guidance and redirect students if they deviate from the required steps, ensuring they stay focused on the objectives of the problems.

EVALUATION

Brief Description: This lesson uses a Choice Board Exit Ticket to engage students with different learning preferences and deepen their understanding of logistic growth. Students select one of three options: a problem-solving scenario, a multiple-choice quiz, or a reflection prompt to demonstrate their knowledge of logistic growth.

Procedure:

This part should take approximately 10 - 15 minutes to complete.

Students will demonstrate their understanding of logistic growth by choosing one of three options:

- **Option 1: Problem Solving Scenario – Foot Fungus Spread**
  Analyze the spread of a contagious foot fungus among 400 athletes using a logistic growth model. Answer questions about carrying capacity, initial infection, growth parameters, and predict infections after 10 days.

- **Option 2: Multiple Choice Quiz – Basement Mold Growth**
  Answer multiple-choice questions based on a logistic growth equation modeling mold growth on a basement wall, including carrying capacity, initial mold area, and growth patterns.

- **Option 3: Reflection Prompt**
  Describe two other real-world situations where logistic growth applies and explain why the model fits each.

REFERENCES

- Baugh, Sue L. “Logistic Function” *Britannica*, January 2025. https://www.britannica.com/science/logistic-function. Accessed June 20 2025.
- Ojanen, Tuomo, et al. "Mold Growth Modeling of Building Structures Using Sensitivity Classes of Materials". ASHRAE, 2010.