STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

STEM Unit Title	**"Excel"ing After the Apocalypse**
Economic Cluster	Agricultural Engineering, Environmental Engineering, Statistics, Civil Engineering, Computer Science, Biological Engineering, Data Analysis
Targeted Grades	10-12
STEM Disciplines	Math, Technology, Science, and Engineering
Non-STEM Disciplines	Social Sciences, English-Language Arts

Section I: STEM Unit Overview

Unit Overview

Congratulations! You are one of the chosen few! The challenge: keep surviving! You are being sent to one of the government designed pods. Everyone in the biosphere has been thoroughly screened and their job assigned. You have been assigned to the civil engineering team and must determine how the land will be divided between housing and farming in order to best sustain the population that will have to live and grow inside the biosphere. Your job will be to design models in order to analyze population growth, carrying capacity, growth rate, and mortality rate to help determine the best way to divide land and resources and control population growth within the sphere. Good luck! The future of the human race depends on you!

Essential Question

How can data-base spread sheets (i.e. Excel) be used to run a simulation to assess population growth over time?

Enduring Understanding

1. Students will be able to create and run a simulation comparing population to various variables and constants.
2. Students will understand carrying capacity and how it is affected by certain variables inside biomes.
3. Students will be able to identify exponential growth and decay functions; create exponential growth and decay equations and graphs, based on authentic scenarios; and apply knowledge to proposed problem situations.

Engineering Design Challenge

Your task is to design a biosphere to preserve human life after the apocalypse. You will develop computer simulations in order to predict the performance of different designs. The land inside the biosphere will be partitioned into areas for housing and farming; your goal is to grow and support the largest possible population by the time it will be safe to go outside.

You will undergo training in biology, mathematics, and computer science, and combine your skills to complete your mission. You will study biological concepts of population growth and decay. You will study a mathematical model for the population growth inside the biosphere, then, develop Excel spreadsheet simulations. You will consider the logistical growth model, which involves two important parameters: the carrying capacity and the growth rate. These parameters depend on your design choices, which then affect the population, predicted by the model. Your spreadsheets will generate data that you must analyze in order to draw conclusions. You will use plots to visualize and present your data, and explain how they support your conclusions.

How many human lives can be taken safely into our future? Perform your task poorly, and humanity is doomed. Do your best to Excel After the Apocalypse!

Time and Activity Overview

Day	Time Allotment	Actvities
1	40-50 minutes	Pre-Test (Part I); read a science article or some science article
2	40-50 minutes	Pre-Test (Part II)and Mathematics Overview
3	40-50 minutes	Mathematics Overview
4	40-50 minutes	Biological Equilibrium within Ecosystems
5	40-50 minutes	Limiting Factors on Population Carrying Capacity

6	40-50 minutes	Building Excel Skills through Guided Templates
7	40-50 minutes	Building Excel Skills through Guided Templates
8	40-50 minutes	Building Excel Skills through Guided Templates
9	40-50 minutes	Building Excel Skills through Guided Templates
10	40-50 minutes	Building Excel Skills through Guided Templates
11	40-50 minutes	Building Excel Skills through Guided Templates
12	40-50 minutes	Presentation Preparation of Results of Data
13	40-50 minutes	Presentation Preparation of Results of Data
14	40-50 minutes	Presentations
15	40-50 minutes	Presentations and Post Test Part I
16	40-50 minutes	Post Test Part II

Academic Content Standards

Pre-requisite Knowledge & Skill

Grades 6-8, and High School (Life Science (LS), Earth and Space Science (ESS), Physical Science (PS))
7-8th grade: (LS) Order and Organization
Systems can exchange energy and/or matter when interactions occur within systems and between systems. Systems cycle matter and energy in observable and predictable patterns. Cycles and Patterns of Earth and the Moon Conservation of Mass and Energy Cycles of Matter and Flow of Energy 8 Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of the Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.
6-8th grade: (LS) Physical and Behavioral Traits of Living Things
Changes in environmental conditions can affect how beneficial a trait will be for survival and reproductive success of an individual or an entire species.
6-8th grade: (LS) Basic Needs of Living Things
Changes in environmental conditions can affect how beneficial a trait will be for survival and reproductive success of an individual or an entire species. In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors.
6th-8th grade: (ESS) The Atmosphere
Thermal energy transfers in the atmosphere, air currents and global climate patterns
6th-8th grade: (LS) Interaction Within Habitats
Matter is transferred continuously between one organism to another and between organisms and their physical environment.
6th-8th grade (ESS) Earth's Resources
The formation of coal, oil and gas, kinetic and potential energy, thermal energy, energy conservation, energy transfer (includes renewable energy systems) and additional examination of nonrenewable resources are studied. Common and practical uses of soil, rock and minerals (geologic resources), biogeochemical cycles, global climate patterns and interactions between the spheres of Earth (Earth Systems) are found.

6th-8th grade: (LS) Behavior, Growth, and Changes
These observations will build to a description and understanding of the biological mechanisms involved in ensuring that offspring resemble their parents. Cell Theory will be introduced which will explore how cells come from pre-existing cells and new cells will have the genetic information of the old cells. The details of reproduction will be outlined. Diversity of species will be explored in greater detail. The study of Modern Cell Theory and rock formation is required (Earth and Space Science). The structure and organization of organisms and the necessity of reproduction for the continuation of the species will be detailed. The reproduction of organisms will explain how traits are transferred from one generation to the next.
6th-8th grade: (LS) Earth's Living History
Organisms that survive pass on their traits to future generations. Climate, rock record and geologic periods are explored in Earth and Space Science
High School: (LS) Earth's Living History
The concepts of evolution and cell biology are explored.

6th – 8th grade: (LS) Interconnections within Ecosystems
The importance of biodiversity within an ecosystem is explored.

Course Specific Knowledge
High School: Science Inquiry and Application (grades 9-12)
Student should already have been actively applying these standards
- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise explanations and models using logic and evidence (critical thinking)
- Recognize and analyze explanations and models

• Communicate and support a scientific argument.

High School: Physical Science
Study of Matter (collecting data and construction of a decay curve)
• Phase changes can be represented by graphing the temperature of a sample vs. the time it has been heated. Investigations must include collecting data during heating, cooling and solid-liquid- solid phase changes.
• For any radioisotope, the half-life is unique and constant. Graphs can be constructed that show the amount of a radioisotope that remains as a function of time and can be interpreted to determine the value of the half-life.
Forces and Motion (related to graphing and interpretation of graphs and use of computer modeling)
• Objects that move with constant velocity and have no acceleration form a straight line (not necessarily horizontal) on a position vs. time graph.
• Objects that are at rest will form a straight horizontal line on a position vs. time graph.
• Objects that are accelerating will show a curved line on a position vs. time graph.
• Velocity can be calculated by determining the slope of a position vs. time graph. Positive slopes on position vs. time graphs indicate motion in a positive direction.
• Negative slopes on position vs. time graphs indicate motion in a negative direction.
• Computer graphing programs or graphing calculators can be used so more time can be spent on graph interpretation and analysis.

High School: Psychology
National Standards for High School Psychology Curricula
Perspectives in Psychological Science
Content Standard 3: Basic concepts of data analysis
• 3.4 Interpret graphical representations of data as used in both quantitative and qualitative methods
• 3.5 Explain other statistical concepts, such as statistical significance and effect size
• 3.6 Explain how validity and reliability of observations and measurements relate to data analysis

Ohio New Learning Standards
Grade 8, and High School Mathematics Standards
General Mathematical Practices
Student should already have been actively applying these standards
• Make sense of problems and persevere in solving them.
• Reason abstractly and quantitatively.
• Construct viable arguments and critique the reasoning of others.
• Model with mathematics.
• Use appropriate tools strategically.
• Attend to precision.
• Look for and make use of structure.
• Look for and express regularity in repeated reasoning.
Grade 8:
Expressions and Equations
• Understand the connections between proportional relationships, lines, and linear equations.
• Analyze and solve linear equations and pairs of simultaneous linear equations.
Functions
• Define, evaluate, and compare functions.
• Use functions to model relationships between quantities.
Statistics and Probability
• Investigate patterns of association in bivariate data
High School: Algebra
Seeing Structure in expressions
• Interpret the structure of expressions
• Write expressions in equivalent forms to solve problems
Creating Expressions
• Create equations that describe numbers or relationships

Reasoning with Equations and Inequalities
• Solve equations and inequalities in one variable.
• Represent and solve equations and inequalities graphically

High School: Functions
Interpreting Functions
• Understand the concept of a function and use function notation
• Interpret functions that arise in applications in terms of the context
• Analyze functions using different representations

Building Functions
• Build a function that models a relationship between two quantities
• Build new functions from existing functions

Linear, Quadratic, and Exponential Models
• Construct and compare linear, quadratic, and exponential models and solve problems
• Interpret expressions for functions in terms of the situation they mode

Miscellaneous Background Knowledge
• Excel or Google Sheets
o Applications
o Writing basic formulas

• Power Point or Google Present
o Using pictures and text to develop a coherent presentation

• Word or Google Docs
o Writing and editing text

Ohio New Learning Standards
Social Studies Standards
Course: Economics and Financial Literacy
Topic: Fundamentals of Ecomomics
• People cannot have all the goods and services they want and, as a result, must choose some things and give up others.

Course: Contemporary World Issues
Topic: Sustainability
• Decisions about human activities made by individuals and societies have implications for both current and future generations, including intended and unintended consequences.
• Sustainability issues are interpreted and treated differently by people viewing them from various political, economic and cultural perspectives.

Course: World Geography
Topic: Spatial Thinking and Skills
• Properties and functions of geographic representations (e.g., maps, globes, graphs, diagrams, Internet-based mapping applications, geographic information systems, global positioning systems, remote sensing, and geographic visualizations) affect how they can be used to represent, analyze and interpret geographic patterns and processes.
• Geographic representations and geospatial technologies are used to investigate, analyze and communicate the results of geographic problem solving.

Topic: Environment and Society
• Human modifications of the physical environment in one place often lead to changes in other places (e.g., construction of a dam provides downstream flood control, construction of a city by-pass reduces commercial activity in the city center, implementation of dry farming techniques in a region leads to new transportation links and hubs).
• Human societies use a variety of strategies to adapt to the opportunities and constraints presented by the physical environment (e.g., farming in flood plains and terraced farming, building hydroelectric plants by waterfalls and constructing hydroelectric dams, using solar panels as heat source and using extra insulation to retain heat).
• Physical processes influence the formation and distribution of renewable, nonrenewable, and flow resources (e.g., tectonic activity plays a role in the formation and location of fossil fuels, erosion plays a role in the formation of sedimentary rocks, rainfall patterns affect regional drainage patterns).
• There are costs and benefits of using renewable, nonrenewable, and flow resources (e.g., availability, sustainability,

environmental impact, expense).
• Human interaction with the environment is affected by cultural characteristics (e.g., plowing with oxen or with tractors, development of water resources for industry or recreation, resource conservation or development).

Topic: Human Settlement
• Patterns of settlement change over time in terms of functions, sizes, and spatial patterns (e.g., a canal town becomes an industrial city, a rural area becomes a transportation hub, cities merge into a megalopolis).
• Urbanization provides opportunities and challenges for physical and human systems in cities and their surrounding regions (e.g., development of suburbs, loss of habitat, central markets, squatter settlements on city outskirts, regional specialization in services or products, creation of ethnic enclaves).

Add Standard	**Mathematics**
Grade/Conceptual Category	
Domain	Functions
Cluster	Interpreting Functions
Standards	(pg. 61): Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. b. Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as y=(1.02)t, y=(0.97)t, y=(1.01)12t, y=(1.2)t/10, and classify them as representing exponential growth or decay.

Add Standard	**English Language Arts**
Grade	9-10
Strand	
Topic	PRODUCTION AND DISTRIBUTION OF WRITING
Standard	(Pg. 54) 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience

Add Standard	English Language Arts	
Grade	9-10	
Strand		
Topic	PRESENTATION OF KNOWLEDGE AND IDEAS	
Standard	(pg. 60) 4. Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. 5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	

Add Standard	Social Studies	Ohio
Grade		
Theme		
Strand (pk-8 only)		
Topic		
Content Standard		

Add Standard	Science	Ohio
Grade		
Theme		
Topic		
Content Standard		

Add Standard	Science	Ohio
Strand	Biology	
Course Content	Diversity and Interdependence	
Content Elaboration	(pg. 293) Mathematical graphing and algebraic knowledge (at the high school level) must be used to explain concepts of carrying capacity and homeostasis within biomes. Use real-time data to investigate population changes that occur locally or regionally. Mathematical models can include exponential growth model and logistic growth model.	

Add Standard	Science	Ohio
Strand	Physical Science	
Course Content	Reaction of Matter	
Content Elaboration	(pg. 314) For any radioisotope, the half-life is unique and constant. Graphs can be constructed that show the amount of a radioisotope that remains as a function of time and can be interpreted to determine the value of the half-life. Half-life values are used in radioactive dating.	

Add Standard	Fine Arts	Ohio
Enduring Understanding		
Progress Points		
Grade Level		
Content Statement		

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

Performance Task, Projects	Excel Spreadsheet with Data Analysis Presentations Degree of Impact Cards (Appendix O)
Quizzes, Tests, Academic Prompts	Pre-Test (Appendices A, C) Post-Test (Appendices A,C) Linear vs Quadratic vs Exponential Worksheet (Appendix K) Food Web Simulation Lab Data Table (Appendix M)
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Food Simulation Lab Data Table (Appendix M) Observations during Group Work Class/Group Discussions
Student Self- Assessment	Lab Notebook (Appendix P) Presentation Rubric - Student Self Reflection (Appendix BB) Peer Evaluation Rubric (Appendix CC)

Technology Integration

ADISC Technology Integration Model*

	Type of Integration	Application(s) in this STEM Unit
A	Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners.	Miscrosoft Excel desmos.com
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Microsoft Excel
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Microsoft Excel https://www.theguardian.com/science/video/2013/apr/23/volunteers-life-mars-video https://www.youtube.com/watch?v=ysa5OBhXz-Q
S	Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships.	Microsoft Excel http://www.learner.org/courses/envsci/interactives/ecology/ecology.html
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Microsoft Excel Power point Presentation
	**The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*	

Career Connections

Career Description

Actuaries use mathematics, statistics, and financial theory to estimate the probability and likely economic cost of an event such as an accident or a natural disaster, and help businesses and clients develop policies that minimize the cost of that risk and uncertainty. Actuaries' work is essential to the insurance industry. http://www.bls.gov/ooh/math/actuaries.htm#tab-2

Agricultural engineers—also known as biological and agricultural engineers—work on a variety of activities, from aquaculture (raising food, such as fish, that thrive in water) to land farming to forestry; from developing biofuels to improving conservation; from planning animal environments to finding better ways to process food. In this lesson, agricultural engineers would work closely with the software modelers to refine the inputs and equations to ensure that the model was robust and accurately simulates the ecosystem. They would also work with urban and regional planners to plan and execute the land and crop allocation based on the simulations. http://www.bls.gov/ooh/architecture-and-engineering/agricultural-engineers.htm#tab-1

Civil engineers design, build, supervise, operate, and maintain construction projects and systems in the public and private sector, including roads, buildings, airports, tunnels, dams, bridges, and systems for water supply and sewage treatment. Civil engineers evaluate construction costs, government regulations, potential environmental hazards, and other factors in planning the stages of, and risk analysis for, a project. Many civil engineers work in design, construction, research, and education. In this lesson, civil engineers would work with urban and regional planners to analyze the data from the simulations, then plan and execute projects to prepare the area to execute the plans. http://www.bls.gov/ooh/architecture-and-engineering/civil-engineers.htm#tab-2

Data Analysis is a critical skill used in this lesson. There are many different career fields where data analysis is a critical skill set. Statisticians use statistical methods to collect, analyze and interpret data and help solve real-world problems in business, engineering, the sciences, or other fields. They decide what data are needed to answer specific questions or problems, determine methods for finding or collecting data, then design surveys or experiments or opinion polls to collect data. http://www.bls.gov/ooh/math/statisticians.htm#tab-2

Economists research and analyze economic issues using mathematical models and statistical techniques. Economists often study historical trends and use them to make forecasts for the future. http://www.bls.gov/ooh/life-physical-and-social-science/economists.htm#tab-2

Environmental engineers use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. They are involved in efforts to improve recycling, waste disposal, public health, and water and air pollution control. They also address global issues, such as unsafe drinking water, climate change, and environmental sustainability. In this lesson, environmental engineers would work closely with the software modelers to refine the inputs and equations to ensure that the model was robust and accurately simulates the ecosystem. http://www.bls.gov/ooh/architecture-and-engineering/environmental-engineers.htm#tab-2

Financial analysts provide guidance to businesses and individuals making investment decisions. They assess the performance of stocks, bonds, and other types of investments. They evaluate current and historical data, study economic and business trends and a company's financial statements to determine its value. http://www.bls.gov/ooh/business-and-financial/financial-analysts.htm#tab-2

Mathematicians use advanced mathematics to develop and understand mathematical principles, analyze data, and solve real-world problems. For example, they may work with chemists, materials scientists, and chemical engineers to analyze the effectiveness of new drugs, or work with industrial designers to study the aerodynamic characteristics of new automobiles. http://www.bls.gov/ooh/math/mathematicians.htm#tab-2

Operations research analysts help organizations solve problems and make better decisions. They examine information to figure out what is relevant to the problem and what methods should be used to analyze it, and then use statistical analysis or simulations to analyze information and develop practical solutions to business problems. For example, they may help decide how to organize products in supermarkets or help companies figure out the most effective way to ship and distribute products, or develop production schedules, or set prices. http://www.bls.gov/ooh/math/operations-research-analysts.htm

Population ecologists examine the environmental impact on population growth and development of various living organisms by investigating organisms' relationships with their environments. Population ecology is a sub-discipline of ecology that is concerned with factors like rainfall, urban growth, pollution and temperature that affect species' population size, density and health. Population ecologists monitor the current environmental situations, and they also research and model potential scenarios to investigate environmental characteristics of the past or to make environmental predictions. Population ecologists may explores species' interactions with one another and their physical environments, how their communities are organized and the flow of energy within the ecosystem. Ecology is an interdisciplinary field, incorporating studies in biology, horticulture, geology, entomology and sociology. In this lesson, population ecologists would work closely with the software modelers to refine the inputs and equations to ensure that the model was robust and accurately simulates the ecosystem.
http://learn.org/directory/category/Biological_Sciences/Evolutionary_Biology_and_Ecology/Population_Ecology.html

Software developers are the creative minds behind computer programs. Some develop the applications that allow people to do specific tasks on a computer or another device. Others develop the underlying systems that run the devices or that control networks. Software developers are in charge of the entire development process for a software program and start by asking how the customer plans to use the software. They design each piece of an application or a system and plan how the pieces will work together. Software developers must also determine user requirements that are unrelated to the functionality of software, such as the level of security and performance needs. They design the program and then give instructions to programmers, who write computer code and test it. If the program does not work as expected or if testers find it too difficult to use, software developers go back to the design process to fix the problems or improve the program. After the program is released to the customer, a developer may perform upgrades and maintenance. In this lesson, the software developers would have developed the model based on multiple inputs and formulas from various engineers and scientists. http://www.bls.gov/ooh/computer-and-information-technology/software-developers.htm#tab-2

Urban and regional planners develop land use plans and programs that help create communities, accommodate population growth, and revitalize physical facilities in towns, cities, counties, and metropolitan areas.Urban and regional planners identify community needs and develop short- and long-term solutions to develop and revitalize communities and areas. For example, planners examine ideas for proposed facilities, such as schools, to ensure that these facilities will meet the needs of a changing population. As an area grows or changes, planners help communities manage the related economic, social, and environmental issues, such as planning a new park, sheltering the homeless, and making the region more attractive to businesses. When beginning a project, planners work with public officials, community members, and other groups to identify community issues and goals. Using research and data analysis, and collaborating with interest groups, they formulate strategies to address issues and to meet goals. In this lesson, urban and regional planners would analyze the data from the simulations, then plan and execute land and crop allocation based on the simulations. http://www.bls.gov/ooh/life-physical-and-social-science/urban-and-regional-planners.htm#tab-2

Section II: STEM Lesson Plan

Title of Lesson — **Day 1 - Unit Introduction**

Time Required — 40-50 minutes

Materials

Computer hooked up to LCD projector
Pre-test (1 per student- Appendices A & B for Key)
Engineering Design Process hand out (1 per student- Appendix E)
Engineering Design Challenge (1 per student- Appendix G)
Background Story (Appendix F)
Discussion suggestions (1 Teacher copy- Appendix H)
Computer- preferably Chromebook (1 per student) or Life Under the Bubble Copies (1 Per student- Appendix I)

Objectives

1. Students will be able understand unit goal and perform pretest.
2. Students will look at real world application of living in a biome.

Instructional Process

1. Administer Pre-Test part 1 (Appendix A).

2. Share and discuss hook video Wanted: volunteers to spend life on Mars- video https://www.theguardian.com/science/video/2013/apr/23/volunteers-life-mars-video
(Note: if your school does not allow you to watch videos directly, you can download the video to a flash drive or to your computer using the video converter available at http://www.online –convert.com/. Select WMV as the target format and make sure Windows Media Player is installed on the computer you will be using to show the videos. If it is not, you can download it from Http://windows.microsoft.com/en-US/windows/products/windows-media-player)

3. Make transition between hook video and design challenge. Discuss people living in extreme conditions with minimal amounts of resources, etc. See suggested discussion questions:
a. What are some limiting factors for people to live?
b. What types of things are difficult for you to live on Mars?
c. What would you have to bring with you to even begin to survive
d. How would you be able to start a colony?
e. Social aspects, what difficulties would you run into?
f. What causes difficulties to live?
g. Relate it to the movie Martian and living in space.

4. Present design challenge problem (Appendix G) to hook students to the unit.

5. Discuss the "Pandora's box" of societal issue this scenario would create. Post the discussion suggestions on the board; have student discuss why these may be ethical issues of the activity. If you have time see if the students can come up with more issues that may apply. (Appendix H)

6. Pass out Engineering Design Process Handout (Appendix E). Explain the handout and quickly go over the process with the students. Explain to students they will be going through the process as we go through the unit.

7. Explain the lab notebook the students will be keeping throughout the unit and how they are to use it.

8. Give the students about 5 minutes to fill out first day of the lab notebook.(Appendix P)

9. Have students read Life Under the Bubble for homework) Print or use Chromebooks (http://discovermagazine.com/2010/oct/20-life-under-the-bubble). (Appendix I)

Differentiation

For students in need of accommodations for reading and or writing on the pre-test, verbal answers could be allowed in place of written answers for shot answers questions. Student could be paired up with an adult or peer who could read each question aloud.

Student could be given alternative reading assignment or guided notes with reading.

Assessments

Using the pretest as a diagnostic assessment of students' prior knowledge regarding the content. Modify this unit of instruction using the results of the Pre-Test as a guide.

Discussion questions formative assessment

Section II: STEM Lesson Plan

Title of Lesson

Days 2-3: Excel Knowledge Pre-Test and Mathematics Overview

Time Required

80-100 minutes

Materials

Pre-Test Part 2 (Appendices C,D) 1 per student
Computer with Internet access for every student
Linear vs Quadratic vs Exponential Worksheet (Appendix K) 1 per student

Objectives

1. Students will discuss key features of exponential functions using appropriate vocabulary.
2. Students will be able to distinguish between linear, quadratic and exponential functions in equation, table, and graph form.

Instructional Process

1. Discuss homework from Day 1 (Appendix I)

2. Administer the Pre-Test Part II. (Appendix C)

3. Once students are finished, have them get on desmos.com and play Polygraphs: Exponentials (Teacher instructions Appendix J)

4. After students have played 2-3 rounds, bring back to full class to discuss questions involving key vocabulary such as increasing, decreasing, intercepts, etc. *** This could be the end of day 2. Playing a few more games could start day 3. Encourage students to use good vocabulary while playing 1-2 more games.

5. Give students the worksheet over linear vs quadratic vs exponentials. Students should work in small groups to complete the worksheet. It is homework if not finished. (Appendix K)

6. Each day, give the students about 5 minutes to fill out that day's portion of the lab notebook. (Appendix P)

Differentiation

Students could play the desmos game in teams.
If needed, reduce the number of homework problems on the worksheet.

Assessments

Worksheet over linear vs quadratic vs exponential equations. (Appendix K)
Class Discussion
Lab Notebook Daily Entry (Appendix P)

Section II: STEM Lesson Plan

Title of Lesson

Day 4: Biological Equilibrium within Ecosystems

Time Required

40-50 minutes

Materials

Food Web Simulation Lab Handout (Appendix L) 1 per student
Dry erase marker 1 per student
White board 1 per student
Student computers (preferably 1 computer-1 student)
Projector for teacher use
Computer with Internet access for teacher use

Objectives

1. Students will be able to explain to another student the importance of maintaining biological equilibrium within a given ecosystem.

Instructional Process

1. Introduce topic by showing the video How Wolves Change Rivers
https://www.youtube.com/watch?v=ysa5OBhXz-Q

2. Have students record independently and then group brainstorm the answers to the following:
a. How did the overpopulation of deer impact the surrounding environment?
(Answer: reduced vegetation down to nearly nothing)
b. How did the introduction of wolves into the environment affect the ecosystem dynamics?
(Answer: killed deer, avoid parts of the park which began to regenerate, birds arrived, beavers, otters, muskrats, mice, hawks, weasels, etc. began to appear in the park)
c. Support the statement that maintaining biological equilibrium within an ecosystem is important for all life. Use examples from nature.
(Possible answer: Having equilibrium in the ecosystem is important for all life in order to ensure that one form of life does not take over the space and use the resources that are needed by others).

3. Show students the on-line simulation http://www.learner.org/courses/envsci/interactives/ecology/ecology.html

4. Pass out handout for Food Web Simulation Lab (Appendix L) and Food Web Simulation Lab Data Table (Appendix M)

5. Students will complete data table and answer questions.

6. Give the students about 5 minutes to fill out that day's portion of the lab notebook. (Appendix P)

Differentiation

There are two copies of the Food Web Simulation Lab: a) Task A b) Task B. Depending on the grouping for these tasks, you can give smaller tasks to certain individuals and more extension tasks to others. Suggested student structure is one student per one computer; however, if grouping is necessary then homogenous grouping is recommended.

Assessments

The assessment for this assignment could be a) the responses from students for the Food Web Simulation Lab Handout, b) the answer to the proposed question found under Instructional Process 3, c) responses to the group brainstorm questions in Instructional Process 2, and/or d) informal observations of student progress through given assignments.

Lab Notebook Daily Entry (Appendix P)

Section II: STEM Lesson Plan

Title of Lesson

Day 5: Limiting Factors on Population Carrying Capacity

Time Required

40-50 minutes

Materials

Degree of Impact cards (Appendix O) 1 per group
Large paper, multiple sheets per group
Markers, 1 package per group
Computer with Internet access

Objectives

1. Students will be able to identify at least three limiting factors that contribute to the carrying capacity of the human population.

2. Students will be able to explain the concept of carrying capacity to another student.

Instructional Process

1. Review food web conclusions from previous lesson.

2. Ask students to brainstorm independently about human population growth— how could an overpopulation of humans impact the environment?

3. Read article (Appendix N) about carrying capacity: http://www.populationeducation.org/content/what-carrying-capacity

4. Break students into groups and ask each group to come up with 5 environmental factors that may impact the carrying capacity of the human population
(Possible answers include: food availability, water, space, pollution, natural disasters, global warming, waste, etc.)

5. Ask students to write their ideas down on a large paper to share with the rest of the class.

6. Have students share their ideas with the rest of the group.

7. Pass out Degree of Impact cards (Appendix O)

8. Students will rank within their groups the degree of impact in order of most impactful to least impactful.

9. Students will share with the rest of the class and the class will vote on the order they think best.

10. Explain to students that all these “limiting factors” contribute to the carry capacity as a whole.

11. Give the students about 5 minutes to fill out that day's portion of the lab notebook. (Appendix P)

Differentiation

The suggested grouping for this activity is pairing high and low level students in the same group, as well as giving distinct discussion roles in order to ensure proper student discussion. These same groups can be used for the design challenge groups.

Assessments

Ask each student to explain the concept of carrying capacity to another student.

Students will identify at least three limiting factors of human carrying capacity on a scrap piece of paper as they exit the room.

Lab Notebook Daily Entry (Appendix P)

Section II: STEM Lesson Plan

Title of Lesson — **Days 6-11: Building Excel Skills using Guided Templates**

Time Required — 160-200 minutes

Materials

Computer (minimum of 1 per team, ideal 1 per student) with Excel (Google Sheets or Numbers may also be used)
Lab Notebook Daily Entry (# per student x # days doing project = #needed- Appendix P)
Engineering Design Challenge (Appendix G)
Part 1: Basic Excel Tutorial (1 per student- Appendix R & S for Key)
Part 2: Creating a Biosphere Population Simulator and Key (1 per student- Appendix T & U for Key)
Part 3: Design Optimization and Key (1 per student- Appendix V & W for Key)
Challenge Cards (# Team w/ challenge x #students in team = # needed- Appendix X)
Peer Evaluation Rubric (# Team x #students in team = # needed- Appendix C)

Objectives

1. Students will be able to demonstrate the basic Excel skills needed to create a program for the Engineering Challenge.

2. Students will create the simulation needed to complete the Engineering Design Challenge applying their knowledge of Limiting Factors on Population and Carrying Capacity.

Instructional Process

1. Go over instructions basic instructions for expectations and directions for the design challenge days.

2. Separate students into teams with students of similar Excel capabilities using the Excel Pre Test.

3. Using the information from the Excel Pretest, assign each team what starting point to begin with based on the team's current abilities. Use the following chart that shows the question correlation between the Excel Pretest and Engineering Design Challenge Part 1 "How long are we going to be trapped?" (Basic Excel Tutorial) below for assistance. If there is an advanced team of students who already understands Excel, skip Part 1 and assign Part 2 to that team.
Excel Concept Excel Pre-test Question Corresponding Basic Excel Tutorial Skill
Data Entry 1-2 Step 1-2
Simulate 3 Step 3-5
Visualize 4 Step 6

4. Handout the "Engineering Design Challenge Part 1 (Basic Excel Tutorial)" to each student in the team and inform the team which step or part to begin based on the team's skill level (1 per student- Appendix R & S for Key)

5. Students will work in their teams to create the Excel Templates following the given instructions.

6. Check and sign off on the team's progress when students/teams reach a checkpoint.

7. Explain and assign next Step or Part of the Design Challenge to team.

8. Based on the abilities of your class and teams the time it takes for each of the different parts of the Engineering Design Challenge will vary. When a team has mastered a part of the challenge, assign the next part the following recommended order:
a. Part 1: Basic Excel Tutorial (1 per student- Appendix R & S for Key)

b. Part 2: Creating a Biosphere Population Simulator and Key (1 per student- Appendix T & U for Key)
c. Part 3: Design Optimization and Key (1 per student- Appendix V & W for Key)

9. Listed below are the Challenge Cards (Appendix X) in order of approximately least to most difficult:
a. Smaller Land (Basic)
b. Two Food Types (Intermediate)
c. Three Food Types (Intermediate)
d. Water Resources (Intermediate)
e. Sudden Death (Advanced)
f. Foreign Trade (Highly Advanced)

The Challenge Cards may be used once a team has completed Part 3 of the Design Challenge. A team may complete none or all of the Design Challenge Cards based on the time allotted and skill level of the team. The team will take their simulation from Part 3 in the Challenge and modify it to meet the circumstance that is presented on their Design Card.

9. Each day, give the students about 5 minutes to fill out that day's portion of the lab notebook. (Appendix P)

Differentiation

Based on students Excel Pre Test, students should be placed in a team with others who have similar Excel abilities. The students in the team should have similar skills to avoid one student dominant over other students.

For advanced students/teams that already shown an understanding of basic Excel skills, they may skip sections of the Part 1: Basic Excel Tutorial and move on to Part 2: Creating a Biosphere Pollution Simulator.

You may always modify team and individual time and assignment requirements as needed.

Assessments

Engineering Design Challenge:
Part 1: Basic Excel Tutorial and Key (Appendices R & S)
Part 2: Creating a Biosphere Population Simulator (Appendices T & U)
Part 3: Design Optimization (Appendices V & W)
Challenge Cards (Appendix X)
Engineering Challenge Rubric (Appendix Y)
Student Checkpoints (Appendix Q)
Lab Notebook Daily Entry (Appendix P)

Section II: STEM Lesson Plan

Title of Lesson

Days 12-13: Presentation Preparation of Results of Data

Time Required

80-100 minutes

Materials

Paper - multiple sheets per student
Pen/pencils for each student
Dry erase markers - at least one per student
White board - one per student
Computer w/presentation software - at least one per group
Rubrics (Appendices Z, AA, BB)

Objectives

Students will be able to present their teams data analysis and how best to set up their population in the biosphere to achieve the maximum population in year 100.

Instructional Process

1. Pre-assess on what students know about making a presentation by giving the students a self assessment using a scale of 1 - 5 on how well each can do the following in PowerPoint and/or Google Slides:
a. Create a slide show
b. Add slides
c. Insert images and charts
d. How to make changes to fonts, color size, layout and theme

2. Show the class how to use PowerPoint and/or Google Slides based on pre-assessment:
a. Create a slide show
b. Add slides
c. Insert images and charts
d. How to make changes to fonts, color size, layout and theme

3. Have each group independently watch video on how to prepare a presentation and show to the class:
Give Presentations Like Steve Jobs!

4, Have students read through the rubrics (Appendices Z, AA, BB) and discuss any questions.

5. Have each team create a presentation plan that addresses how they will fulfill the criteria discussed in the video.

6. The rest of the time to be used for each team to create their final presentation.

7. Each day, give the students about 5 minutes to fill out that day's portion of the lab notebook. (Appendix P)

Differentiation

While the students are working on each phase of building their practice presentation those students that are more proficient and have completed the practice presentation can watch the Give Presentations Like Steve Jobs! video while the teacher gives direction to those who need more one on one help.

Assessments

At the end of the period the teacher can have a 1 minute assessment conference with each group so that the teacher can cover any needed topics at the beginning of class the next day.

Final assessment will be on their ability to make and present their presentation based on the criteria from the video and the rubrics.

Lab Notebook Daily Entry (Appendix P)

Section II: STEM Lesson Plan

Title of Lesson	**Day 14 - Presentations**
Time Required	40-50 minutes
Materials	Interactive Whiteboard/Projector Presentation Rubric-Teacher Version (1 per group - Appendix AA) Student Self-Reflection Rubric (1 per student – Appendix BB) Peer Evaluation Rubric (# of groups x # of students = # needed - Appendix CC)

Objectives	1. Students will present their data, conclusions, and reflections about the growth of their population inside the biosphere. 2. Students will participate in both self-evaluation of their own work and peer evaluation of their peers work.
Instructional Process	1. Make sure that you have established the order that groups will be presenting prior to Day 12 so that students are aware of when they will be presenting. 2. While students should have received a copy of the presentation rubric prior to the first day of presentation, make sure that they are given a copy of the teacher presentation rubric. 3. Each student should be given several peer evaluations; enough so that they can fill out an evaluation for each group that will present that day. Each student should be given a self- evaluation rubric for their own presentation. 4. Go over the peer evaluation rubric and emphasize the importance of peer review both for the group presenting and the student doing the evaluating. It is at this time you can discuss the importance of ethics and honesty when performing peer evaluation. 5. Go over the self-evaluation that students will be filling out after their presentation. Emphasize the importance of ethics and honesty when filling out a self-evaluation. 6. Allow each group time to set up their presentation. 7. Allow each group time to self-assess while the next group is setting up. Collect peer evaluations and self-evaluations while the next group is setting up.
Differentiation	For students in need of writing or reading accommodations during the peer and self-evaluation process, an adult or peer scribe may be provided.
Assessments	Students will be both peer assessing and self – assessing during the presentation process .

Section II: STEM Lesson Plan

Title of Lesson — **Day 15-Presentations and Post-Test Part 1**

Time Required — 40-50 minutes

Materials

- Interactive Whiteboard/Projector
- Presentation Rubric-teacher Version (1 per group - Appendix AA)
- Student Self-Reflection Rubric (1 per student – Appendix BB
- Peer Evaluation Rubric (# of groups x # of students = # needed -- Appendix CC)
- Post-Test (1 per student- Appendices A & B for key)

Objectives

1. Students will be able to explain the unit goal and perform the post-test
2. Students will present their data, conclusions, and reflections about the growth of their population inside the biosphere.
3. Students will participate in both self-evaluation of their own work and peer evaluation of their peers' work.

Instructional Process

1. Make sure that you have established the order that groups will be presenting prior to Day 13 so that students are aware of when they will be presenting.

2. Each student should be given several peer evaluations; enough so that they can fill out an evaluation for each group that will present that day. Each student should be given a self- evaluation rubric for their own presentation.

3. Reiterate the importance of peer review both for the group presenting and the student doing the evaluating. Reiterate the importance of ethics and honesty when performing peer evaluation and self-evaluation.

4. Allow each group time to set up their presentation.

5. Allow each group time to self-assess while the next group is setting up. Collect peer evaluations and self-evaluations while the next group is setting up.

6. Once presentations have been concluded and all self and peer evaluations have been collected, administer the content half of the pretest.

Differentiation

For students in need of writing or reading accommodations during the peer evaluation, self-evaluation process, an adult or peer scribe or reader may be provided.

This same peer or adult may act as a reader or scribe during the content post-test as well.

Assessments

Students will be both peer assessing and self – assessing during the presentation process .
Students will be taking the content post-test. (Appendix A)

Section II: STEM Lesson Plan

Title of Lesson	**Day 16-Post-Test Part 2**
Time Required	40-50 minutes
Materials	• Post-Test Part 2 (1 per student - Appendices C & D for key) • Computer with Internet access for every student
Objectives	1. Students will use their knowledge gained from this lesson to perform tasks involving Excel.
Instructional Process	1. Administer the Excel portion of the post-test.
Differentiation	For students in need of writing or reading accommodations an adult or peer scribe or reader may be provided.
Assessments	Excel Post-Test (Appendix C)

Section III: Unit Resources

Materials and Resource Master List

Printable Resources
Day 1
Appendix A: Pre/Post Test Part 1 (Content Knowledge) - 1 per student
Appendix B: Pre/Post Test Part 1 (Content Knowledge) - Key
Appendix E: Engineering Design Process - 1 per student
Appendix F: Background Story - 1 per student or whole class on projector
Appendix G: Engineering Design Challenge Explanation - 1 per student
Appendix H: “Pandora’s Box” Discussion Guide
Appendix I: “Life Under the Bubble” (Discover Magazine, 2010)** - 1 per student

Days 2-3
Appendix C: Pre/Post Test Part 2 (Excel Knowledge) - 1 per student
Appendix D: Pre/Post Test Part 2 (Excel Knowledge) - Key
Appendix J: Desmos Teacher Instructions and Guiding Questions
Appendix K: Linear vs. Quadratic vs. Exponential worksheet
Appendix P: Lab Notebook - 1 per student per day

Day 4
Appendix L: Food Web Simulation Handout - 1 per student
Appendix M: Food Web Simulation Data Table - 1 per student
Appendix P: Lab Notebook - 1 per student per day

Day 5
Appendix N: “What is Carrying Capacity” Article –Hard Copy - 1 per student
Appendix O: Degree of Impact Cards - 1 set per group
Appendix P: Lab Notebook - 1 per student per day

Days 6-11
Appendix P: Lab Notebook - 1 per student per day
Appendix Q: Student Checkpoints - 1 per student
Appendix R: Engineering Design Challenge- Part 1: Basic Excel Tutorial - 1 per student
Appendix S: Engineering Design Challenge- Part 1: Basic Excel Tutorial Key
Appendix T: Engineering Design Challenge- Part 2: Biosphere Population Simulator - 1 per student
Appendix U: Engineering Design Challenge- Part 2: Biosphere Population Simulator -Key
Appendix V: Engineering Design Challenge- Part 3: Design Optimization - 1 per student
Appendix W: Engineering Design Challenge- Part 3: Design Optimization Key
Appendix X: Challenge Cards - per group

Days 12-14
Appendix P: Lab Notebook - 1 per student per day
Appendix Y: Engineering Challenge Rubric - 1 per student
Appendix Z: Preparing to Present Scientific Conclusions-Student Preparation Rubric - 1 per student
Appendix AA: Presentation Rubric – Teacher Version
Appendix BB: Presentation Rubric- Student Self Reflection - 1 per student
Appendix CC: Peer Evaluation Rubric - multiple copies per student
Appendix A: Pre/Post Test Part 1 (Content Knowledge) - 1 per student
Appendix B: Pre/Post Test Part 1 (Content Knowledge) - Key

Day 15
Appendix C: Pre/Post Test Part 2 (Excel Knowledge) - 1 per student
Appendix D: Pre/Post Test Part 2 (Excel Knowledge) - Key

Challenge Materials
Day 1
Computer hooked up to LCD projector
Computer with internet access (1 per student)

Days 2-3
Computer with Internet access (1 per student)

Day 4
Dry erase markers
White board
Computer with Internet access (1 per student)
Computer hooked up to LCD projector

Day 5
Large paper (one per group)
Markers (set per group)
Computer with Internet access (1 per student)

Days 6-11
Computer with Excel and Internet access (1 per student)

Day 12-15
Paper
Pen/pencils
Dry erase makers
White board
Computer with presentation software

** Can be done via website or computer and not printed

Key Vocabulary

Linear equation: A first-order equation involving two variables: its graph is a straight line in the Cartesian coordinate system.

Quadratic equation: An equation containing a single variable of degree 2. Its general form is ax^2+ bx+ c = 0, where x is the variable and a, b, and c are constants (a ≠ 0).

Excel program: Computer program using Microsoft programing for developing a graph for verification.

Exponential growth: When an original amount is increased by a consistent rate over a period of time, exponential growth is occurring.

Carrying capacity: The maximum, equilibrium number of organisms of a particular species that can be supported indefinitely in a given environment.

Growth rate: Absolute or relative growth increase, expressed in units of time.

Mortality rate: Another term for death rate

Apocalypse: Any universal or widespread destruction or disaster: the apocalypse of nuclear war.

Initial population: A start on how the population consists of everything or everyone being studied in an inference procedure. Populations can be large in size, although this is not necessary.

Independent/Manipulation Variable: In math/statistics (in an experiment), a variable that is intentionally changed to observe its effect on the dependent variable/x-axis.

Dependent/Responding Variable (in an experiment): The event studied and expected to change when the independent variable/y-axis is changed.

Lottery: Any happening or process that is or appears to be determined by chance.

Composite: Any happening or process that is or appears to be determined by chance: to look upon life as a lottery.

Extrapolation: The act or process of estimating the value of a variable or function outside the tabulated or observed range.

Population control: a policy of attempting to limit the growth in numbers of a population, especially in poor or densely populated areas.

Verification: A process of evaluating the intermediary work products of a software development life cycle to check if we are in the right track of creating the final product.

Validation: The process of evaluating the final product to check whether the software meets the business needs.

Exponential decay: An original amount is reduced by a consistent rate over period of time.

Constant: A quantity assumed to be unchanged throughout a given discussion.

Function: Assigns a single unique output for each of their inputs.

All taken from www.Dictionary.com & abouteducation .com

Technical Brief

Top 8 reasons "Excel"ing After the Apocalypse Models STEM Careers

1.STEM professionals actually use math!
In this lesson, when we started with formulas that defined relationships between different inputs (constants or variables), we created a model. When we changed the values of the inputs to see how the outcome changed, we simulated different outcomes using our model. When we changed the values of the inputs to determine the “best answer” based on the given situation, we used our model to simulate an optimized solution.

2. Modeling and simulation techniques are used in many different ways in STEM careers.
It allows engineers and scientists to use software to run “experiments” and analyze the results. It is fast and inexpensive way to evaluate many different ideas and paths and use those results to determine a solution. Without the software model, progress in research would be much slower because scientists and engineers would need to create and test the scenarios in the lab. In many fields of research, this would be impossible to do.

3. Even when you think you are done, the model will change.
Input and variables change with new information and new scenarios. And models become more robust and replicate the scenario more closely with more detailed information. STEM professionals know this to be true: a customer tells you this is what they want, but during the design process they realize that they forgot to tell you something very important that is critical to meeting their need, like it needs to fit into this size box, or be manufactured by a certain type of equipment, or their budget was reduced and we need to design something to meet their new budget. The “Challenge Cards” are examples of how the model needs to change with changing conditions.

4. STEM professionals use Excel all the time.
Excel is a powerful tool for the STEM professional because it makes their job easier and faster - think about much time is saved by not having to calculate everything by hand? That time savings means that STEM professionals can keep pushing technology forward at a faster pace.

5. “Design” in STEM careers has different definitions - it doesn’t always mean that you physically build something.
Traditionally design as presented in STEM curriculum is thought of as a physical contraption that is designed and built to address a given problem. However, many STEM careers use the Engineering Design Process but

“design” in different ways. “Design“ can be:
a computer model that simulates an scenario (like this lesson)
the steps in a process to make 1,000,000 cookies that are exactly the same
A series of chemical reactions to produce a new material
defining the raw materials (type of resin and type of fabric) for a new airplane part made from composites, making sure that it has the same strength as a metal part

6. In any design process, there is no one perfect answer.
There are typically 3-4 really good designs that each have pros and cons. This is very different than the homework and assessment problems that students answer on a daily basis in school. But in the STEM workforce, there is never the “perfect” answer.

7. Because there is no perfect answer, the designer must be able to explain and defend his/her design choices.
The ability to defend why a designer chose the design he chose, and why the other designs are not as good of a choice, is a critical skill in STEM careers. This happens literally every day in the STEM workforce. Without a clear “right” path, the teams of STEM professionals must critically assess each design and decide to move forward on a design that is not - nor will ever be - perfect. Then they must defend their decisions to their peers, convincing them that this is the correct design choice. A strong argument for a design balances specific data to back-up the design plus how the design fits into the overall system or situation. For example, if you choose a design that meets every performance criteria and looks perfect on paper, but would cost $50,000,000 to build and the customer’s budget is $10,000, it is not a good design choice.

8. STEM professionals have an ethic obligation in what they design.
When designing a solution to a problem, designers focus on the problem they are trying to solve. But designs have impact and implications beyond the intended use. STEM professionals have a responsibility to consider the impact when making design decisions.

Safety and Disposal

During this lesson, students should be reminded of specific safety measures and instructions when using the computers. A parent/guardian permission form, per your district's policy, should be signed, granting them access to technology and internet resources.

References

Lesson Resources

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Teacher Resources

Video Converter Resources-
http://windows.microsoft.com/en-us/windows/windows-media-player
http://www.online-convert.com/

Excel Resources-
http://learn_excel.tripod.com/excel/

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Section IV: Appendices

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