MISSION PRIME

INSTRUCTOR'S GUIDE

VIRTUAL LEARNING
EXPERIENCES

The K20 Center for Educational and Community Renewal is a statewide education research and development center which promotes innovative learning through school-university-community collaboration. Our mission is to cultivate a collaborative network engaged in research and outreach that creates and sustains innovation and transformation through leadership development, shared learning, and authentic technology integration.

The K20 Center's **Virtual Learning Experiences** (VLE) development team is tasked with creating game-based learning experiences to be used in undergraduate courses at The University of Oklahoma. The experiences are designed and developed by a small team working with volunteer university professors.

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ABOUT THE GAME

PURPOSE

The purpose of Mission Prime is to support the teaching of undergraduate calculus to college freshmen and sophomores. Instruction focuses on cultivating the ability to identify, model, select tools, and set up a function to solve a word problem. The performing of calculations is deemphasized in favor of a conceptual understanding of the problem. The objectives of this instruction are as follows.

Given a calculus word problem, the student will be able to:

- *Identify the type of problem*
- *Model the problem*
- *Select the appropriate tools to solve the problem*
- *Set up a function to solve the problem*
- *Find the correct answer to the problem*

GAME NARRATIVE

It is the not-too-distant future, and the people of Earth have decided to undertake a great project: to send a few brave scouts across the cosmos to explore potentially habitable world light years away. The mission of these lonely space-travelers, when they awaken at their destinations, is to prepare a safe, habitable environment for the colonists who will follow a few years behind them.

The student takes on the role of one such astronaut after arriving on the planet. With only a rudimentary AI assistant as company, the student must mathematically work out the best way to use their limited resources to survive and build a colony in this alien environment.

HOW TO USE THIS GAME

Mission Prime is designed as a supplement to classroom or online teaching methods.

The game is not intended to teach calculus skill to students who have no background in calculus; instead, it is intended as an alternative practice activity that can be assigned instead of homework or other practice activities. While many students may struggle with the abstract nature of mathematics, this game offers a rich interactive environment and a unique way for students to visualize and interact with math problems.

THE RESEARCH

Calculus is the foundation for higher-level mathematics, such as physics, engineering, and economics. However, many studies have shown a gap in the ability of students to transfer knowledge from the calculus classroom to other disciplines (Lesh & Zawojewski, 2007). One explanation for this failure is that, while students master the formulas and functions of calculus, they lack and hands-on experience to apply the concepts to real world problems (Lithner, 2004).

Sonya Stanley (2002) has shown that providing students with real-life problem-solving scenarios improves their conceptual understanding of calculus applications, their motivation to work on problems, and their ability to identify and use the appropriate resources to solve them. This stands in contrast to traditional mathematics courses which are designed to teach students a specific sequence of actions to solve problems, focusing more on equations, formulas, and operations then a deeper conceptual understanding.

Robert Siegler (2009) states that with the traditional method, even students who do well in mathematics often can manipulate and answer the mathematical equations put before them, but they fail to recognize the relation between those equations and real-world problems they apply to. To combat this, many math instructors now suggest problem-based learning as a superior method of teaching mathematics concepts. Providing authentic problems as a framework within which the concepts can be broken down into smaller modules along with visual aids which students can manipulate to visualize the problem from multiple angles. Using such a format allows students to take a more active role in determining the proper way to solve a problem and provides an active transfer between equations and real-world application (Disessa & Sherin, 2000; Kaput, 1994; Oehrtman, 2009).

PLAYING THE GAME

Each scenario of Mission Prime provides the student with a calculus word problem and asks them to find the answer in the context of the objects present within the world. The student selects objects, makes necessary measurements, views how objects move or change through time, creates viable parameters, and ultimately selects the mathematical "tools" necessary to solve the given problem.

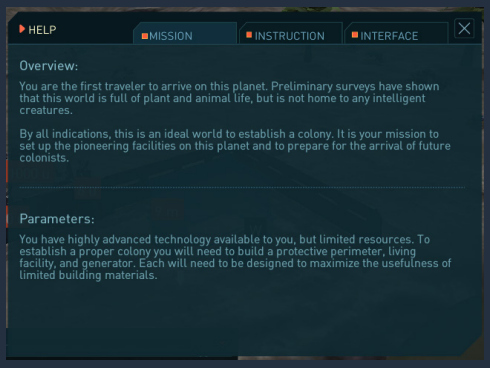
Each scenario in the game represents a different topic in calculus. The scenarios are designed to build upon one another, adding new concepts as the game progresses.

TUTORIAL

Upon the first time they play the game, students will be taken through a quick tutorial that explains the interface and the purpose of the game. Each tutorial panel will explain a different portion of the interface. Students should be instructed to read the tutorials carefully to avoid later confusion.

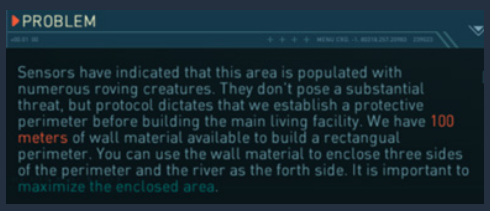
Most tutorials require the student to take some action in the game to move on. For most students, this tutorial should be all that is required to learn the game.

USER INTERFACE



Help Screen

The student can access the help screen at any time during the game. This screen gives a quick review of the interface, mission, and learning goals.



Problem Text

This section describes the word problem that the student is trying to solve. All the information necessary to solve the problem is included here.

The Environment

The bulk of the screen is taken up by a three-dimensional rendering of the problem. All known values and variables are displayed and correspond directly to the values and variables in the problem and in the tool box.

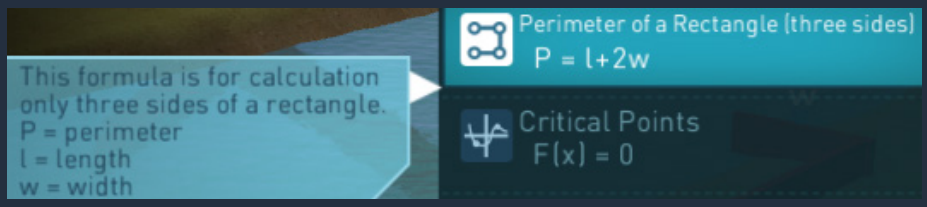
All variables of the problem are adjustable and can be moved within in the environment. The student can click and drag these variables to alter the dimensions of the objects and view how the variables change. Seeing and interacting with these environmental objects helps students visualize how the word problem relates to the real word and how variables change as the dimensions of the problem are altered.

Camera Controls

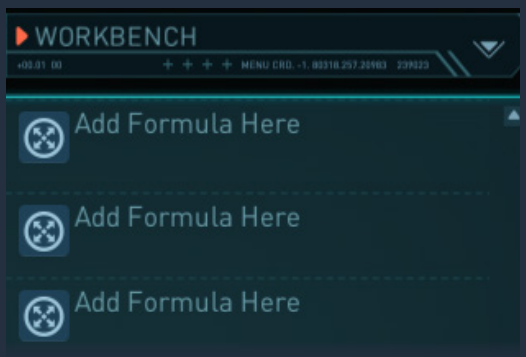
These controls allow students to rotate the camera and switch between 3D and 2D views of the environment. The 3D mode is meant to simulate a realistic view of the objects involved in the problem. The 2D view simulates the type of diagram the student might encounter in a traditional math course. Many students find that viewing objects from multiple angles can clarify the problem.

Tools

The Tools panel houses all the formulas and operations available to the student, both those necessary to solve the problem as well as some additional tools designed to act as distractors and force the student to think critically about what it is they are trying to do. By clicking on any formula, the student can see a helpful explanation of that formula and the variables it contains.



Students can drag items from the Tools panel into the Workbench to manipulate them and work toward a solution for the problem. Note that some items in the Tools panel are for use in the Solution panel. These will have a different icon and display an actual function.



Workbench

The Workbench area allows the student to work with mathematical tools and apply them to the problem at hand. The student can drag tools from the Tools panel onto the Workbench. This will display the formula with a solution for each variable displayed below it.

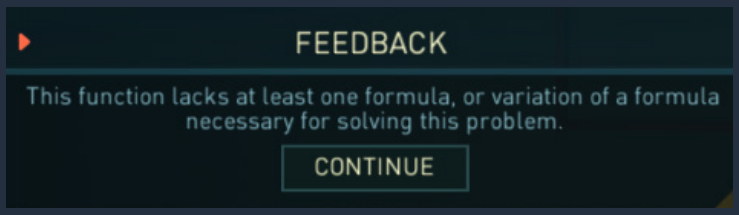
The student can also drag known values from the environment onto any of the solutions displayed below the formula. This will replace the solution variable with the known value. All other instances of that variable in the workbench will automatically be replaced, and all solutions will be updated. This way, the student can see how the known values affect the chosen formulas and can work toward customizing the formulas for the problem they are trying to solve.

Solution

In this section, the student assembles the function they will use to solve the problem by dragging formulas form the Workbench and the Tools panel. Each item added to the Solution panel will be applied in order. This means that the student can add a formula from the Workbench to create a function and then add another formula that will combine with the first and replace any common variables.

Feedback

Instructional feedback is delivered to the student when they select a solution to any given problem. The feedback is intended to help direct the student toward the correct solution without explicitly stating how to solve the problem. Students will be expected to test different strategies, review feedback, and revise their strategies before finding the final solution. Students will not be penalized for selecting wrong solutions, but they will only be able to progress when they choose the correct solution for any given scenario.



Solve Button

The solve button, located on the right side of the solution panel, allows the student to complete the level once they feel that they have gotten the right answer. If the student doesn't have the right answer, they will receive feedback that gives hints on how to improve their function.

Undo button

The undo button appears as a red X in the workbench and function area. It allows the student to remove any formula form the Workbench or Solution areas

SCENARIO OVERVIEW

The student has just arrived on the alien planet and is tasked with setting up the initial facilities to start the colony. These facilities include a living facility, power plant, and defensive wall. The student must use calculus to adjust the design of each structure to maximize utility, given limited resources.

SCENARIO 1

Problem Text

Sensors have indicated that this area is populated with numerous roving creatures. They don't pose a substantial threat, but protocol dictates that we establish a protective perimeter before building the main living facility. We have 100 meters of wall material available to build a rectangular perimeter. You can use the wall material to enclose three sides of the perimeter and the river as the fourth side. It is important to maximize the enclosed area.

SCENARIO 2

Problem Text

The living facility is a rectangular building. We will be using a special protective alloy to on the walls, foundation, and roof. But, we only have 1000 units of the material. Each square meter of roof space requires 6 units, the walls require 1 unit per square meter, and the foundation requires 10 units per square meter to be stable. The facility must be exactly 3 stories tall (9 meters). We need to maximize the floor space of the facility, given our limited building materials.

SCENARIO 3

Problem Text

To power the facilities, you will need to set up the hydraulic generator unit. The unit has a conical protective casing with a radius of 6 meters and a height of 10 meters. Before installing the casing, we need to build a generator unit that will fit inside of it. The generator unit is cylindrical, but its dimensions can vary, based on your specifications. The larger the generator is, the more power it can produce, so try to maximize the volume while remaining within the dimensions of the protective cone.

SCENARIO 4

Problem Text

Now that the living facility and generator are both built, we need to connect them. My measurements indicate that the distance between the two is 100 meters. The river is 50 meters wide. It will cost us 10 kg of cabling material per meter in the water and 7 kg of cabling material per meter on land. We need to find the most efficient route for the cable to minimize the weight of the materials used.

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