Lesson Title	The Black Box Mystery
Length of Lesson	Three 50 minute periods
Created By	Corey Ladner
Subject	Geometry
Grade Level	10^{th} – 12^{th}
State Standards	2.a, 5.a
DOK Level	DOK 2
DOK Application	Cause/Effect, Infer, Interpret, Distinguish, Make Observations, Relate, Compare.
National Standards	Measurement Understand measurable attributes of objects and the units, systems, and processes of measurement Data Analysis and Probability Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
Graduate Research Element	In my research, stream systems often experience a water loss between a certain upstream to downstream distance, which can be the result of high permeability of the stream's channel and bank walls or a water table lying below the level of the stream channel.

Student Learning Goal:
Students will represent data from real-world contexts with expressions, formulas, tables, charts, relations, and functions while applying multiple strategies and representations such as models to solve problems. This lesson will focus on a real-world problem that requires the students to observe, collect data, analyze data to develop inferences and relations, and form a mathematical function and predictive model that represents the data.

National Standards
Measurement:
Understand measurable attributes of objects and the units, systems, and processes of measurement
Data Analysis and Probability:
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

Materials Needed (supplies, hand-outs, resources):
Data collection worksheet, poster paper, markers, black box materials (pre-cut plywood, screws, box door hinges, master lock for door, rubber tubing, input funnel, containers)

Lesson Performance Task/Assessment:

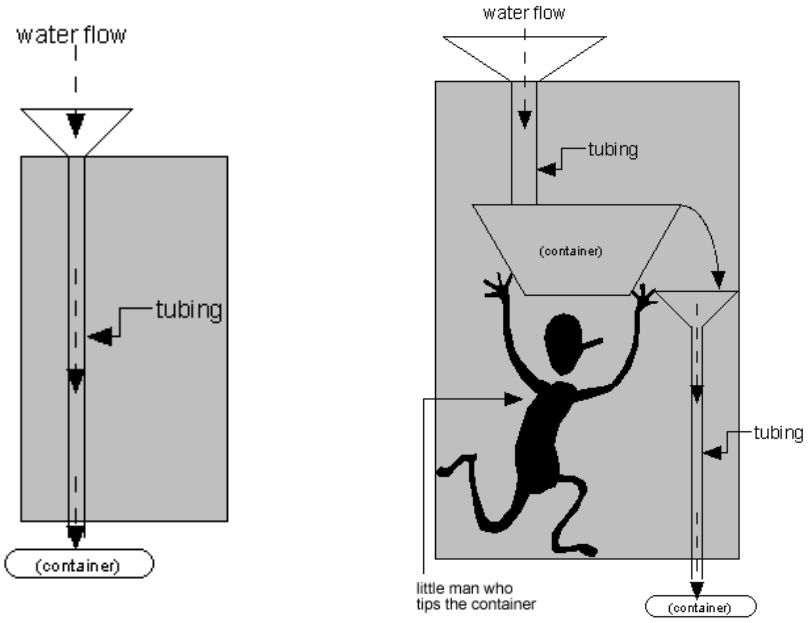
The students will be presented with the "Black Box Mystery." The "Black Box" (http://ncisla.wceruw.org/muse/earth-moon-sun/materials/intro/material1D/index.html), first developed for the Modeling for Understanding in Science Education Project, is system constructed with an input where water is added and an output where the water is to be retrieved. The internal transfer system between the input and output is designed so that when water is added through the input, sometimes the water will exit through the output and sometimes it will not. Also, the amount of water that does exit through the output will not be the same each time. Once the black box system is introduced, the students will manipulate the black box by collecting data of inputs and outputs in order to recognize patterns in the data, develop a mathematical function based on those patterns observed, and ultimately propose a predictive model of the internal system of the black box. The students will be assessed on their ability properly measure and record their inputs and retrieved outputs, recognition of patterns in data, and efforts to create a predictive model and mathematical function that represents the black box.

Lesson Relevance to Performance Task and Students:
The lesson provides the students with real world problems involving the practice of measurements and data collection that allows them to infer relations, functions, and patterns of the data.

Anticipatory Set/Capture Interest:

The teacher will capture the students' interest by initiating inquiry with the mystery of how the Black Box works. Further detail on initiating interest is included in the day 1 Guided Practice.

Guided Practice:
On day 1, The teacher will present the Black Box to the students; demonstrating what happens when water is added through the input of the box. Each time water is added, the students will be told what volume the teacher is adding and subsequently what volume is retrieved from the output. After several cycles of adding and collecting water from the Black Box, the students will be asked to recall the volumes that were added and collected. Since it is unlikely that the students took good notes, the teacher will take a moment to discuss the importance of recording the data properly in order to recognize patterns, make inferences, and even create a mathematical equation to explain how the black box works. After discussing the input and output data obtained from the demonstration, the teacher will draw some "impossible" models of the Black Box (such as the ones illustrated below) and allow the students to evaluate the models based on whether the models could realistically represent the obtained data.



Independent Practice:
After being introduced to the Black Box during the guided practice, the students will be divided into groups and given the remaining class time of day1 and 50 minutes on day 2 to manipulate the Black Box by added reasonable amounts of water to test how the Black Box reacts. Students will collect input and output data, analyze the data for patterns, and create a mathematical function and an illustrated model that explains the Black Box. Students should record their data and create a predictive mathematical function on the data worksheet (data worksheet_LP_8.1.12.doc). The models should be drawn on provided poster paper. The teacher will demonstrate how the mathematical function should look by showing the students a sample equation, where y = predictive output and x= input.

Remediation and/or Enrichment:
Remediation:
In the case that remediation is needed the student can meet with the instructor for individual tutoring. The student can also be grouped with a higher performing student that understands the lesson.
Enrichment:
In situations where there is complete understanding and performance, the lesson can be extended by incorporating the relations and patterns derived from the data to test the accuracy of the function equation for the Black Box.

Check(s) for Understanding:
On day 3, student groups will present their work before their class. Students will explain their test for the Black Box and collected data, the patterns that were recognized in the data, and their mathematical function and model representing the Black Box. After each presentation, the teacher will discuss with the students each group's work in terms of whether the group's mathematical function and model reflect the data.

Closure:
The teacher will close the lesson by explaining to the students how the Black Box and the lesson's concepts can be applied to my research as a model of water loss in a stream system.

Possible Alternate Subject Integrations:
This lesson can be easily incorporated into high school algebra, physics, physical science, and biology courses.

Teacher Notes:

Attachments

- data worksheet_LP_8.1.12.doc

Back Box Internal Structure

Teachers should refer to the Modeling for Understanding in Science Education Project webpage:
(http://ncisla.wceruw.org/muse/earth-moon-sun/materials/intro/material1D/index.html) for demonstrations, student presentations, and other information about the Black Box. Provided below is a tentative illustration of the internal structure of the Black Box.