CaSTL

Investigating Gravity

Boys and Girls Club After School Science
NSF Center for Chemical Innovation
Chemistry at the Space Time Limit (CaSTL)
https://www.castl.uci.edu/

Standard(s) Addressed:

With a primary understanding of gravity, children will use their prior knowledge to make assumptions about and investigate how gravity works.
California Science Standards
Grade 2 Physical Sciences: "Students know the way to change how something is moving is by giving it a push or a pull. The size of the change is related to the strength, or the amount of force, of the push or pull." "Students know objects fall to the ground unless something holds them up."
Grade 2 Investigations and Experimentations: "Make predictions based on observed patterns and not random guessing."
Grade 3 Investigations and Experimentations: "Predict the outcome of a simple investigation and compare the result with the prediction. Collect data in an investigation and analyze those data to develop a logical conclusion."
Primary introduction to Grade 8: "Students know how to identify separately the two or more forces that are acting on a single static object, including gravity, elastic forces due to tension or compression in matter, and friction."

Lesson Objective:

Children will conduct three investigations to determine if their assumptions about gravity were correct. They will be able to report their findings to the class with a greater understanding of gravity.

Materials Used:

- Whole Class Time: chart paper, markers, copies of teacher forms (below)
- Activity 1, The Spinning Bucket (or "Artificial Gravity): bucket, water, sign "Centrifugal Force" or "Artificial Gravity"
- Activity 2, The Hole in the Cup (or "Watching Gravity"): paper cups, water, sign "Watching Gravity"
- Activity 3, "Center of Gravity": pencils or pens with caps, sign "Center of Gravity"

Classroom Management:

Setting up: Fill buckets with water, have more water in pitchers accessible, put holes in paper cups

During Explore: Have one staff member at each station to support the activity, ask questions, and help keep classroom management going well.

Signal: Clap three times and have children repeat, then prepare to listen- as the activity will be outdoors and it will be more effective to listen for a signal than spot a teacher for a visual clue.

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ENGAGE: ***Connect to Prior Knowledge and Experience, Create Emotionally Safe Learning Environment, Preview New Vocabulary*** **Estimated time: 15 minutes**

Description of Engage: Students will connect to prior knowledge by discussing previous activities about gravity and review their learning. Once divided into three small groups, they will predict how gravity will act in each investigation.

Descriptions of Three Investigation Centers (see notes below):

- The Spinning Bucket/Artificial Gravity: Showing the relation between motion and gravity, for this experiment you need a bucket with water and someone with a strong arm to spin it. In theory, when the bucket turns upside down the water should come spilling out as gravity pulls it downwards. Spinning it fast enough, the water tends to keep going in a straight line, counteracting the pull of gravity and thus wedging it to the end of the bucket, preventing the natural pull of gravity from spilling the water. This is why this effect, called "centrifugal force" is often referred to as artificial gravity.
- The Hole in the Cup (or "Watching Gravity"): For this experiment you need a paper cup and some water. Poke a hole in the cup and cover it with a finger; fill the cup with water. Take your finger from the hole and notice the water spills out. Though gravity pulls down both objects, only water moves freely (because you're holding the cup); thus, gravity forces the water out. Fill the cup again and drop it to the ground. Now that both objects are free to move, they drop at the same speed so the water isn't forced out of the hole.
- Center of Gravity: A center of gravity experiment can be done quite easily; all that is required is a pencil or pen and your finger. Try to balance the pen at different positions on your finger until you reach the point where it doesn't fall off. This is the center of gravity of the pen, the point in which its weight averages out and, if it were in a weightless environment, the point at which it can freely rotate. Put on the cap and try to balance it again. As the weight of an object changes, so does its center of gravity.

Teacher's Role	Teacher Questions	Children's Role
Teacher reviews what the students have learned in the last lessons about gravity.	Turn to a partner: What is gravity? How does it work?	Students first tell their partners about gravity, then report back to the class. *"Gravity is a downward force."* *"Gravity makes things fall on Earth."*

Teacher tells students that today they will continue to explore gravity. They will complete three different activities to watch the distinct ways that gravity works. Teacher divides students into three equal groups.		Students divide into groups.
At the beginning of each station, the staff member explains the activity and asks students to predict what will happen when they try the activity.	Ex: When we spin the bucket around, what will happen to the water? When I try to hold the pencil on my finger, where should I hold it? What will happen when I drop the cup of water? Why do you think that?	*"The water might fall out because gravity makes things fall."* *"I should hold the pencil exactly in the middle because otherwise it will fall."* *"The water will fall out of the cup."*
Teacher moves students through each center-beginning each one with the prediction component.		Students cycle through each center.

EXPLORE: ***Hands-On Learning, Contextualize Language, Use of Scaffolding (Graphic Organizers, Thinking Maps, Cooperative Learning), Use of Multiple Intelligences, Check for Understanding*** **Estimated time: 10-15 minutes**

Description of Explore: In small groups, students perform the investigations to determine if their predictions were correct and to further investigate how gravity works on Earth. Staff members at each center ask questions to further children's understanding.

Teacher's Role	Teacher Questions	Children's Role
Teachers demonstrate each center, and then help students perform the investigations. They ask relevant and probing questions as the students spin the bucket, balance the pencils/pens, drop the cups. Teacher moves students along so that each group experiences each center.	What do you notice? Why do you think this is happening? How does this compare to what we know about gravity? What would happen if… (we spin more slowly, held the pencil this way, etc.)?	Students perform investigations and compare their findings to their predictions and knowledge about gravity. *"The water isn't falling out, if I spin fast enough."* *"The pencil falls if I don't hold it in the middle."*

EXPLAIN: ***Listening, Speaking, Reading, and Writing to Communicate Conceptual Understanding*** **Estimated time: 10-15 minutes**

Description of Explain: Students regroup with the whole class to report their findings and explain what happened.

Teacher's Role	Teacher Questions	Children's Role
Teacher regroups students and has them report what they did and what they observed at each center. Teacher has students explain why they think it happened. Teacher records each group's response on 1 chart paper per center.	What happened at the (Spinning Bucket) center? Why do you think did that happened? Have you ever seen anything like that before? How does that compare to what we know about gravity?	Students share their learnings with peers and listen to the others. *"The water didn't fall out."* *"I think this happened because we were spinning the water so fast, it didn't have time to fall out."* *"This is different from what we've seen before about gravity, because usually gravity makes things fall."* *"I've seen this before on my racetrack. Sometimes I make a loop-de-loop and the car doesn't fall upside down if I go fast enough."*

EVALUATE: ***Thinking Maps, Summarize Lesson and Review Vocabulary, Variety of Assessment Tools, Games to Show Understanding*** **Estimated time: Throughout**

Description of Evaluate: Evaluation will occur throughout the lesson and particularly during the explain component. Teachers should listen carefully to the conversations and presentations during the explain. Teachers should check for understanding throughout the investigations and explain.

Teacher's Role	Teacher Questions	Children's Role
Teacher will review what students had previously learned about gravity, then ask what special conditions might have to exist for gravity to work as they had learned. Teachers check for understanding.	What is gravity? How does it work? When might gravity do something different than we expect?	*"Gravity is a downward force, but if you spin something fast enough, it might not make an object fall down."* *"Gravity pushes things down, but if you hold an object's center, it might not continue to be pushed down."*

EXTEND/ELABORATE: ***Group Projects, Plays, Murals, Songs, Connections to Real World, Connections to Other Curricular Areas*** **Estimated time: 5 – 10 minutes**

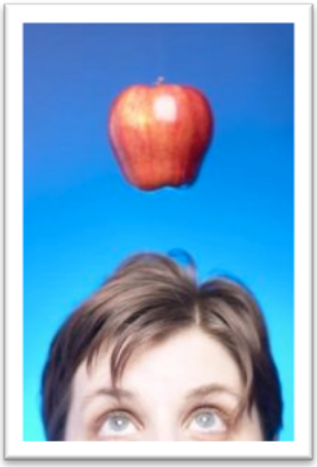
Description of Extend/Elaborate: Students will connect their learning to real life examples by thinking of other times that they can "test" gravity on Earth.

Teacher's Role	Teacher Questions	Children's Role
Teacher asks students to get into pairs and think of times/examples from real life where they could "test" gravity and investigate how it works. Teacher could use an example from the class (i.e. a racetrack where the car goes loop-de-loop) or create a new one to help demonstrate the thinking. Teacher records answers for all to see, then encourages students to try the investigation!	How could we be on the lookout for gravity at work when we leave the classroom? What other investigations could we try at school/home/on the playground?	Students pair up and think about various gravity experiments they could try. They report to the class. *"We could drop different liquids in the cup."* *"We could try the center of gravity experiment with larger or disproportioned objects."*

Teachers' Notes

Gravity affects everything around people.

Gravity is a fundamental part of nature that keeps our feet planted firmly on the ground. This unseen force is responsible for tides, keeping Earth from careening into the darkness of space, and for causing food to hit the kitchen floor when it slips from your hand. Though invisible, gravity's effects can be observed by performing simple and easy-to-do experiments.



Galileo's Experiment

- Named after the scientist who is popularly believed (though not verified) to have performed this experiment, it involves taking two objects of different sizes and weights and dropping them to see which one hits the ground first. As the Earth's gravity affects objects at the same rate regardless of their weight, without air resistance the objects should hit the ground at the same time. Try this with different objects with varying weights and air resistance and observe its effects.

1. The Spinning Bucket (or "Artificial Gravity)

- Showing the relation between motion and gravity, for this experiment you need a bucket with water and someone with a strong arm to spin it. In theory, when the bucket turns upside down the water should come spilling out as gravity pulls it downwards. Spinning it fast enough, the water tends to keep going in a straight line, counteracting the pull of gravity and thus wedging it to the end of the bucket, preventing the natural pull of gravity from spilling the water. This is why this effect, called "centrifugal force" is often referred to as artificial gravity.

Materials Needed:

- bucket
- water
- sign "centrifugal force" "artificial gravity"

2. The Hole in the Cup (or "Watching Gravity")

- For this experiment you need a paper cup and some water. Poke a hole in the cup and cover it with a finger; fill the cup with water. Take your finger from the hole and notice the water spills out. Though gravity pulls down both objects, only water moves freely (because you're holding the cup); thus, gravity forces the water out. Fill the cup again and drop it to the ground. Now that both objects are free to move, they drop at the same speed so the water isn't forced out of the hole.

Materials Needed:

- paper cups
- water
- sign "Watching Gravity"

3. Center of Gravity

- A center of gravity experiment can be done quite easily; all that is required is a pencil or pen and your finger. Try to balance the pen at different positions on your finger until you reach the point where it doesn't fall off. This is the center of gravity of the pen, the point in which its weight averages out and, if it were in a weightless environment, the point at which it can freely rotate. Put on the cap and try to balance it again. As the weight of an object changes, so does its center of gravity.

Materials Needed:

- pencils
- sign "Center of Gravity"