MOMATH
NATIONAL MUSEUM OF MATHEMATICS

THE 2021 ROSENTHAL PRIZE
for Innovation and Inspiration in Math Teaching

Astronaut Explorer:
A Measurement Conversion Conundrum

Ryan Smith

Lesson Plan
GRADE
4

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Task at a Glance

In this activity, students take on the role of astronauts exploring the planet Keplizmi, home to an extinct civilization. Their goal is to land on Keplizmi and perform an exploratory mission to learn about the civilization's measurement system. This activity is designed to help students construct procedures for converting from one unit to another regardless of the measurement system.

The activity begins with a pre-landing debrief. Students are given field journals and start with a recap of what they know about Earth units. Most students are familiar with basic equivalence in customary units of length and this is our reference point. Students practice several simple conversions, (2ft=24in, 36in=3ft, etc.) and are prompted to try using multiplication/division (2x12=24) and to possibly consider smaller units of measure as fractions of larger units (36/12=3).

After the debrief, this video plays as we land on Keplizmi. Upon landing, they're told that there are several artifacts around the room. These include measuring devices modified to represent the Keplizmi measurement system such as a beaker with intervals equivalent to 10 tablespoons, modified tablespoons, and meter sticks that have been cut down and had intervals added. There are also several clues that will help them learn about the system including recipes, maps, a grocery list, etc. The measuring devices and clues give them enough information to figure out intermediate units and take measurements of objects in appropriate units. Students record data, calculations, and conclusions in the field journal.

**COVID-19 note: In order to keep students as distanced as possible and not bunched up around clues, this lesson is organized in stations. It can be really fun to have the clues around the room at random but that sometimes takes longer and students definitely do not stay socially distanced. To even further reduce contact between students, the lesson could also be run with them staying at their seats. In this case, it would probably be best to use only the low prep stations (money and long length) since each student would need their own materials.*

Lesson Goals

The purpose of this lesson is to help students develop a better conceptual understanding of unit conversions that could be applied to any measurement system, even a completely new one like that of an alien civilization. There are varying levels of difficulty in the clues and most students will probably not get every single one in the amount of time given. The idea is to get them looking for clues about unit relationships in the world around them and to begin wrestling with conversions using what they have learned previously about fractions and operations.

Prerequisite Knowledge

Prior to the lesson, it is helpful if students are comfortable with addition, subtraction, multiplication, and division as well as being able to reduce fractions and convert between improper fractions and mixed/whole numbers. It is also helpful, but not necessary if students have some familiarity with at least one basic measurement conversion.

Common Core Standards for Mathematical Practice

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
CCSS.MATH.PRACTICE.MP4 Model with mathematics.
CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.
CCSS.MATH.PRACTICE.MP6 Attend to precision.
CCSS.MATH.PRACTICE.MP7 Look for and make use of structure.

Common Core Standards for Mathematical Content

CCSS.MATH.CONTENT.4.MD.A.1
Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...

CCSS.MATH.CONTENT.4.MD.A.2
Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

Time Required

Preparation Time: 1 hour Class Lesson Time: 45 minutes

Materials & Setup

Total List of Materials (Beyond Printouts)

Stopwatch

Whiteboard

Projector (for optional video)

2 meter sticks

Duct tape

Permanent marker

½ cup measuring cup

¼ cup measuring cup

Clear container (beaker or empty 2 liter)

5 clear plastic ziploc baggies

Balance

Five 10-gram pieces

Five 5-gram pieces

Five 1-gram pieces

Small amount of sand or sugar

Clipboard for each student to use with packet

Materials & Setup by Station

****There are five different stations that are set up in the full lesson****

Station 1: Length

- *Materials*
  - 2 meter sticks
  - Duct tape
  - Permanent marker
  - *Room Decoration Note w/ Room Picture*
- *Setup*
  - Cover one meter stick with duct tape
  - Label one side Kebbie Stick
  - Use the second meter stick to mark off every 5 cm

Station 2: Volume

- *Materials*
  - 1 half cup
  - 1 quarter cup
  - 1 clear container larger than 1 liter
    - Could be a soda bottle
    - 1 liter beaker may be okay depending on the extra space above measuring lines (needs to hold 5 cups, or 10 half cups, which is 1180 mL of water)
  - Tape
  - Permanent marker
  - *Kewkey Recipe* printout
- *Setup*
  - Cover any measurement markings on the containers with tape
  - Label the ½ cup measuring cup as 1 Glorb
  - Label the ¼ cup measuring cup as 1 Meep
  - Label the large clear container as 1 Borg
    - Place tape vertically from the top to the bottom of the container
    - Pour in ½ cup and mark the location of the top of the water
    - Continue doing this until you have poured the ½ cup 10 times
    - Mark the 10th line as 1 borg
  - **This station should be near a sink or some other water source & students should be careful not to get their field guides wet**

Station 3: Longer Units of Length

- *Materials*
    - *Trip Planner* printout
    - *Note to Dad* printout
- *Setup*
    - No setup besides printouts

Station 4: Money

- *Materials*
    - *Grocery List* printout
    - *Piggly Bank Note* printout
    - *Money* printouts (1 Dinak bill and 2 Norp coins)
    - *Groceries: Exact Change* printout
    - Clear plastic bag
- *Setup*
    - Cut out “money” and *Groceries: Exact Change* label.
    - Place money in clear bag and tape/glue label onto bag

Station 5: Mass

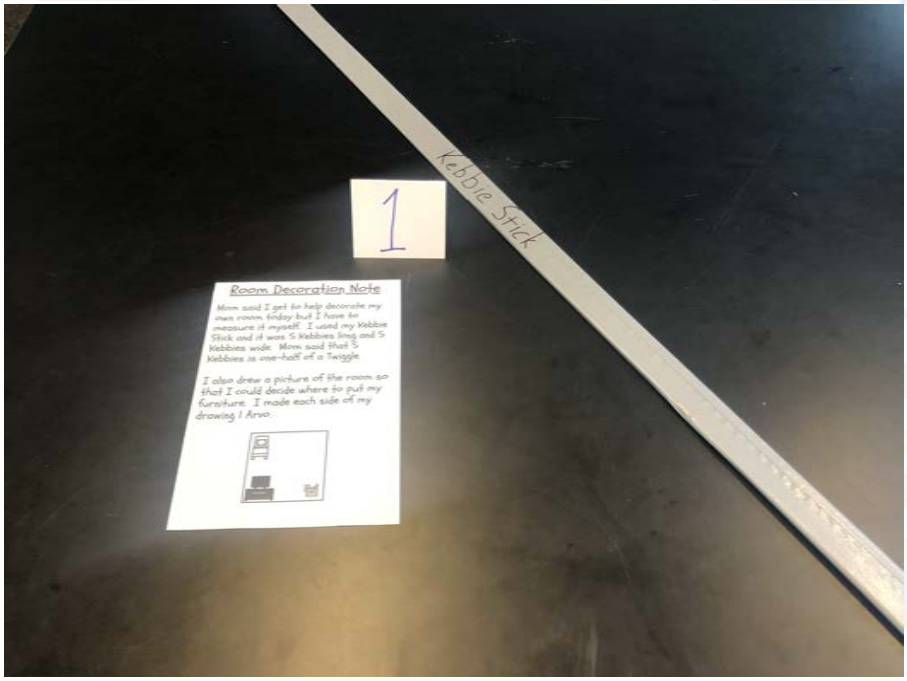
- *Materials*
  - Balance
  - 4 ziploc bags
  - Permanent marker
  - Five 10-gram pieces in a baggie labeled Humgos
  - Five 5-gram pieces in a baggie labeled Stypes
  - Five 1-gram pieces in a baggie labeled Elos
  - Small amount of sand or sugar
- *Setup*
  - Label the three bags as: Hummus, Stypes, and Elos
  - If your gram pieces have markings on them you may choose to leave them but let students know that there are no Earth measurements on Keplizmi. If you do cover them use marker, not tape or paper, so that you do not change the mass substantially.
  - Place the 10-gram pieces in the Humgos bag
  - Place the 5-gram pieces in the Stypes bag
  - Place the 1-gram pieces in the Elos bag
  - Use the last plastic bag to make your bag of sugar/sand.
    - Label the bag 1 Zid
    - Use the balance and place 20 grams on one side
    - On the other side place the 1 Zid bag and slowly fill with sand or sugar until it is balanced

Task Directions

- **Introducing the Activity:**
  - During the introduction, the teacher will take on the role of mission commander and will welcome the student astronauts to the mission debrief. The script in the appendix may be used if the teacher does not feel comfortable improvising and does not have the time to prepare a speech.
- **Activate Prior Knowledge:**
  - After the introduction, the teacher should pass out the *Keplizmi Expedition Astronaut Training & Field Journal* packets and direct students to the *Brainstorming Strategies for Exploration* page.
  - Here students will take a few minutes to think about what they already know about measurement and the teacher can direct students to consider their previous lessons on fractions and multiplication. Since most students in the U.S. already know that there are 12 inches in 1 foot, this is a good place to start a class review. Some examples of strategies might be to:
    - Draw a picture of a foot divided into 12 sections.
    - Write 1 inch as a fraction of a foot, 1 inch = 1/12 foot.
    - Write 24 inches as a fraction of a foot and simplify, 24 inches = 24/12 feet, 24/12 = 2.
    - Show that each foot is a group of 12 inches and multiply. If I have 2 feet and each is a group of 12 inches, then I have 12 x 2 = 24.
- **Assign Students to Stations:** Before starting it's a good idea to let students know that they may not get every clue and every conversion, there are a lot, and that they should write down as much information as possible while they are at a station so that they might be able to solve the problems later. It can also be fun to play a video like this to simulate "landing" on Keplizmi.
- **During the Lesson:** The teacher should circulate throughout the classroom to both help students who get stuck or frustrated and to take notes on different students strategies. Notes on strategies can be incredibly helpful in getting students involved in the post-lesson wrap-up.
- **Wrap-Up & Sense Making Discussion:** The last page of the field guide is a wrap-up page. This can happen right after the lesson, the next day, or both; each has their own benefits. This is a time for students to share not just their conclusions but discuss their processes and consider and try other methods. One way to do this is to ask students to apply the new strategies they hear to their own conclusions:
  - Can you write a multiplication or division sentence for that?
  - Can you write that as a fraction?
  - Can you draw a picture of that?

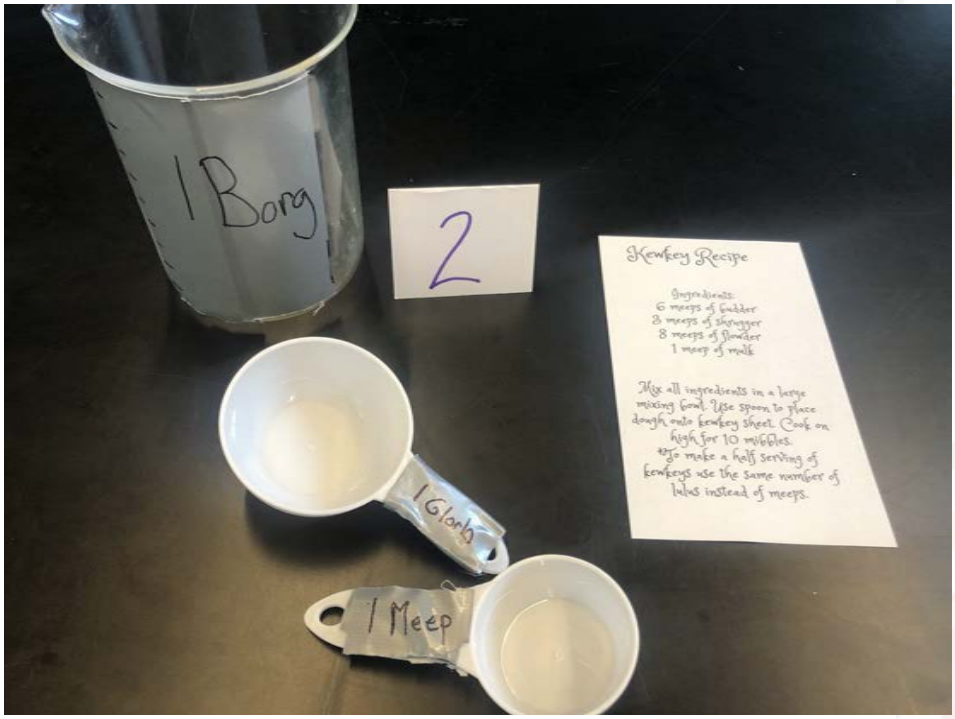
Pictures of Stations with Teacher Notes

- Station 1: Length
  - Station Picture:



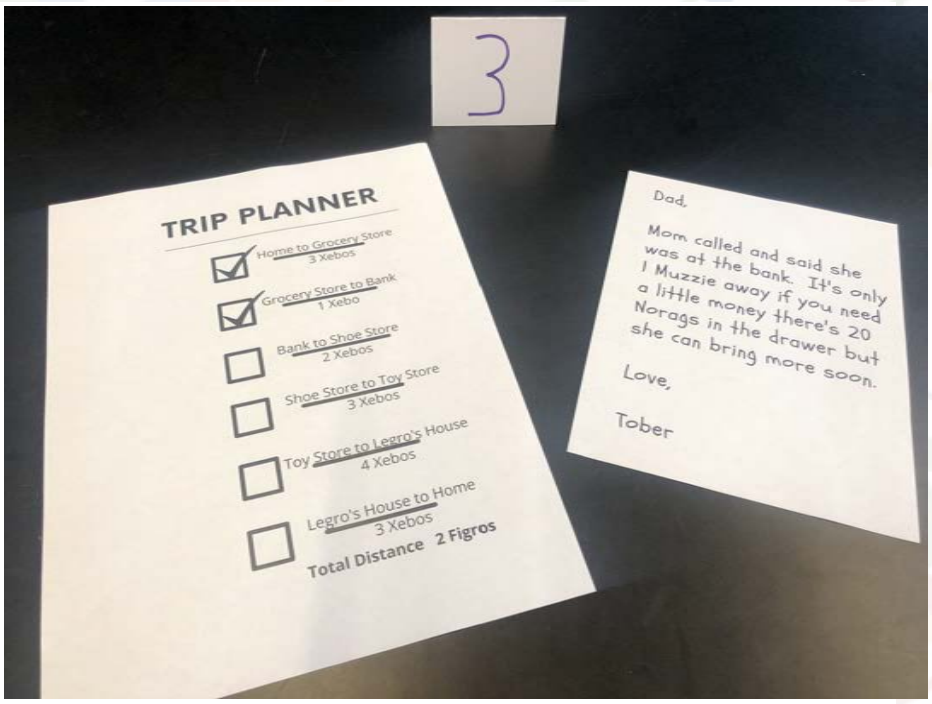
  - Teacher Notes
    - The child's *Room Decoration Note* will give the students the clues to figure out each of the conversions for Kebbies to Twiggles (5 Kebbies is ½ a Twiggle). It also lets them know that the Room Picture is 1 Arvo.
    - The Kebbie Stick is divided into unlabelled 5 cm sections, these are Arvos. When they measure the Room Picture they should be able to figure out that these unlabelled units are Arvos (Room Picture *must* be 1 Arvo and you can draw it if needed)
    - Conversions:
      - 20 Arvos = 1 Kebbie
      - 10 Kebbies = 1 Twiggle
      - Smallest to largest: Arvo, Kebbie, Twiggle
      - Finding intermediate conversions is also encouraged

- Station 2: Volume
  - Station Picture:



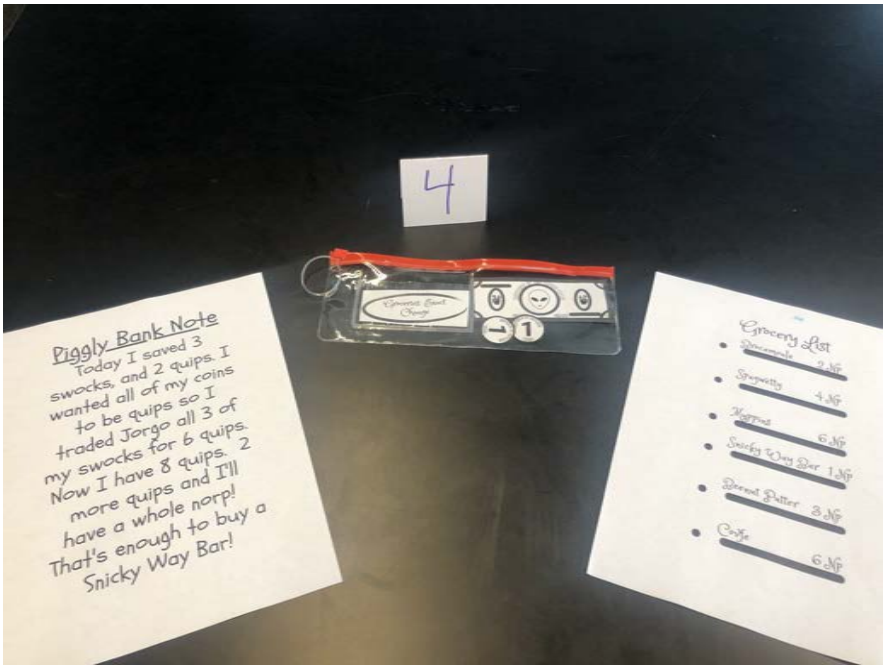
  - Teacher Notes
    - This station should be near a sink. Students can pour 2 Glorbs into a Meep cup to figure out Glorbs to Meeps, and either Glorbs or Meeps into the Borg container to figure out Glorbs and Meeps to Borgs.
    - The key to the recipe is that it gives directions to make a half recipe by using the same number of Lulus instead of Meeps, so 2 Lulus = 1 Meep.
    - Conversions:
      - 2 Lulus = 1 Meep
      - 2 Meeps = 1 Glorb
      - 10 Glorbs = 1 Borg
      - Smallest to largest: Lulu, Meep, Glorb, Borg
      - Finding intermediate conversions is also encouraged

- Station 3: Longer Units of Length (Maps)
  - Station Picture:



  - Teacher Notes:
    - The total distance on the *Trip Planner* will add up to 16 Xebos but is listed as 2 Figros, students will use this to find the 8 Xebos to 1 Figro conversion.
    - The *Note to Dad* says that Mom is 1 Muzzie away when she is at the bank. Using the *Trip Planner* will allow students to figure out that she is 4 Xebos away.
    - Conversions:
      - 4 Xebos = 1 Muzzie
      - 16 Xebos = 1 Figro
      - 4 Muzzies = 1 Figro
      - Smallest to largest: Xebo, Muzzie, Figro
      - Students may finish this one earlier. Make sure they explore all possible conversions and revisit any previous stations if applicable.

- Station 4: Money
  - Station Picture:



  - Teacher Notes
    - The child's Piggly Bank Note will give the students the clues to figure out each of the conversions for quips, Swocks, and Norps (three smallest denominations).
    - The grocery list and money bag will give the conversion from Norp to Dinak (the largest) because the list will add up to 22 Norps and the bag with exact change will have a 2 Dinak bill and 2 Norp coins.
    - Conversions:
      - 1 Swock = 2 Quips
      - 10 Quips = 1 Norp
      - 10 Norp = 1 Dinak
      - Smallest to largest: quip, Swock, Norp, Dinak
      - Finding intermediate conversions is also encouraged

- Station 5: Mass:
  - Station Picture:

  - Teacher Notes:
    - There are no printouts or additional directions at this station but students may need prompting to understand how a balance works. No labels are added to the gram pieces so that the mass is not changed but if they have unit markings from the manufacturer they should be covered if possible.
    - Students can balance 1 Humgo with 2 Stypes and 1 Stype with 5 Elos.
    - Students can balance the baggie of sand/sugar with any combination that equals 20 grams to get 1 Zid
    - Conversions:
      - 5 Elos = 1 Stype
      - 2 Stypes = 1 Humgo
      - 2 Humgos = 1 Zid
      - Smallest to largest: Elo, Stype, Humgo, Zid
      - Finding intermediate conversions is also encouraged

Modification & Extension Possibilities

- *Modification*
    - Less preparation time- Using every measurement category is not necessary. Some of the categories, such as money, require fewer materials and less time to prepare.
    - No stations- Ordinarily this activity is done without stations and clues are placed around the room. Students are free to explore the room as they desire. Because of social distancing requirements stations help keep students a bit more spaced out and orderly.
    - Multiple class periods- This activity could realistically be extended over multiple class periods by giving students more time at each station and allowing them more time for discussion at the end.
- *Extension*
    - After further study of measurement and conversion, students could begin converting the Keplinian units to metric and customary units (could even work for higher-level science students who are doing conversions in physics and chemistry).
    - Older students could explore the possibility of a non-base 10 number system.
    - After further study of measurement and conversion, students could begin converting the Keplinian units to metric and customary units (could even work for higher-level science students who are doing conversions in physics and chemistry).

Appendix

Mission Debrief Script:

Good morning astronauts and welcome to the debrief for the Keplizmi Measurement Expedition. I am Commander _____, your mission commander. I will be here to help prepare you for the mission and give you guidance if you get stuck along the way. We are about to step foot on the planet Keplizmi of the Ornack Solar System for the first time in human history.

So far we have been able to explore the surface of Keplizmi with rovers and have discovered an extinct civilization that we have referred to as the Keplinian Society. Unfortunately, our rovers can only do so much and have not been able to gain entrance into the Keplinian buildings. That is where you will help us take the historic next steps as you make entrance into, and explore a Keplinian building. There is still much that is unknown about this alien society but based on their building construction they were clearly an advanced civilization. On this mission, your purpose is to learn as much as possible about the Keplinian system of measurement.

As you know from your vast experience and astronaut training, it is important to review and utilize what you already know to solve new problems. Let's take a few minutes to discuss what you know about measurements on Earth and what you've learned so far this year. I will now pass out your field guides.

Before Sending to Stations Script:

Congratulations astronauts, your training is now complete! Please sit back, hold on tight and prepare for our Keplizmi landing.

****You can now play a video like this to simulate "landing" on Keplizmi****

Images/Printouts for Stations:

- *Length Station Printouts:*

Room Decoration Note

Mom said I get to help decorate my own room today but I have to measure it myself. I used my Kebbie Stick and it was 5 Kebbies long and 5 Kebbies wide. Mom said that 5 Kebbies is one-half of a Twiggle.

I also drew a picture of the room so that I could decide where to put my furniture. I made each side of my drawing 1 Arvo.

- *Volume Station Printouts:*

Kewkey Recipe

Ingredients:
6 meeps of budder
3 meeps of shrugger
8 meeps of flowder
1 meep of mulk

Mix all ingredients in a large mixing bowl. Use spoon to place dough onto kewkey sheet. Cook on high for 10 mibbles.
*To make a half serving of kewkeys use the same number of lulus instead of meeps.

- *Longer Length Station Measurement*

Dad,

Mom called and said she was at the bank. It's only 1 Muzzie away if you need a little money there's 20 Norags in the drawer but she can bring more soon.

Love,

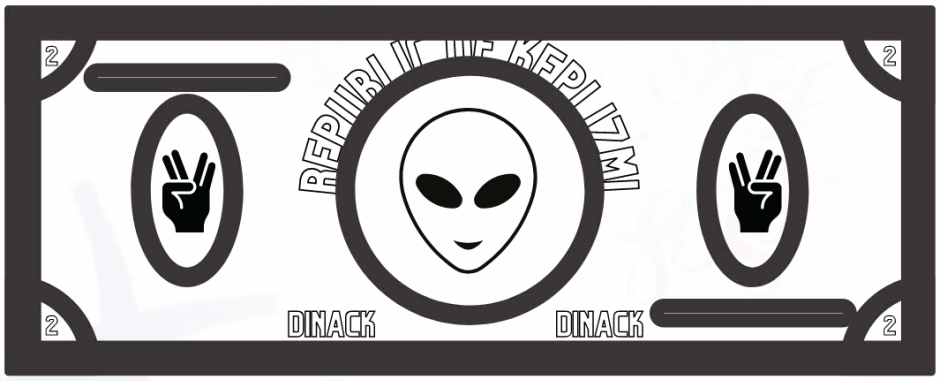
Tober

TRIP PLANNER

- [x] Home to Grocery Store
  3 Xebos
- [x] Grocery Store to Bank
  1 Xebo
- [ ] Bank to Shoe Store
  2 Xebos
- [ ] Shoe Store to Toy Store
  3 Xebos
- [ ] Toy Store to Legro's House
  4 Xebos
- [ ] Legro's House to Home
  3 Xebos

Total Distance 2 Figros

- *Money Station Printouts:*



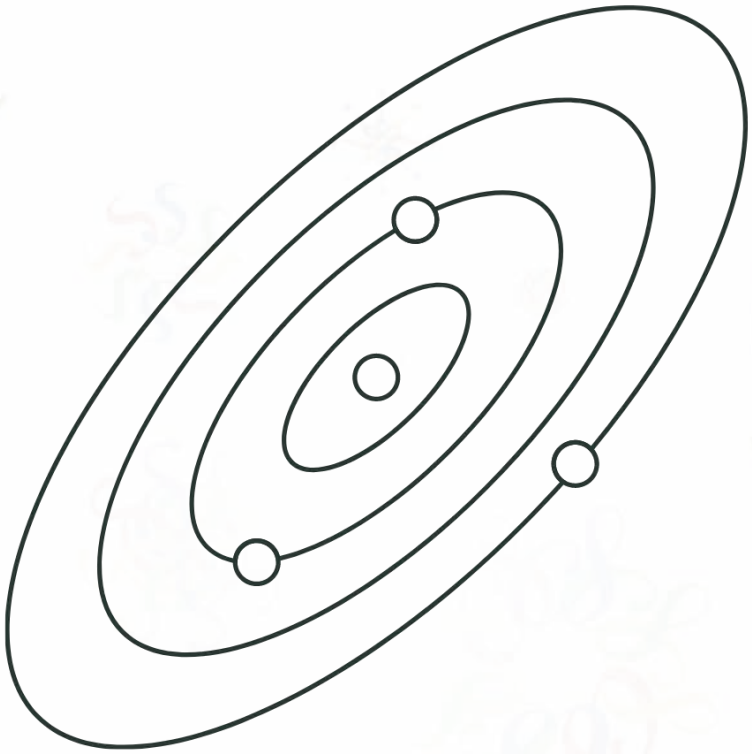
Piggly Bank Note

Today I saved 3 swocks, and 2 quips. I wanted all of my coins to be quips so I traded Jorgo all 3 of my swocks for 6 quips. Now I have 8 quips. 2 more quips and I'll have a whole norp! That's enough to buy a Snicky Way Bar!

Grocery List

- Brocamoule 2 Np
- Spagwetty 4 Np
- Myppins 6 Np
- Snicky Way Bar 1 Np
- Beenut Putter 3 Np
- Covfe 6 Np

KEPLIZMI EXPEDITION



ASTRONAUT TRAINING
&
FIELD JOURNAL

Brainstorming Strategies for Exploration:

- What do you already know about measurements? It is okay if you don't know some of these and it's ok to add some that aren't listed, they are just examples to get your brain looking for what it already knows.
    - Inches in one foot?
    - Feet in a yard?
    - Ounces in a cup?
    - Centimeters in a meter?
    - Grams in a kilogram?
    - Milliliters in a meter?
    - Pennies in a dollar?

- Think about what you learned about fractions. Can we use fractions to help make sense of different units of measurement?
    - What fraction of a foot is one inch?
    - What about 24 inches?

- Think about what you learned about multiplication and division. Are there multiplication and division strategies that can help me convert from one unit to another?

Sample Station Field Notes **Type of Measurement:** *Time*

Keplinian Units of Measurement Identified:

Seconds

Hours

Days

Months

Years

Clues:

A stopwatch goes up to 59 seconds then changes to a new minute.

A one-year calendar has 12 months.

A note says that John has been awake for 22 hours straight, 2 more and it's a whole day.

My Work (Pictures, Equations, etc.):

22 hours + 2 hours= 1 day

24 hours= 1 day

Keplinian Unit Conversions:

60 seconds = 1 minute

24 hours= 1 day

1 year = 365 days

12 months = 1 year

? days = 1 month

Station 1 Field Notes_____Type of Measurement:_____

Keplinian Units of Measurement Identified:

Clues:

My Work (Pictures, Equations, etc.):

Keplinian Unit Conversions:

Station 2 Field Notes_____Type of Measurement:_____

Keplinian Units of Measurement Identified:

Clues:

My Work (Pictures, Equations, etc.):

Keplinian Unit Conversions:

Station 3 Field Notes_____ Type of Measurement:_____

Keplinian Units of Measurement Identified:

Clues:

My Work (Pictures, Equations, etc.):

Keplinian Unit Conversions:

Station 4 Field Notes_____Type of Measurement:_____

Keplinian Units of Measurement Identified:

Clues:

My Work (Pictures, Equations, etc.):

Keplinian Unit Conversions:

Station 5 Field Notes_____Type of Measurement:_____

Keplinian Units of Measurement Identified:

Clues:

My Work (Pictures, Equations, etc.):

Keplinian Unit Conversions:

Wrap-Up: Making Sense of Our Discoveries

What strategies were most effective in figuring out the conversions?
What was the most difficult part of the expedition? What are you still confused about?
How could you use what you learned today to think about Earth's measurement systems?

No Stations Field Notes

Keplinian Units of Measurement Identified:

Type of Measurement (length, volume, etc.)	Units Identified & Clues

My Work (Pictures, Equations, etc.):

Keplinian Unit Conversions: