Data
How many are there? Let's just estimate!

For this activity, students use strategies for estimating as they answer order-of-magnitude problems. Discussions center on different strategies, reasonableness of solutions, and situations where estimates suffice (or are preferred) in real-life situations.

I. About the lesson

1. Mathematics content and process learning objectives
    a. Estimation
    b. Reasonableness of solutions
    c. Communicating and critiquing strategies
    d. Drawing upon experience and intuition

2. Related creativity traits
    a. Making connections
    b. Questioning norms
    c. Being inquisitive
    d. Identifying similarities and differences
    e. Having flexibility
    f. Having aesthetic taste
    g. Being unorthodox
    h. Being motivated
    i. Dismissing conventional thinking – new approaches and perspectives
    j. Convince others of the value of ideas

3. Other disciplinary connections including to everyday life
    a. Science
    b. Everyday life

II. Preparing for the lesson

Students can work with paper, pencil, and calculator. Not much in way of preparation is necessary for this lesson.

III. Conducting the lesson

1. Students can work individually, in pairs, or in small groups. (We wrote this lesson for small groups.)
2. Pose the following questions (or similar) to the students. The questions would be more meaningful if they were adapted to the demographics, geography, and age group of the students. Be sure to tell them that "smart"

technology is not allowed, as the point of the lesson would be lost if one could just search for the solutions online.

3. Give students ample time to discuss the questions. We suggest at least 20 minutes. (Or you can cut down on the number of questions.)
4. After that time, ask for each group's answers to each of the questions. You can reveal the actual answer and have students determine whether or not each estimate was within one order of magnitude (x1/10 to x10) of the actual answer. Students should be asked to describe their approach to each problem.
5. Suggested questions with answers in parentheses
    a. What is the area of the Pacific Ocean? (62.46 million sq miles)
    b. What is the thickness of paper? (0.1 mm= 0.004 inches)
    c. What is the weight of your foot? (2 lbs)
    d. How many gallons of gasoline are used in the US each year? (140.43 billion gallons)
    e. How many revolutions will the wheel of your car make between Montclair and Washington DC? (Average car diameter from the internet is= 20.83 inches. Distance between Montclair and DC= 227 miles= 14382720 inches. No. of revolutions= distance travelled÷(πd)= 219, 898 (approx.
    f. How many K12 teachers are there in NJ? (114,584)

IV. Assessment

1. In the spirit of embracing imprecision, no formal assessment is suggested. The instructor can move about the room to gauge the conversation, but the questions usually spark enough interest on their own.
2. Students should be encouraged to take notes on their process. One option is to assign one note-take for each question. The note-taker would take notes on the different paths (both fruitful and not) that the group took as they attempted each question.

V. Modifications to this lesson

1. Potential follow-up questions
    a. When in our everyday lives is an estimate enough? When is it preferred? Why is it preferred in those cases?
    b. Who uses estimate of this sort regularly in their profession?
    c. Come up with questions based on your interests (both academic and extracurricular). State why estimates would suffice in answering these questions.
2. An added challenge would be to pose questions that suggest very small numbers. For example, what is the diameter of a nerve cell? What is the weight of a goldfish tooth?