

Lesson 1.1: Introduction to Quantitative Reasoning

Theme: Citizenship

Main Math Topic	Main Quantitative Reasoning Context	Productive Persistence Focus	Level of Productive Struggle
Defining quantitative reasoning	Statistical data in media	Group norms	Level 1

Prerequisite Assumptions

Before beginning this lesson, students should be able to

- understand the concept of doubling.
- do calculations involving doubling or multiplication with numbers under 1,000.
- understand the structure of place value.

Specific Objectives

Students will understand that

- quantitative reasoning is the ability to understand and use quantitative information. It is a powerful tool in making sense of the world.
- relatively simple math can help make sense of complex situations.

Students will be able to

- identify quantitative information.
- round numbers (based on homework).
- name large numbers (based on homework).
- work in groups and participate in discussion using the group norms for the class.

Explicit Connections [Connections to future lessons]

- The foundation of quantitative reasoning is the mindset to ask questions about information.
- Estimation and understanding and using large numbers are two valuable skills that students will see used repeatedly in lessons.

Notes to Self

One thing I want to do during this lesson ...

One thing I want to pay attention to in my students' thinking ...

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One connection or idea I want to remember ...

Suggested Timeline

Duration	Activity	Suggested Structure
10 minutes	Set norms for group work and classroom discussion	Class discussion
5 minutes	Question 1	Students work/discuss in small groups with full-class discussion as indicated in lesson
10 minutes	Questions 2 and 3	
8 minutes	Question 4	
4 minutes	Question 5	Class discussion
8 minutes	Making Connections	Class discussion
5 minutes	Discussing the out-of-class experience (OCE)	Class discussion

Special Notes

This lesson has two overarching goals. The first is to introduce students to the concept of quantitative reasoning and to set the stage for this course. The problem situation utilizes math calculations and even has extensions to exponential growth, but the calculations are not the objective. Instead, the problem situation is designed to demonstrate to students that mathematics can be used to examine a quantitative situation. In teaching this lesson, you need to allow students to do enough of the mathematics to make sure they understand the situation and start to recognize that mathematical tools (such as exponents) can be useful, but not allow them to get bogged down or frustrated with calculations. The productive struggle of this lesson is around thinking about the situation and about which skills would be necessary to answer the question. This lesson also motivates the skills of rounding and naming large numbers, but again, you do not need to spend a lot of class time on these skills as the out-of-class experiences (OCEs) provide support for them.

The second goal is to establish a culture of discourse. Careful attention to how you facilitate the group work and class discussion will set the stage for the nature of the discourse in future classes. Be prepared with strategies that encourage students to speak up in class. For example:

- Listen to groups for observations, comments, or questions that students can share with the class.
- Allow wait time for questions. Do not answer your own questions.
- Do not allow individuals to dominate. You can avoid this by calling on individual students or by asking for a response from a certain part of the room (this can be less stressful than calling on a

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student). For example: “Now I’d like someone in the back row to answer.” Make it clear that blurting out an answer is not acceptable.

- Encourage students to respond to each other.
- Do not stand in the front of the room—if you are in the front, you are the focus.
- Honor any serious contribution. Thank students in class and after class for their comments.

While this is the first lesson, it is assumed that the beginning-of-term “business” (i.e., talking about the syllabus, policies, etc.) will be handled in another class period or that this lesson will be split over two days to allow for the business items to be spread over several days.

Regarding calculator use: Because this is the first lesson and students may not have calculators yet, this lesson is written so that students may or may not use calculators. The notes below indicate some of the choices you might make based on the amount of calculator use.

[Student Handout]

Specific Objectives

Students will understand that

- quantitative reasoning is the ability to understand and use quantitative information. It is a powerful tool in making sense of the world.
- relatively simple math can help make sense of complex situations.

Students will be able to

- identify quantitative information.
- round numbers (based on homework).
- name large numbers (based on homework).
- work in groups and participate in discussion using the group norms for the class.

Point out to students that the objectives for the lesson are on their student handouts. Explain to them that these are the things they should understand and be able to do after the lesson (which includes the OCE). Use the last objective to start the discussion on group norms. Explain the term *norms*.

Discuss the role of group work and class discussions. Points to consider:

- Why talking about concepts in both small and large groups is important
- Norms for group work and discussion
- Importance of respect
- Value of “wrong” answers
- How groups will be assigned

Put students into groups (since the group portion of the lesson is short, you may just want to do pairs). Emphasize that students should introduce themselves.

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[Student Handout]

Problem Situation: Does This Information Make Sense?

In this lesson, you will learn how to evaluate information you see often in society. You will start with the following situation.

You are traveling down the highway and see a billboard with this message:

Every year since 1950, the number
of American children gunned down
has doubled.

- (1) You do not see the name of the organization that put up the billboard. What groups might have wanted to publish this statement? What are some social issues or political ideas that this statement might support?

Discuss for one to two minutes in groups and then as a class. Students may not be accustomed to thinking in this way, so you may need to give an example to get them started. Here are some ideas:

- Gun control laws
- To convince people that America is a violent place
- To convince people that America is becoming more violent due to ...
 - violent video games
 - drug use
 - breakdown of the family
 - more immigrants
- To convince people to spend more money on police

Depending on your student population, you may choose to read this as a class. Check for understanding on the reading. Here are some prompts you might use:

- Ask for an example of doubling.
- What examples can you think of in which someone presents information to get you to vote a certain way? To donate money? To understand a health risk? (Choose one or two.)
- What is a reasonable answer to the question, “How many students are in this class?” What would not be reasonable?

[Student Handout]

The information in this statement is called *quantitative*. Quantitative information uses concepts about quantity or number. This can be specific numbers or a pattern based on numerical relationships such as doubling.

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You hear and see statements using quantitative information every day. People use these statements as evidence to convince you to do things like

- vote a certain way
- donate or give money to a cause
- understand a health risk

You often do not know whether these statements are true. You may not be able to locate the information, but you can start by asking if the statement is reasonable. This means to ask if the statements make sense. You will be asked if information is “reasonable” throughout this course. This lesson will help you understand what is meant by this question.

- (2) In 1995,¹ a group published the statement in the Problem Situation. Do you think this was a reasonable statement to make in 1995? Discuss with your group.
- (3) You only have the information in the statement. Using only that information, how can you decide if the statement is reasonable? Talk with your group about different ways in which you might answer this question.

Give students a few minutes to discuss Questions 2 and 3. This early in the course, they may struggle to come up with ideas, so monitor very carefully and do not allow the discussions to disintegrate or go off track. Move on to class discussion and prompt the students towards a strategy. In order to move on to Question 3, they need to start working with some numbers by choosing a starting value and doubling over time. Here are some suggestions about how to facilitate a discussion by building on student ideas.

Facilitation Prompts

Students may suggest that they have to know the starting number for 1950 ...

- Suppose you do know a starting number. What would you do with it?
- What if you made up a starting number, just to get an idea of the change? What kind of number would you want to use? (A number that is easy to work with, especially for doubling.)
- If you are testing to see if the statement is reasonable, would you use a very large number or a small number? (Both could have merits—might need to try both; a small number would be easier to work with so it is a good starting place.)
- If using a small number, would your calculations lead to overestimating or underestimating?

Students may think they have to know more information in general or have no ideas ...

- What do you know? (Years, doubling.)
- If you wanted to start exploring with numbers, what would you need to know? (A starting number. Go to questions above about making up a starting number.)

¹Best, J. (2001). *Damned lies and statistics*. University of California Press: Berkeley and Los Angeles.

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After you get some ideas out, have students start working with numbers. Depending on how much scaffolding they seem to need, you might suggest they start with increments of one year as shown in the table below or have them move directly on to Question 3.

The example answers below are based on starting with the smallest possible number for 1950 (1 child). However, you can also allow students to select a starting number. In this case, you want everyone to use the same starting number so that you can discuss the rounding.

Year	Number of Children
1950	1
1951	2
1952	4
1953	8
1954	16
1955	32

[Student Handout]

- (4) In Question 3, you thought about ways to decide if the statement was reasonable. One approach is to start with a number for the first year. Put this number into the table below. Complete the other values in the second column of the table. Do not complete the third column right now.

Year	Number of Children	Rounded (using words)
1950	<i>1</i>	
1960	<i>1,024</i>	<i>1 thousand</i>
1970	<i>1,048,576</i>	<i>1 million</i>
1980	<i>1,073,741,824</i>	<i>1 billion</i>
1990	<i>1,099,000,000,000</i> <i>(rounded to nearest billion)</i>	<i>1 trillion</i>
1995	<i>35,184,000,000,000</i>	<i>35 trillion</i>

Answers (in italics) do not appear on the student handout.

You will have to decide how long to allow students to work on this section in groups. Remember, the goal of the lesson is not the calculations themselves or the concepts about exponents. You want them to do enough work that they understand the calculations, but after that, the goal is to discuss the ideas of

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quantitative literacy. If groups have calculators, some may move to using exponents, but if that does not happen, you can move into class discussion and make the following points. As much as possible, get students to bring out each point.

- Calculations are based on repeated multiplication. For example, 1953— $1 \times 2 \times 2 \times 2$.
- A shorthand way to write that is 2^3 . (Note that the 3 is the number of years after 1950.)
- The number for 1995 is 2^{45} . (Can do other interim steps as needed)
- As you fill in the numbers, ask students to round and name the numbers. You will probably need to model this for them, and it is okay if you have to prompt them with the names. You want to avoid having the discussion bog down because they are trying to read the long list of digits.

Tell students that it is okay if they did not get every single step in this work. Today's lesson is more about the ideas behind the course. They will focus on math more in the future.

You may want to use a Think/Pair/Share strategy for some or all of the next questions. This strategy allows students to think about a question on their own for a short time, then discuss with a partner, then share with the class.

[Student Handout]

- (5) Does the number you predicted for the number of children shot in 1995 seem reasonable? What kind of information might help you decide?

Elicit ideas from students. At some point, you can give them the information that the current U.S. population is around 300 million. (Explain to students that this is a number they will use often in the course, so they should record it in their notes.) This makes it easy to see that the statement cannot be true. As a matter of interest, you may want to share with students that this error occurred when an author reworded the following statement: "The number of American children killed each year by guns has doubled since 1950." (This information is also in the OCE).

Note: The Making Connections section is the most important part of this lesson. Be sure to leave time for it. Explain to students that this section will occur in every lesson. There will always be classroom discussion about the important mathematical ideas. Students should take notes. You can support this by recording a few bullet points on the board. The first question of the OCE will always relate to this section of the lesson. Make sure the students realize this!

[Student Handout]

Making Connections

Record the important mathematical ideas from the discussion.

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Making Connections: Main Ideas to Highlight

The foundation of quantitative reasoning is the mindset to ask questions about information.

Estimation and understanding and using large numbers are valuable skills that students will see used repeatedly in lessons.

Facilitation Prompts

What skills or information did you need to determine if the statement was reasonable?

You will elicit many ideas from the students. Here are some points that are particularly important in this course. Use these points to bring out the two main ideas listed above.

- Used estimation and rounding.
- Needed some understanding of large numbers. (Note that large numbers occur in a lot of situations: population, national budget, environmental debates, even housing prices!)
- Needed a “benchmark” to measure the numbers by, some basic fact that is easy to remember and easy to verify for accuracy.
- Most importantly, needed the mindset to ask the question.
- What *was not* needed: a bunch of research, complex calculations, a lot of time.

Explain that this is a preview of what students can expect from this course—working with quantitative situations that help them understand their world.

Further Applications

Because this is the first lesson and the OCE contains extra reading, there are no Further Application questions included in this lesson.

Preparing Students for the OCE

The first OCE contains information to help students understand how the assignments are structured. Stress to them that it is important that they read it carefully. As time allows, you may want to go over some of the information in class.

Students can read the following information outside of class if you do not have time in class.

[Student Handout]

About This Course

This course is called a quantitative reasoning course. This means that you will learn to use and understand quantitative information. It will be different from many other math classes you have taken. You will learn and use mathematical skills connected to situations like the one you discussed in this lesson. You will talk, read, and write about quantitative information. The lessons will focus on three themes:

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- **Citizenship:** You will learn how to understand information about your society, government, and world that is important in many decisions you make.
- **Personal Finance:** You will study how to understand and use financial information and how to use it to make decisions in your life.
- **Medical Literacy:** You will learn how to understand information about health issues and medical treatments.

This lesson is part of the Citizenship theme. You learned about ways to decide if information is reasonable. This can help you form an opinion about an issue.

Today, the goal was to introduce you to the idea of quantitative reasoning. This will help you understand what to expect from the class. Do not worry if you did not understand all of the math concepts. You will have more time to work with these ideas throughout the course. You will learn the following things:

- You will understand and interpret quantitative information.
- You will evaluate quantitative information. Today you did this when you answered if the statement was reasonable.
- You will use quantitative information to make decisions.

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Key to OCE

- (1) i
(2) iii
(3) ii and iii
(4)

Hundred trillions	Ten trillions	Trillions	Hundred billions	Ten billions	Billions	Hundred millions	Ten millions	Millions	Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Ones	
10^{14}	10^{13}	10^{12}	10^{11}	10^{10}	10^9	10^8	10^7	10^6	10^5	10^4	10^3	10^2	10^1	10^0	Power of 10

- (5) i
(6) (a) iii; (b) i; (c) ii
(7)

	Number	Word/Number Combination
Number of children and adults with diabetes in 2010	25,800,000	25.8 million
Number of children under age 20 with diabetes in 2010	215,000	215 thousand
Cost due to diagnosed diabetes cases in 2007—includes medical costs, disability payments, loss of work, and premature death	\$174,000,000,000	\$174 billion

- (8) (a) Answers will vary. (b) Answers will vary. (c) yes; (d) no; (e) (Answers will vary. At this point, students probably will not think this question through as deeply as the following answer, but this will be revisited later.) The rounded number would be easier to work with and in terms of relative size, is accurate enough. The population counts have the appearance of high accuracy because they are not rounded, but they are still just estimates.
- (9) Answers may vary.
- (10) Answers may vary.
- (11) Answers may vary.

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- (12) (a) Answers may vary. (b) Answers may vary. (c) Answers may vary.
- (13) Answers may vary.

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