3-5 At-Home Learning Resources (Blue Packet)

Week #6

The Richland School District cares deeply about the well-being of our students and families. We highly encourage our students and families to set a daily routine that includes the following:

For our elementary families:

- Read daily with your child
- Play family games (board games, cards, puzzles, charades, pictionary, etc.)
 - Engage in an outside activity
 - Cook/bake with your child
 - Maintain relationships with your child's teacher

These supplemental activities, readings, and other resources are available to students and families to continue learning and exploring while schools are closed in response to the novel coronavirus.

Students are not required to complete and/or turn in any assignments nor will any of these materials be used to assess students academically. Please feel free to use these optional resources as needed. Additional resources are available at: <u>https://www.rsd.edu/programs/at-home-learning/pre-k-elementary-resources</u>

Vocabulary

Word Knowledge

Antonym Dominoes



Objective

The student will identify antonyms.

Materials

Antonym domino cards (Activity Master V.002.AM1a - V.002.AM1b)

Activity

Students match antonyms by playing a domino game.

- 1. Scatter antonym domino cards face up on a flat surface.
- 2. Taking turns, student one places the START domino on the table, and reads the word on the other end of the domino (i.e., awake).
- 3. Looks for a domino with an antonym (i.e., asleep). Connects it to the domino.
- 4. Student two reads the word on the other side of the domino (i.e., brave), finds the domino with a matching antonym (i.e., fearful), and reads the word. Connects it to the domino.
- 5. Continue until all the dominoes are connected.
- 6. Peer evaluation



Extensions and Adaptations

- Use synonym dominoes (Activity Master V.002.AM2a -V.002.AM2b).
- Make other dominoes (Activity Master V.002.AM3).



Antonym Dominoes



START/awake, asleep/brave, fearful/brief, long/capture, release/allow, forbid/success

V.002.AMIa

Vocabulary

Antonym Dominoes

V.002.AMIb



failure/answer, question/argue, agree/plus, minus/rude, polite/hero, coward/STOP



START/anger, rage/surprise, astonish/one, single/hide, conceal/wealth, riches/pardon

Vocabulary

Antonym Dominoes - Adaptation (Synonyms)

V.002.AM2b



forgive/supply, provide/vacant, empty/turn, revolve/terrify, frighten/write, record/STOP



V.002.AM3

Antonym Dominoes



blank dominoes



Comprehension

Text Analysis

Inference Innovations

Objective

The student will make inferences.

Materials

- Text
 - Choose text within students' instructional-independent reading level range. Choose text from which inferences can be made.
- Student sheet (Activity Master C.029.SS1)
- Sticky notes
 Place sticky notes throughout the text in places where it is appropriate to make inferences.
- Pencils

Activity

Students use information from text combined with background knowledge to make inferences.

- 1. Provide the student with a copy of the text and multiple copies of the student sheet.
- 2. The student reads up to the first sticky note.
- 3. Determines what the author is suggesting by using the information from the text and what is already known about the content.
- 4. Writes that information in the designated columns on the student sheet. Uses multiple sheets, if necessary.
- 5. Reviews recorded information and writes an inference in the designated box.
- 6. Teacher evaluation



Extensions and Adaptations

- Compare and discuss inferences with a partner.
- Use graphic organizers to write inferences (Activity Master C.029.SS2 and C.029.SS3).

Name

Inference Innovations

C.029.SSI

Inference			
I know			
Text says			

Name

C.029.SS2

Inference Innovations



Name

Inference Innovations

C.029.SS3



Questions to Ask Before, During, and After Reading

These are questions to help engage students in discussions and conversations about reading. These questions are just suggestions and other questions can be added to this list based upon the type of reading students are involved in.

Before Reading

- What is the title of the book or text?
- What does this title make you think about?
- What do you think you are going to read about? (Make a Prediction)
- Does this remind you of anything?
- Are you wondering about the text or do you have any questions before reading?
- Skim through the article. Do any pictures, key words, and/or text features stand out to you?

During Reading

- What is happening so far?
- What does the word _____ mean on this page?
- What do you think the author is trying to communicate in this part?
- What do you think was important in this section? Why do you think it was important?
- What can you infer from this part of the text?
- Where is the story taking place?
- Who are the characters so far?
- What do you think will happen next?
- What does this part make you think about?
- What questions do you have?
- What words help you visualize what the author is saying?
- Is there a word that you struggled with? What is the word? Let's break the word into parts and look at context clues.

After Reading

- What was this text about?
- What was the main idea? What details from the text helped you determine the main idea?
- What did you learn from this text?
- How did the author communicate his/her ideas?
- What does this text remind you of?
- What was your favorite part and why?
- Did this text have a problem? If so, what was the problem and what was the solution?
- What is your opinion about this text? What are some parts that helped you make that opinion?
- What are some questions you still have about the text?
- Does this text remind you of other texts you have read? How are they alike and/or different?
- What is a cause and effect from the text you read?

	Cross-Curricular Reading Comprehension Worksheets: C-23 of 36
Displaying Data Cross-Curricular Focus: Mathematics	Name:
	Answer the following questions based on the
There are many kinds of graphs that can be used to show information. Another name for information is data . Graphs make reports and science research more powerful. They let	reading passage. Don't forget to go back to the passage whenever necessary to find or confirm your answers.
us see with our eyes what the numbers actually mean. They bring the numbers to life so we can analyze them. We can look at the results and understand them better. You choose a graph depending on what you want to	1) Why should you use graphs to display your data?
information stand out. When you have data to include in a	
data best. A pie chart is good for showing a part of a whole. A line	 If you wanted to show how much of your allowance you spent on each thing you bought,
something changes over time. It is also good for showing bin differences. Use it to compare the highest and lowest	which graph would be a good choice?
numbers or the shortest and tallest plants. Data is represented with pictures or symbols on a pictograph. Each	3) Which kind of graph allows you to use lots of
picture or symbol can represent whatever number of items vou choose. A colorful bar graph can show changes over	color to display your data?
time. You can also use it to make comparisons between two or more things. A Venn diagram uses two overlapping	4) How is a Venn diagram used?
circles. They are perfect for sorting information. You can use	
go on the left. Plants with flowers go on the right. Plants with both go in the middle where the circles overlap	5) What kind of graph would you be willing to try
Choosing the right graph can help you create a better	
to understand.	

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of and and and all and a second	Cross-Curricular Keading Comprehension Worksheets: D-27 of 36
What S Iour Angle:	Name:
Cross-Curricular Focus: Mathematics	Answer the following questions based on the reading passage. Don't forget to go back to the
Did you know that an angle is part of a circle?	passage whenever necessary to find or confirm your answers.
A circle is divided up into 360 tiny little slices, called degrees. The word "degrees" can also be replaced by this mathematical symbol: °. It is usually written after the number in a measurement, such as 360°. When you	1) Why do we measure angles in degrees?
measure an angle, you are counting how many of the circle's 360° fit in the space between the two arms of the angle	2) Which kind of angle has a special symbol that
A straight angle forms when the two arms of the angle lav flat in a straight line. A straight angle	helps you know its measurement?
measures 180°. A right angle forms a perfectly square corner, as in a rectangle. A right angle measures exactly	
90°. An angle with less than 90° is called an acute angle. An angle that has more than 90° is called an	b) what tools can help you find out the precise measurement of an angle?
obtuse angle. It is nossible to estimate the size of an angle just by	
Nith a right andle. a special symbol lefs vou know	4) What is another name for a straight angle?
quickly that it measures exactly 90°. The special symbol is a small source inside the angle. For other angles, you	
may want to use either a protractor or an angle ruler. Both have markings that show the degrees of a circle.	5) Which is larger, an acute angle or an obtuse angle?
You can line them up with the arms of the angle you want to measure. It will tell how much of the circle fits	
between the two arms of the angle.	

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****	CLOSS-CUTICUAL REACTING COMPLETENSION VORKSHEETS. E-30 01
Meteorologists Cross-Curricular Focus: Earth Science	Name:
	Answer the following questions based on the reading
Meteorology is the scientific study of the weather. The scientists who specialize in this area are called meteorologists. Their job is to	whenever necessary to find or confirm your answers.
collect data, make observations about the data and interpret the data. T interpret means to say what they think the data means. Their goal is to	1) Which direction do most weather systems move in the
make informed predictions about what kind of weather we can expect. Most weather systems in the United States move from the west to	United States?
the east. Meteorologists track weather patterns to the west. Then they can be reasonably sure of the kind and severity of the weather that is	
approaching the areas that lie to the east. Technological advances over the years have made the work of the	2) Do vou think it is easier or harder than it used to he to he
meteorologists more and more respected. Over time, their ability to makaccurate predictions has increased. Using commuters, meteorologists	e a meteorologist? Explain your thinking.
are able to design and print weather maps. The maps show approachin	
weather patterns and how they are likely to behave when they reach us	
temperatures of wind, cloud formations, and storm systems.	
Doppler radar stations provide meteorologists with radar images of weather all over the United States. They make it possible to anticipate	b) Name (wo technologically auvanced tools that a meteorologist uses.
weather systems sooner, and to understand how strong they are.	
Weather balloons are sent up into the higher levels of the atmosphere	
to gather data and take pictures. Satellites relay weather data from high	
above Earth down to reporting stations. In addition to their high-tech computers and radar systems,	4) What is the central idea of this reading passage?
meteorologists have some basic weather instruments that have	
been around for many years. We are all familiar with the first one: a thermometer. A thermometer allows us to measure the air temperature	
using either the Celsius or Fahrenheit scale. The United States mostly	
uses the Fahrenheit scale. An anemometer is used to measure the spe of the wind as it blows. A weather vane, or wind vane, is used to show	d 5) What is an anemometer?
the direction the wind is blowing. A barometer measures air pressure. Ir	
spite of all these tools, there is always a little bit of mystery involved in	
the weather.	

Cross-Curricular Reading Comprehension Worksheets: E-30 of 36

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"Becoming Jane: The Evolution of Dr. Jane Goodall" is a multimedia exhibition charting the life and career of the world's foremost expert on chimpanzees. (AF Archive/Alamy Stock Photo/Ray in Manila/Flickr)

Immerse yourself in Jane Goodall's wondrous, chimpanzee-filled life



By Katherine J. Wu Smithsonian Magazine February 21, 2020

No one knows chimpanzees like Jane Goodall.

The now 85-year-old English researcher has revolutionized the entire field of primatology. This occurred over the past six decades. Goodall was among the first to study her subjects in the wild. She treated them as conscious, complex individuals. She showed they have distinct personalities

and surprising quirks. She found that chimps displayed a wide range of emotions. They engaged in longstanding relationships. They have startling spates of violence. They were tool users and meat-eaters. They were ticklish.

Goodall argued that chimpanzees were worthy of names. They were worthy of respect.

Goodall's work opened the world's eyes to our closest great ape relatives. Now, that lens has finally been reversed. This comes six decades after she began her first round of fieldwork. That was in Tanzania in 1960.

There's an ongoing multimedia exhibition at the National Geographic Museum in Washington, D.C. It charts the life and career of the world's foremost expert on chimpanzees. It's titled "Becoming Jane: The Evolution of Dr. Jane Goodall." The show invites https://www.tweentribune.com/article/tween56/immerse-yourself-jane-goodalls-wondrous-chimpanzee-filled-life/

4/2/2020

Immerse yourself in Jane Goodall's wondrous, chimpanzee-filled life | Smithsonian TweenTribune

patrons to journey alongside Goodall. It takes visitors on a journey. It follows her earliest scientific explorations to her current adventures.

Goodall's story is told through a collection of childhood mementos and field notes. It displays other personal effects. Her story begins early in childhood. Her first recorded encounter with a chimpanzee happened at age one. Her father gifted her with a stuffed toy primate named Jubilee. Goodall kept the plush chimp close throughout her adult life. More than eight decades later, it is understandably worn. That's according to Erin Wayman writing for Science News.

Also evident in the display is Goodall's passion for nature. She had her favorite books. These included "Tarzan of the Apes" and "The Story of Doctor Dolittle." Goodall spent her free time doodling when she was a bit older. She anatomically labeled careful drawings of wild animals with her friends.

"Jane was always Jane," said Kathryn Keane. She is director of the National Geographic Museum. She shared this with the Washington Post's Stephanie Williams last month. "She was born with this incredible curiosity, incredible bravery and desire to explore the world that was so obvious, even at such an early age. It seemed predestined for her to do what she did."

The lines between Goodall's personal and professional passions for wildlife quickly blur. Her life hit a clear milestone in 1960. It was her first research foray into the Gombe Stream Game Reserve. It's located in what's now Tanzania. This was under the mentorship of famed paleoanthropologist Louis Leakey. This trip is immortalized by a facsimile of Goodall's campsite. It was a bare bones setup. A 3-D film immerses viewers in some of her most impactful observations on chimpanzee behavior. Patrons can also enjoy an interactive experience. This is at the "Chimp Chat" station. It invites users to mimic various primate vocalizations. This includes hoots, hollers and all.

The show also hits more somber notes. Chimpanzee populations worldwide continue to dwindle. This is under the combined threats of poaching, habitat destruction and disease. Researchers and conservationists are fighting to rescue them from the brink. This fight includes Goodall. The show suggests that the future of these animals is in our hands.

But the exhibition's star is reason enough not to lose hope. Sixty years into her career, Goodall and her inspiring work carry on.

"At 85 years old, she still travels 300 days a year doing her advocacy and education work," Keane told Williams last year. "This exhibit is to really celebrate Jane. It just felt like the right time to do this."



Endangered Species: The chimpanzee

By Gale, Cengage Learning, adapted by Newsela staff on 01.11.18 Word Count **717** Level **810L**



Image 1. Three chimpanzees sit in a tree in the African country of Uganda. Human's closest relatives, chimps are very social animals. They live in groups of up to 60 chimps. Photo from: USAID Africa Bureau.

Chimpanzees, gorillas and orangutans are all considered great apes. Of the three, chimpanzees are the most closely related to humans. Chimpanzees and humans share most of the same genetic makeup. Genes are made up of DNA. They hold the information that tells bodies how to grow. Thanks to their similar DNA, chimps and humans share many traits. Scientists have documented chimpanzees expressing complex emotions. They have seen the animals forming bonds and friendships. They have even seen chimps communicating using sign language.

An average chimpanzee stands 5 feet tall and weighs about 150 pounds. Chimps walk on the ground. Because their arms are longer than their legs, a chimpanzee walks using both its feet and the knuckles of its hands. Most of its body is covered with long black hair. A chimpanzee's hairless face can range in color from almost white to almost black. The hair around a chimpanzee's face grays with age. Older chimpanzees often become bald.

Chimpanzees are highly social animals. They live in communities made up of 30 to 60 members. During the day, the animals often travel on the ground. At night, they stay in nests they build in treetops. A chimpanzee's diet consists mainly of fruit, but they also eat insects, leaves, flowers, seeds and eggs. At times, chimpanzees band together to hunt animals. They hunt for antelope and monkeys.

Mating between chimpanzees takes place anytime during the year. Unlike many other animals, female chimpanzees do not have to mate with the dominant male in their group. Instead, females often mate with males of their choosing. After mating, there is a pregnancy period of 230 to 240 days. It ends with a female giving birth to a single infant. Bonds between



mothers and infants are very strong, and some last a lifetime.

Habitat

A few hundred years ago, several million chimpanzees lived in Africa. They covered a range of ecosystems, from dense forests to open grasslands. Today, there are thought to be fewer than 300,000 chimpanzees in the wild. They can be found across a wide area of central Africa.

Thousands of chimpanzees live in captivity around the world. In the United States, there are 2,000 chimpanzees in captivity. Many are used as subjects in medical studies. Others are kept as zoo exhibits, entertainment props or pets. In 2015, the U.S. government declared all chimpanzees endangered. This means that all captive chimpanzees in the United States are covered by the same protections that apply to wild chimpanzees. They are protected under the Endangered Species Act. This law limits the selling and buying of the animals. However, it still allows the use of chimpanzees as pets and in the entertainment business.

History And Conservation

Habitat destruction has led to a decline in the number of chimpanzees. So have disease and expanding human populations. Mining has destroyed the chimpanzee habitat in parts of Sierra Leone and Liberia. The cutting of forests for timber has destroyed the animals' habitat in Uganda. Forest removal has also threatened chimpanzees in Rwanda and Burundi.

Certain laws restrict the hunting and sale of chimpanzees. However, these laws are not always enforced. Many chimpanzees are killed for their meat. Others are caught and traded illegally. For each chimpanzee successfully shipped overseas, 10 die during transport. In the African countries Gambia and Zambia, there are sanctuaries for orphaned chimpanzees. Most African nations have passed laws to set aside safe areas for the animals.

In 2003, a group of scientists issued a warning. They called for chimpanzees to be classified as critically endangered. This was the result of new data from Gabon and the Democratic Republic of the Congo. The data showed that the ape population in these African countries had fallen by half between 1983 and 2000. One of the reasons for the decline was hunting. Another was outbreaks of Ebola, a very deadly disease.



The scientists warned that chimpanzees were in more danger of dying out than people realized. In 2015, scientists in England made an announcement. They said that they had created an Ebola vaccine for chimpanzees. That is good news for wild chimpanzee populations.

Quiz

3

4

1 If more chimpanzee habitat is preserved, it would take a long time for the chimpanzee population to increase from thousands back to millions.

What is the reason this population growth would take a long time?

- (A) Chimpanzees are protected under the Endangered Species Act.
- (B) Chimpanzees live in communities of 30 to 60 members.
- (C) Chimpanzees can mate with any male in their community.
- (D) Chimpanzee mothers give birth to one baby at a time.
- 2 Read the list of sentences from the article.
 - 1. Thanks to their similar DNA, chimps and humans share many traits.
 - 2. They have seen the animals forming bonds and friendships.
 - 3. Habitat destruction has led to a decline in the number of chimpanzees.
 - 4. The data showed that the ape population in these African countries had fallen by half between 1983 and 2000.

What two MAIN ideas does this evidence support?

- (A) Mining has destroyed much of the chimpanzee's habitat; chimpanzees are very social animals who live in groups.
- (B) Several nations have sanctuaries for orphaned chimpanzees; chimpanzees are also held in captivity.
- (C) Chimpanzees are closely related to human beings; chimpanzees face several threats to their survival.
- (D) Chimpanzees are hunted for their meat; scientists have created an Ebola vaccine for chimpanzees.

Which of these animal species has the most in common with chimpanzee mothers?

- (A) Elephant mothers will form bonds with their offspring that last over 50 years.
- (B) Mice mothers are pregnant for 19-21 days before giving birth to their young.
- (C) Dogs will give birth to litters of 5-8 puppies at one time and can have more than one litter a year.
- (D) Manatee mothers give birth to live young that weigh around 65 pounds.
- Read the summary of the article.

The chimpanzee, a member of the great ape family, is a close relative of human beings. Chimps are highly social animals who live in large groups in the grasslands of central Africa. Additionally, thousands of chimps live in captivity around the world.

Which option below would BEST complete the summary?

- (A) Mining had destroyed much of the chimpanzee's habitat in Sierra Leone and Liberia.
- (B) Chimpanzees are endangered due to loss of land, hunting and deadly diseases.
- (C) Most African nations have set up sanctuaries for orphaned chimpanzees.
- (D) Chimpanzees are sometimes caught and transported to the United States illegally.

This article is available at 5 reading levels at https://newsela.com.

- 1. Decrease consumer demand for diamonds.
- 2. Provide alternatives to timber for construction.
- 3. Expand captive breeding programs in zoos.
- (A) 1 and 2
- (B) 2 and 3
- (C) 1 and 3
- (D) 1, 2 and 3
- Look at Image 1 at the beginning of the article and read the first paragraph of the article.

Chimpanzees, gorillas and orangutans are all considered great apes. Of the three, chimpanzees are the most closely related to humans. Chimpanzees and humans share most of the same genetic makeup. Genes are made up of DNA. They hold the information that tells bodies how to grow. Thanks to their similar DNA, chimps and humans share many traits. Scientists have documented chimpanzees expressing complex emotions. They have seen the animals forming bonds and friendships. They have even seen chimps communicating using sign language.

How does the image support the information in this paragraph?

- (A) It compares chimpanzees to gorillas and orangutans.
- (B) It confirms the way that chimpanzees communicate.
- (C) It illustrates some social traits that chimpanzees share with humans.
- (D) It explains how DNA impacts the growth of chimpanzees.

According to information from the article, what is a benefit of chimpanzees living in groups compared to individually?

- (A) the ability to hunt certain animals
- (B) protection from predators at night
- (C) increased mother- infant bonding
- (D) mating with the dominant male
- Examine Image 2 in the introduction [paragraphs 1-4].

What does the image show about the chimpanzee?

- (A) It shows the areas where the chimpanzee's habitat is in the most danger.
- (B) It shows how the chimpanzee interacts with its infant.
- (C) It shows how chimpanzees walk with their knuckles and feet.
- (D) It shows basic information and characteristics about chimpanzees.

5

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7

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Reading

- Read the poem "Why Salt" by yourself or with someone in your family.
- Think about what the poem says about how salt gets to the ocean water.
- Highlight or circle any words in the poem that are new to you.

Speaking

- Read the poem aloud to someone in your family.
- Explain to someone in your family the process of salt getting to ocean water. Why does the salt stay in the water?
- Explain an experience that you've had with salt water.

Listening

- Have someone else in your family read the poem aloud to you.
- Close your eyes while you listen to the poem and imagine pictures in your mind that match the words in the poem.

Writing

- Under the poem, write about the process of salt getting into the ocean water?
- Under the poem, write about a personal experience you've had at the ocean. If you have never been to the ocean, write what you would do if you did go to the ocean.



Why is there salt in the ocean water? Have you ever been to the ocean? Write about a time you played in salt water. If you've never visited the ocean, write what you would do if you did visit the ocean.

Writing Ideas 3-5 Elementary Week #6

Students can compose sentences and/or paragraphs to respond to the prompts and ideas below. This will vary depending on their age/grade level.

Narrative

• April showers bring May flowers! Tell about a time when you had a raining day adventure or create a new story of a rainy day adventure! Be sure to include characters, sequence of events, details, descriptions, and the setting. Establish an introduction, middle, and conclusion.

Opinion/Argument

• What is your favorite season? Winter, Spring, Summer, or Fall? Write an opinion piece on your favorite season. Why is this season the best? Add reasons, examples, and/or details to support your opinion. Be sure to have an introduction and a conclusion that relates to the opinion stated.

Informational/Explanatory

Mother's day is coming up soon! Interview someone you know who is a mother! It can be anyone you know. Brainstorm a list of questions you want to ask them about being a mom. You can call them on the phone or email them. Learn as much as you can about that person and write an informational piece on them. Introduce the person and add be sure to add enough facts, information, and/or details. Introduce your topic and have a conclusion.

Writing in Response to Reading Bingo

Complete the Bingo board by engaging in various writing ideas from this week's reading selections. Try to get 3-in-a row!

Vocabulary words are fun! Write a story, song, or poem using some of the words from this week's reading! Want additional fun, create your own game like bingo or memory using this week's words!	Want to learn more about chimpanzees? Conduct some additional research on them? In a letter to a friend or family member, describe what you found out about chimpanzees.	Write about how the two reading selections Immerse yourself in Jane Goodall's wondrous, chimpanzee-filled life and Endangered Species: The chimpanzee are similar and/or different.
Create a Prezi, PowerPoint, Poster, and/or infographic about something you learned from the reading selections. Present what you learned to a family member!	WRITER'S CHOICE	Want to learn more about angles? Maybe you want to learn what professions use angles. Do some research and find more information about angles. Write an informative piece about your findings.
Chimpanzees are fascinating animals! Write your own narrative story about the adventures of a chimpanzee! Be sure to have an introduction, a conclusion, and details.	Many jobs and business use data! Conduct some research on that job or business and write an informational piece on your findings! For some extra fun, collect some data on something that interests you. Represent that data in a chart or table.	Want to learn more about meteorology? Do some research! You can write an informational piece on what you learned or a narrative piece about the adventures of a meteorologist!

	Roll a Fraction	
Mat	rials: Roll a Fraction boards, 2 number cubes (1-10)	Number of Players: 2
.	Each player chooses a board. Take turns to roll to create a fraction. You may decide which number and which number will the denominator.	two number cubes to r will be the numerator
<u>0</u>	If the fraction you rolled belongs on a number lin it below the appropriate point and explain your th does not belong on any of your number lines you next turn. You may use equivalent fractions. For $\frac{1}{2}$ you may record $\frac{2}{4}$, $\frac{3}{6}$ or $\frac{4}{8}$ because all of these f equivalent to $\frac{1}{2}$.	ne on your board write hinking. If the fraction u must wait until your example, if you roll fractions are
с С	he first player to label ten points on the number l board wins the game.	lines on his or her

















 \mathbf{C} Comparing Fractions to a Benchmark Cards: Set 2



I Comparing Fractions to a Benchmark Cards: Set 3 I I ľ T I

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Activity 5

Twenty Guesses—Information Theory

Summary

How much information is there in a 1000-page book? Is there more information in a 1000-page telephone book, or in a ream of 1000 sheets of blank paper, or in Tolkien's *Lord of the Rings*? If we can measure this, we can estimate how much space is needed to store the information. For example, can you still read the following sentence?

Ths sntnce hs th vwls mssng.

You probably can, because there is not much 'information' in the vowels. This activity introduces a way of measuring information content.

Curriculum links

- ✓ Mathematics: Number Level 3 and up. Exploring number: Greater than, less than, ranges.
- ✓ Algebra Level 3 and up. Patterns and sequences
- ✓ English

Skills

- ✓ Comparing numbers and working with ranges of numbers
- ✓ Deduction
- ✓ Asking questions

Ages

✓ 10 and up

Materials

- \checkmark No materials are required for the first activity
- There is an extension activity, for which each child will need:
- ✓ Worksheet Activity: Decision trees (page 40)

Twenty Guesses

Discussion

- 1. Discuss with the children what they think information is.
- 2. How could we measure how much information there would be in a book? Is the number of pages or number of words important? Can one book have more information than another? What if it is a very boring book, or a particularly interesting one? Would 400 pages of a book containing the phrase "blah, blah, blah" have more or less information than, say, the telephone directory?

Explain that computer scientists measure information by how surprising a message (or book!) is. Telling you something that you know already—for example, when a friend who always walks to school says "I walked to school today"—doesn't give you any information, because it isn't surprising. If your friend said instead, "I got a ride to school in a helicopter today," that *would* be surprising, and would therefore tell us a lot of information.

How can the surprise value of a message be measured?

One way is to see how hard it is to guess the information. If your friend says, "Guess how I got to school today," and they had walked, you would probably guess right first time. It might take a few more guesses before you got to a helicopter, and even more if they had travelled by spaceship.

The amount of information that messages contain is measured by how easy or hard they are to guess. The following game gives us some idea of this.



Twenty Questions Activity

This is an adapted game of 20 questions. Children may ask questions of a chosen child, who may only answer yes or no until the answer has been guessed. Any question may be asked, provided that the answer is strictly 'yes' or 'no'.

Suggestions:

I am thinking of:

- \checkmark a number between 1 and 100
- \checkmark a number between 1 and 1000
- \checkmark a number between 1 and 1,000,000.
- ✓ any whole number
- ✓ a sequence of 6 numbers in a pattern (appropriate to the group). Guess in order from first to last. (e.g. 2, 4, 6, 8, 10)

Count the number of questions that were asked. This is a measure of the value of the "information".

Follow-up Discussion

What strategies did you use? Which were the best ones?

Point out that it takes just 7 guesses to find a number between 1 and 100 if you halve the range each time. For example:

Is it less than 50?	Yes.
Is it less than 25?	No.
Is it less than 37?	No.
Is it less than 43?	Yes.
Is it less than 40?	No.
Is it less than 41?	No.
It must be 42!	Yes!

Interestingly if the range is increased to 1000 it doesn't take 10 times the effort—just three more questions are needed. Every time the range doubles you just need one more question to find the answer.

A good follow up would be to let the children play Mastermind.

Extension: How much information is there in a message?

Computer scientists don't just use guessing with numbers—they can also guess which letter is more likely to be next in a word or sentence.

Try the guessing game with a short sentence of 4-6 words. The letters must be guessed in the correct order, from first to last. Get someone to write down the letters as they are found and keep a record of how many guesses it takes to find each letter. Any questions with a yes/no answer can be used. Examples would be, "It it a *t*?" "Is it a vowel?" "Does it come before *m* in the alphabet?" A space between words also counts as a "letter" and must be guessed. Take turns and see if you can discover which parts of messages are easiest to find out.

Worksheet Activity: Decision Trees

If you already know the strategy for asking the questions, you can transmit a message without having to ask anything.

Here is a chart called a 'decision tree' for guessing a number between 0 and 7:



What are the yes/no decisions needed to 'guess' the number 5?

How many yes/no decisions do you need to make to work out any number?

Now look at something very fascinating. Underneath the numbers 0, 1, 2, 3... in the final row of the tree write the number in binary (see Activity 1).

Look closely at the tree. If no=0 and yes=1, what do you see?

In the number guessing game we try to choose questions so that the sequence of answers works out to represent the number in exactly this way.

Design your own decision tree for guessing numbers between 0 and 15.

Extra for experts: What kind of tree would you use to guess someone's age? What about a tree to guess which letter is next in a sentence?

What's it all about?

A celebrated American mathematician (and juggler, and unicyclist) called Claude Shannon did a lot of experiments with this game. He measured the amount of information in bits-0 each yes/no answer is equivalent to a 1/0 bit. He found that the amount of "information" contained in a message depends on what you already know. Sometimes we can ask a question that eliminates the need to ask a lot of other questions. In this case the information content of the message is low. For example, the information in a single toss of a coin is normally one bit: heads or tails. But if the coin happens to be a biased one that turns up heads nine times out of ten, then the information is no longer one bit-believe it or not, it's less. How can you find out what a coin toss was with less than one yes/no question? Simple—just use questions like "are the next *two* coin tosses both heads?" For a sequence of tosses with the biased coin, the answer to this will be "yes" about 80%, of the time. On the 20% of occasions where the answer is "no," you will have to ask two further questions. But on average you will be asking less than one question per coin toss!

Shannon called the information content of a message "entropy". Entropy depends not only on the *number* of possible outcomes—in the case of a coin toss, two—but also on the *probability* of it happening. Improbable events, or surprising information, need a lot more questions to guess the message because they tell us more information we didn't already know—just like the situation of taking a helicopter to school.

The entropy of a message is very important to computer scientists. You cannot compress a message to occupy less space than its entropy, and the best compression systems are equivalent to a guessing game. Since a computer program is making the 'guesses', the list of questions can be reproduced later, so as long as the answers (bits) are stored, we can reconstruct the information! The best compression systems can reduce text files to about a quarter of their original size—a big saving on storage space!

The guessing method can also be used to build a computer interface that predicts what the user is going to type next! This can be very useful for physically disabled people who find it difficult to type. The computer suggests what it thinks they are likely to type next, and they just indicate what they want. A good system needs an average of only two yes/no answers per character, and can be of great assistance to someone who has difficulty making the fine movements needed to control a mouse or keyboard. This sort of system is also used in a different form to 'type' text on some cellphones.

Solutions and hints

The answer to a single yes/no question corresponds to exactly one bit of information whether it is a simple question like "Is it more than 50?" or a more complex one like "Is it between 20 and 60?"

In the number-guessing game, if the questions are chosen in a certain way, the sequence of answers is just the binary representation of the number. Three is 011 in binary and is represented by the answers "No, yes, yes" in the decision tree, which is the same if we write no for 0 and yes for 1.

A tree you would use for someone's age might be biased towards smaller numbers.

The decision about the letters in a sentence might depend upon what the previous letter was.