



Expanding the Universe

By Marcie A. Farrell, Revised by Heather Miller

Focus on Inquiry

Students will make inferences and explanations based on observations recorded using a student-made model of the universe. Additionally, students will explore how evidence supports existing theories and/or can lead to the changes in existing theories.

Lesson Content Overview

Students will explore with three dots marked on a balloon that, as the universe expands, the galaxies appear further and further apart. Observational data that the galaxies are moving further apart provides evidence of the expansion of the universe and the Big Bang Theory. In working with and discussing galaxies and the universe, students will gain a greater understanding of the hierarchy of celestial objects and of distances in space.

Duration 2 days @ 50 min/day	Setting Classroom	Grouping Cooperative groups of 3-4 students	PTI Inquiry Subskills 1.1, 1.3, 2.1, 2.2, 2.5, 3.1, 3.2, 3.5, 3.7, 4.2, 4.3, 5.2, 5.8, 7.2, 7.3, 7.4
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Lesson Components	Estimated Time Day 1	Estimated Time Day 2	Inquiry Subskills Used	Technology Used	Level of Student Engagement	Brief Description
Engage	5 min		1.1, 1.3	Proboard or smartboard, electronic devices	2	Students view and discuss a video clip about our expanding universe. Then they contemplate the boundary of our universe (if any). Alternate also available)
Explore	30 min		2.1, , 2.2 2.5, 3.1, 3.2, 3.5, 3.7, 4.2, 4.3, 5.2, 5.8, 7.3	None	3	Students use an expanding balloon and drawn dots to model the universe. Students will take measurements of the distance between the dots as the balloon expands.
Explain	15 min	30 min	7.4	Optional Electronic devices	2	Students will respond to questions about their activity and collaborate with other groups to share data and discuss the ideas related to the activity. Students understanding of distances in space and scientific theories will be further enhanced by teacher-led whole group discussion.
Expand		10 min	7.3	Optional electronic devices	3	Students have several different option of how they would like to expand upon their knowledge of the universe expansion theory and the associated historical aspects.
Evaluate		10 min	7.2, 7.3	Optional electronic devices	2	The expand project can be part of the evaluative phase. Also, students will complete a summative assessment.

Level of Student Engagement

1	Low	Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction
2	Moderate	Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance
3	High	Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered

Next Generation Science Standards – Inquiry

NGSS Practice 2: Developing and Using Models
 NGSS Practice 3: Planning and Carrying Out Investigations
 NGSS Practice 4: Analyzing and Interpreting Data
 NGSS Practice 6: Constructing explanations
 NGSS Practice 8: Obtaining, Evaluating and Communicating Information

**Next Generation Science Standards – Earth Science**

MS-EESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.

Florida Science Standards – Nature of Science

SC.8.N.1.6 Understand that scientific investigations involve the collection of relevant empirical evidence; the use of logical reasoning; and the application of imagination in devising hypotheses, predictions, explanations, and models to make sense of the collected evidence.

SC.8.N.3.2 Explain why theories may be modified but are rarely discarded.

Florida Science Standards – Earth and Space Science

SC.8.E.5.1 Recognize that there are enormous distances between objects in space and apply our knowledge of light and space travel to understand this distance.

Materials and Advance Preparation**Materials List**Class set:

- Large latex balloons (1 per 2 or 3 students)
- Medium Point permanent markers (1 per group)
- Tape measure (metric/one per group)
- Promethean or SmartBoard / computer set up with video and Padlet chat for Engage questions
- Caliper (optional)

Individual Student Materials

- Electronic devices for entering Padlet responses and answering assessment questions (if available)
- Post-It Notes (optional) - If devices are not available, students can write answers on mini Post-It Notes and place on designated chart paper or white board.
- Blackline Masters (one for each student)

Blackline Masters

1. **Blackline Master 1** - Expanding the Universe Student Worksheet
2. **Blackline Master 2** – Expanding on the Expanding Universe Directions Sheet
3. **Blackline Master 3** - Checking for Understanding: Expanding the Universe
4. **Blackline Master 4** - Alternative for EdPuzzle Questions
5. **Blackline Master 5** – Answer Keys

Advance Preparation

1. Set computer to view video clip <http://www.tubechop.com/watch/5344684>
2. If using and familiar with Padlet.com, set up the following Padlet questions for viewing and entering. (If unable to use Padlet, these can be asked orally and students respond on Post-It Notes).
 - What do you think our universe might be expanding into? (responses will vary)
 - Do you think there is a boundary to our universe? (responses will vary)
3. Copy assessment or create in an online assessment program (Schoology or Quia)
4. Place a bin on each table with one balloon, a tape measure and a medium point permanent marker.

- Join EdPuzzle (<http://www.edpuzzle.com>) and preview the film *What is the Universe Expanding Into?* (1:13). Edpuzzle allows teachers, in this case Marcie (the author of this lesson), to insert questions into a video clip to check student knowledge as the video plays.

Lesson Information

Learning Objectives

- Investigate and state that there are enormous distances between objects in space.
- Investigate and state that the universe is expanding.
- Create a model of the expanding universe.

Prior Knowledge Needed by the Students

- The Earth and our solar system are part of the Milky Way Galaxy.
- The Milky Way Galaxy is part of the universe.

Background Information

For years there have been many questions regarding the universe: What is the age of the universe? What is the origin of the universe? Is the universe finite or infinite? Many theories for multiple concepts regarding such questions can be found. The most prevalent is the Big Bang Theory which roughly states that the universe was once very dense, has expanded and continues to expand.

Lesson Procedure

Engage

- Ask the following leading questions and have students enter their responses on www.padlet.com (alternately can be done using Post-It notes):
 - Do you think there is a boundary to our universe?
 - (responses will vary but may include "I think there is a boundary to our universe, because all things come to an end," or I believe there is not a boundary to our universe because space is constantly changing.)
 - If yes, what do you think is at the very edge of our universe?
 - (responses will vary but might include another universe, a black hole, a solar system)
 - These questions are meant to generate curiosity and illicit interest. There are not currently any known answer to these questions and students are not expected to be able to definitively answer these questions by the end of the lesson.***
- Show the video clip "What is the Universe Expanding Into" <http://www.tubechop.com/watch/5344684>
- Ask the following questions and have students type their responses into www.padlet.com (alternately can be done using Post-It notes)
 - What do you think our universe might be expanding into?
 - (responses will vary but may include other universes, a black hole)
 - Do you think there is a boundary to our universe?
 - (responses will vary but may include "I think there is a boundary to our universe, because all things come to an end," or I believe there is not a boundary to our universe because space is constantly changing.)
- State the problem/question and write it on the board: "How could we support the idea that the universe is expanding?"
- Students enter the problem/question on their data chart.

Alternate Engage (optional)

- Set up an Edpuzzle account at www.edpuzzle.com
- Once in Edpuzzle be sure to click the Edpuzzle channel box in the selection area on the left.
- Click on the search icon in the top black bar and search for Marcie Farrell or *What is the Universe Expanding Into?* (1:13) title and open it.

4. You can click to “save” it if you want to use it as it is or you can click “use it” and be able to edit the video.
5. The video can be used along with **Blackline Master #4** instead of setting up EdPuzzle accounts, if preferred.

Explore

1. Briefly explain the premise of the activity.
2. Allow student to use their prior knowledge and explanation of the activity to brainstorm ideas that would support the idea that the universe is expanding (what would they have to see or experience to accept that the universe is expanding?).
3. Students write their brainstorming ideas on their data collection sheet.
4. Discuss the following safety procedures with your class.
 - a. the importance of not blowing the balloon beyond its capacity to avoid breakage
 - b. only one student is to blow up the balloon so that germs are not passed between students and so that our data is accurate (discuss constants)
 - c. cap the marker after use to avoid drying out and excessive fumes
5. Students remove the balloon and the permanent marker from the bin.
6. Student #1 stretches the balloon to make it easier to inflate.
7. Student #2 use the marker to make three dots 5 centimeters apart on one side of the balloon.
8. Student #2 label the dots A, B, and C.
 - a. Explain that the dots represent three different galaxies in the universe.
 - b. Students measure exactly the distance between each dot and multiplies this number by 10 million light years. (This accurately approximately the average distance between galaxies in the universe. Teacher discuss the enormous distances between galaxies.)
 - c. Students document the large number in their data chart.
9. Student #1 blows up the balloon with two blows.
10. Student #3 marks the spots in the center of the previous dot because the dot also expands.
11. While Student #1 pinches the end of the balloon to prevent air leakage, Student #2 measures the distance between the following galaxies in centimeters to the nearest half centimeter. Then the number is multiplied by 10 million light years.
 - a. A to B
 - b. B to C
 - c. A to C
12. All students document these measurements on their data tables.
13. Student #1 then adds two more blows of the balloon.
14. Student #3 remarks the spots in the center of the previous dot because the dot also expands.
15. While Student #1 pinches the end of the balloon to prevent air leakage, Student #3 measures the distance between the following galaxies in centimeters to the nearest half centimeter. Then the number is multiplied by 10 million light years:
 - a. A to B
 - b. B to C
 - c. A to C
16. All students document these measurements on their data tables.
17. Student #1 then adds two more blows of the balloon.
18. Student #3 remarks the spots in the center of the previous dot because the dot also expands.
19. While Student #1 pinches the end of the balloon to prevent air leakage, Student #3 measures the distance between the following galaxies in centimeters to the nearest half centimeter. Then the number is multiplied by 10 million light years:
 - a. A to B
 - b. B to C
 - c. A to C
20. All students document measurements on their data tables.

Explain

1. In their groups, students will answer the questions on their student worksheet (Blackline Master #1).
 - What did you notice about the measurements in your data? (Answers will vary but students should be able to see that the measurements keep getting larger and larger)
 - Can you devise an explanation of your data based on your observations? (Students should be able to respond that as they added more air to the balloon, the dots (galaxies) got farther and farther apart.)
 - How is the model that you created (balloon and dots and puffs of air) similar to the universe and its expansion? (Answers may vary but could include that the dots (galaxies) are moving apart as the balloon (universe) expands. The balloon is like the universe in that it contains all of the galaxies (dots).)
 - How is the model that you created (balloon and dots and puffs of air) different than the universe and its expansion? (Answers may vary but could include that the universe is not made of rubber (to our knowledge), the galaxies are much bigger and much farther apart than the dots that were drawn, air is what's causing the expansion of the balloon but that's not what's causing the expansion of the universe.)
 - How can this model support or refute the idea that the universe is expanding? (This model shows that if the measurements between galaxies demonstrate that the galaxies are moving further and further apart, this could be evidence to support that the universe is expanding).
 - Compare the distances within our solar system to other distances throughout the universe. (Answers may vary but could include that the distances within our solar system are extremely small compared to those outside our solar system).
2. Students will share out their responses and data by visiting other groups.
 - Students #1 & #2 will take their data sheets to a new table and discuss their findings.
3. In their new groups, students will discuss their follow-up questions orally.
4. After approximately 5 minutes, students #1 & 2 should return to their original group.
5. Explain to the students that this is a model and many models have some shortcomings or aspects that are not "perfect." In this model the air is forcing the dots away. However, it is not air that forces galaxies apart. It might also be mentioned that in the world not all galaxies are moving apart from each other. Some are actually getting closer like the Milky Way and Andromeda galaxies.

Expand

1. Students will be presented a scenario about the history of our knowledge of the universe (**Blackline Master #2**) and they will choose from several different assignments to complete to expand their knowledge.
2. Scenario: Since the 16th century, scientists like Tycho Brahe, Isaac Newton, Nicolas Copernicus, Johannes Kepler, and Albert Einstein (to name a few) have theorized about the nature of the solar system and the universe as a whole. To explore the changing theories of the nature of the universe, choose and complete one of the following tasks:
 - A research paper about the astronomer, cosmologist, philosopher or physicist of your choosing and how they contributed to the theory of the expansion of the universe.
 - A travel brochure that is detailed and in color which describes the sights and phenomenon that one would encounter when traveling the universe. This must contain relevant science vocabulary and demonstrate your understanding of distances in space and the theory of the expansion of the universe.
 - A timeline highlighting important dates, scientists, and contributions to the theory of the expansion of the universe.
 - A song, poem, or rap about the expanding universe and at least 3 major milestones and contributions to the theory of the expanding universe.
 - Create a multimedia presentation that represents one of the above assignments.

Evaluate**FORMAL EVALUTION**

1. Students complete the assessment on **Blackline Master #3**

WRAP UP.

Bring the lesson to a conclusion by having the students write an exit slip on a post-it note completing the following three sentence stems: *I knew ... I learned ... I wonder ...*

As students leave class they place the post-it note on designated area for teacher to use to address any misconceptions and the *I wonder* statements as an opening the following day.

Supplementary Resources**Teachers**

Amil, R. (2007). Galaxies and the Universe. In *Florida Course 3 Science Glencoe McGraw-Hill Education* (pp. 118-125). Columbus, OH: McGraw-Hill Education.

What is the Universe Expanding Into? (n.d.). Retrieved March 6, 2015.
(<http://www.tubechop.com/watch/5344684>)

Students

GLIMPSE360 gives astronomers a wider glimpse at the Milky Way. (n.d.). Retrieved June 23, 2015. (<https://www.newsela.com/articles/milkyway-discovery/id/3171>)
A reading about the Milky Way Galaxy with adjustable lexile levels.

CITATION OF SOURCES.

Borkar, A. (2014). What is the average distance between galaxies? Retrieved from <https://www.quora.com/What-is-the-average-distance-between-galaxies>

EarthSky. (2015). How far is a light year? Retrieved from <http://earthsky.org/astronomy-essentials/how-far-is-a-light-year>

Imhoff, K. (2016). The Solar System. Retrieved from <http://www.scholastic.com/teachers/article/solar-system-0>

NASA. (2015). Astronomical Unit. Retrieved from <http://neo.jpl.nasa.gov/glossary/au.html>

NASA. (2015). The Milky Way. Retrieved from http://imagine.gsfc.nasa.gov/features/cosmic/milkyway_info.html

NASA/MSU-Bozeman CERES Project. (N.D.) The Expanding Universe. Retrieved from <https://btc.montana.edu/ceres/html/Universe/uni1.html#activity2>

Sharp, T. (2012). Alpha Centauri: Nearest star system to the Sun. Retrieved from <http://www.space.com/18090-alpha-centauri-nearest-star-system.html>

Sloan Digital Sky Survey. (2015). The Expanding Universe. Retrieved from <http://cas.sdss.org/dr5/en/proj/basic/universe/expanding.asp>

Photo credit for balloon image: <http://clipartcotttage.deviantart.com/art/Balloons-Aqua-441284203>

Yes, I cited all materials and resources used in this lesson.

Marcie A. Farrell

Lesson author signature

Expanding Universe Student Worksheet

Problem/Question: How does evidence support the idea that the universe is expanding?

Background Knowledge about Distances in Space

- Distance from Earth to the Sun: 1 Astronomical Unit (AU); 93 million miles, 150 million kilometers (km)
- Distance across our solar system: 60,000 AU, 5.6 trillion miles, 9 trillion km
- Light Year (LY): the distance light travels in one year. 5.88 trillion miles, 9.5 trillion km
- Distance to nearest star outside our solar system (Alpha Centauri): 4.22 LY
- Parsec (pc): Equal to 3.26 LY; also kilo parsec (kpc), 1000 parsecs and mega parsecs (mpc), 1,000,000 parsecs
- Distance across our galaxy (The Milky Way): 100,000 LY or 30.8 kpc
- Distance to the next closest galaxy (Canis Major): 8 kpc
- Average distance between galaxies: a few mega parsecs (approx. 10 million LY)

Expanding Universe Data Collection			
Balloon Size	A-B (cm)	B-C (cm)	A-C (cm)
Deflated balloon	5 cm	5 cm	5 cm
<i>(multiplied by 10 million light years)</i>	<i>50 million LY</i>	<i>50 million LY</i>	<i>50 million LY</i>
Small (2 blows)			
<i>(multiplied by 10 million light years)</i>			
Medium (4 blows)			
<i>(multiplied by 10 million light years)</i>			
Large (6 blows)			
<i>(multiplied by 10 million light years)</i>			

- What did you notice about the measurements in your data?
- Can you devise an explanation for your data based on your observations?
- How is the model that you created (balloon and dots and puffs of air) similar to the universe and its expansion?
- How is the model that you created (balloon and dots and puffs of air) different than the universe and its expansion?
- How could this model support or refute the theory that the universe is expanding?
- Compare the distances in our solar system to other distances throughout the universe.

Name _____ Date _____ Student No. _____

Expanding into the Expanding Universe

Since the 16th century, scientists like Tycho Brahe, Isaac Newton, Nicolas Copernicus, Johannes Kepler, and Albert Einstein (to name a few) have theorized about the nature of the solar system and the universe as a whole. To explore the changing theories of the nature of the universe, choose and complete one of the following tasks:

- A research paper about the astronomer, cosmologist, philosopher or physicist of your choosing and how they contributed to the theory of the expansion of the universe.
- A travel brochure that is detailed and in color which describes the sights and phenomenon that one would encounter when traveling the universe. This must contain relevant science vocabulary and demonstrate your understanding of distances in space and the theory of the expansion of the universe.
- A timeline highlighting important dates, scientists, and contributions to the theory of the expansion of the universe.
- A song, poem, or rap about the expanding universe and at least 3 major milestones and contributions to the theory of the expanding universe.
- Create a multimedia presentation that represents one of the above assignments.

Checking for Understanding: Expanding the Universe

1. The illustration below can represent a model of the universe. What is represented by the white areas on the balloons? (*SC.8.N.1.6*)



Photo credit: <http://clipartcottage.deviantart.com/art/Balloons-Aqua-441284203>

- A. comets B. galaxies C. stars D. universes
2. Evidence that the universe is expanding can come from data and observations that scientists make over the course of their studies. How does new evidence impact existing scientific theories? (*SC.8.N.3.2*)
- A. New evidence is not given as much credit as old, existing ideas so it rarely enacts changes.
B. New evidence is often used to change existing theories, but the theories are rarely discarded.
C. When new evidence is found scientists will discard old theories and start over with new ideas.
D. When new evidence is found that contradicts existing theories, it is ignored and discarded.
3. There are great distances between objects in space. Which relationship below represents the greatest distance between objects? (*SC.8.E.5.1*)
- A. The distance between two stars
B. The distance between two galaxies
C. The distance between two solar systems
D. The distance between two planets in our solar system
4. Which of the following statements provides evidence for the theory that the universe is expanding? (*SC.8.E.5.1, SC.8.N.1.6*)
- A. There isn't a measureable change in the distance between galaxies.
B. The distance between most galaxies continues to get smaller and smaller.
C. The distance between most galaxies continues to get greater and greater.
D. Some galaxies are getting closer together while others are moving farther apart.
5. We are currently not able to travel to other stars and galaxies because: (*SC.8.E.5.1*)
- A. They are too hot for our space vehicles to travel there.
B. They are too far away to get there in a human lifetime.
C. There is not enough funding to support travel beyond our moon.
D. We are uncertain the best route to take to travel outside our solar system.

Name _____ Date _____ Student No. _____

Alternative for EdPuzzle Questions

Think about this question while watching the video at the following link:

Do you think the universe has a boundary where it ends?

View the video at the following link:

<https://edpuzzle.com/assignments/m/558c0ccb8d5e8ad74766451c/558c0959462ec046037b25ed>

(Stop video at :35 and answer this question)

1. What are you seeing on the screen at this moment?
 - a. A galaxy
 - b. The entire universe
 - c. A comet

=====

(Stop the video at 1:03 and answer this question.)

2. What does he mean by other dimensions or alternate realities?

=====

3. At the end of the video, discuss the two following questions with your partner or table mates:
 - a. Is there a boundary to our universe?
 - b. What might possibly be beyond our universe?

Blackline Master #5 KEYS**Answer Keys****Expanding the Universe Student Worksheet**

For the lab chart the answers will vary depending on starting measurements and the amount of air added to the balloons.

1. What did you notice about the measurements in your data? (Answers will vary but students should be able to see that the measurements keep getting larger and larger)
2. Can you devise an explanation of your data based on your observations? (Students should be able to respond that as they added more air to the balloon, the dots (galaxies) got farther and farther apart.)
3. How is the model that you created (balloon and dots and puffs of air) similar to the universe and its expansion? (Answers may vary but could include that the dots (galaxies) are moving apart as the balloon (universe) expands. The balloon is like the universe in that it contains all of the galaxies (dots).)
4. How is the model that you created (balloon and dots and puffs of air) different than the universe and its expansion? (Answers may vary but could include that the universe is not made of rubber (to our knowledge), the galaxies are much bigger and much farther apart than the dots that were drawn, air is what's causing the expansion of the balloon but that's not what's causing the expansion of the universe.)
5. How can this model support or refute the idea that the universe is expanding? (This model shows that if the measurements between galaxies demonstrate that the galaxies are moving further and further apart, this could be evidence to support that the universe is expanding).
6. Compare the distances within our solar system to other distances throughout the universe. (Answers may vary but could include that the distances within our solar system are extremely small compared to those outside our solar system).

Expanding the Universe Check for Understanding

1. B
2. B
3. B
4. C
5. B