



What Is Perfection?

It may be a relief to discover that being “imperfect” has some advantages. This issue of MUSE explores how variation and diversity contribute to excellence. In a world where we are compelled to strive for excellence, the articles in this guide examine why the journey, rather than the destination, should be our primary focus.

CONVERSATION QUESTION

When can imperfection be extraordinary?

TEACHING OBJECTIVES

- Students will learn about the use of the golden ratio in art.
- Students will learn why game developers avoid perfection.
- Students will learn how variations in biology can be the key to excellence.
- Students will investigate number patterns utilizing the Fibonacci sequence.
- Students will compare and contrast the elements of a wide game with the elements of a deep game.
- Students will examine the structure and function of variations in the human body that contribute to the extraordinary functioning.
- Students will research examples of the golden ratio in art history.
- Students will use mathematical concepts to express game preferences.
- Students will study additional examples of adaptation in the animal kingdom.



In addition to supplemental materials focused on core STEM skills, this flexible teaching tool offers vocabulary-building activities, questions for discussion, and cross-curricular activities.

SELECTIONS

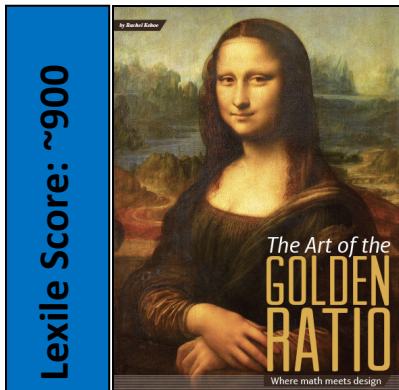
- **The Art of the Golden Ratio**
Expository Nonfiction, ~900L
- **Good Gaming**
Expository Nonfiction, ~1100L
- **Perfectly Imperfect**
Expository Nonfiction, ~700L

Muse® Teacher Guide: September 2020

The Art of the Golden Ratio

pp. 20–22, Expository Nonfiction

This article explores the use of mathematical concepts in art. Students will learn how closely math and design are intertwined by studying the golden ratio and the Fibonacci sequence.



RESOURCES

- A Special Sequence

OBJECTIVES

- Students will learn about the use of the golden ratio in art.
- Students will investigate a series of numbers using the Fibonacci series.
- Students will research examples of the golden ratio in art history.

KEY VOCABULARY

- **composition** (p. 21) the resulting state of combining parts and elements to form a whole; a work of music, literature, or art
- **phi** (p. 21) a mathematical concept similar to the golden ratio in which the terms of an irrational number go on forever after the decimal point without repeating
- **subdivide** (p. 21) to divide into smaller pieces something that has already been divided

ENGAGE

Conversation Question: When can imperfection be extraordinary?

Post the title of the article, “The Art of the Golden Ratio,” and tell students that the golden ratio utilizes perfect squares and special rectangles to create design. Review the criteria of a perfect square (a quadrilateral with four equal sides and four right angles). Have students use rulers to create perfect squares of various sizes.

INTRODUCE VOCABULARY

Post and discuss the key terms. Be sure that students understand the definitions before reading the article. As a post-reading activity, have students use the three vocabulary words to summarize the article in paragraph form.

READ & DISCUSS

Post and discuss the questions prior to reading. Read the article aloud, pausing when answers to the questions are revealed, and encourage students to elaborate.

- Explain the golden ratio.
- What is the relationship between the golden ratio and the Fibonacci sequence?
- Where do we see evidence of the usage of the golden ratio in art history?
- How does understanding phi help make the connection between math and art?
- How do graphic artists make use of the golden ratio?

CONCEPT/SKILL FOCUS: Investigating Patterns

INSTRUCT: Direct students to return to page 21 to study the elements of the Fibonacci sequence. Discuss how the next number in the Fibonacci sequence is determined. Distribute copies of *A Special Sequence* graphic organizer and instruct the students to identify and complete the Fibonacci sequence to fill in the missing numbers.

ASSESS: Review worksheets to evaluate individual abilities to determine subsequent numbers in the Fibonacci sequence. (Answer Key: **A:** 3; 8; 13 **B:** 144; 610; 987 **C:** 4,181; 10,946; 75,025 **Challenge:** 7,778,742,049; 12,586,269,025)

EXTEND

Art History The article states that famous artists such as Leonardo da Vinci and Salvador Dali have used the golden ratio to achieve beauty, balance, and harmony in their work. Have students peruse art books or the internet to find examples of other famous masterpieces that employ the principle of the golden ratio. Challenge students to create a class mural utilizing the golden ratio as described on pages 21 and 22.

A Special Sequence

Study the Fibonacci sequence on page 21 of “The Art of the Golden Ratio” and complete the chart.

A 0; 1; 1; 2; _____; 5; _____; _____; 21; 34

B 55; 89; _____; 233; 377; _____; _____; 1,597

C
2,584; _____; 6,765; _____; 17,711; 28,657; 46,368; _____

Challenge:

2,971,215,073; 4,807,526,976; _____; _____

Good Gaming

pp. 32–25, Expository Nonfiction

Power up and read this article written by a game developer that explains why “perfection” in game design is NOT a good thing. Students will learn that success is indeed the journey, and not the destination.



RESOURCES

- Let the Games Begin!

OBJECTIVES

- Students will learn why game developers avoid perfection.
- Students will compare and contrast the elements of a wide game with the elements of a deep game.
- Students will use mathematical concepts to express game preferences.

KEY VOCABULARY

- **master (p. 3)** show proficiency
- **mechanics (p. 34)** the way in which something is operated; the details of something
- **strategy (p. 33)** a plan of action designed to achieve a major goal

ENGAGE

Conversation Question: When can imperfection be extraordinary?

Ask students to name their favorite board games and video games. List the responses on the board. Discuss the reasons that students have chosen certain games. Revisit the list after reading the article and have the class label each game as “wide” or “deep.”

INTRODUCE VOCABULARY

Display the title of the article, “Good Gaming.” Post and discuss the vocabulary terms and how they relate to gaming. How could these words also apply to other disciplines such as sports, cooking, and architecture?

READ & DISCUSS

Read the article aloud with the class. Have students reread the article in small groups to answer the questions below. Share responses.

- What do game developers mean when they use the word *perfect*?
- Why is perfecting a game “bad” in the opinion of developers?
- What are the two methods that game developers use to ensure that it is difficult for players to perfect their game? Explain.
- Do you prefer wide or deep games? Why?

CONCEPT/SKILL FOCUS: Compare and Contrast

INSTRUCT: Elicit from the students that the main idea of the article is to explore how game developers use two methods (width & depth) to produce enjoyable and challenging games. Allow students to work with a partner to complete the graphic organizer, comparing specific details of games that are wide and deep. Encourage the pairs to share their finished work, instructing them to amend their own charts if necessary.

ASSESS: Collect and review the *Let the Games Begin!* organizers.

EXTEND

Mathematics Use the list from the first activity in this guide (or create a new one). Have students poll other classes to determine game favorites. After the data is collected, challenge students to represent the findings as a ratio, in fractional terms, and as percentages.

Let the Games Begin!

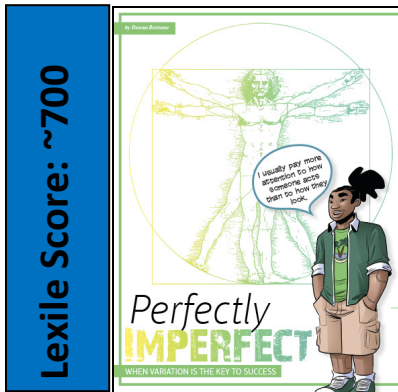
Reread the article, "Good Gaming" and discuss the definitions of wide and deep games with a partner. Then, complete the chart.

GAME TYPES	PROS	CONS	AUDIENCE
Wide Games Examples: _____ _____ _____ _____			
Deep Games Examples: _____ _____ _____ _____			

Perfectly Imperfect

pp. 38–40, Expository Nonfiction

This article explores why variation, and not perfection, is often the key to success. Examples from the human and animal kingdoms are explored.



RESOURCES

- Amazing Imperfections

OBJECTIVES

- Students will learn how variations in biology can be the key to excellence.
- Students will examine the structure of variations in the human body that contribute to extraordinary functioning.
- Students will study additional examples of adaptation in the animal kingdom.

KEY VOCABULARY

- **proportion** (p. 39) a part considered in comparative relation to a whole
- **traits** (p. 40) genetically determined characteristics
- **variation** (p. 40) a deviation between individuals within a species

ENGAGE

Conversation Question: When can imperfection be extraordinary?

Display Leonardo da Vinci's drawing, "Vitruvian Man." Explain how the sketch combined mathematics and art to illustrate a perfect human form. Discuss why most people find symmetry, patterns, and proportions in art appealing. Conversely, discuss why we also find flaws to be beautiful.

INTRODUCE VOCABULARY

Invite pairs of students to find definitions for the key vocabulary terms. Then post the definitions provided so that students may check their work. Have the pairs choose seven additional words from the article and procure definitions. They will then create a crossword puzzle using all ten words. Share puzzles with another class for use as a prereading activity for this article.

READ & DISCUSS

Reinforce comprehension of the concepts in the article by using the following prompts to direct discussion.

- What is depicted in Leonard da Vinci's "Vitruvian Man"?
- Explain how people and animals adapt to their environments.
- What are some imperfections in the human body?
- How can variability provide athletes with the physical characteristics to approach perfection in action?
- Why is variation essential for our survival?

CONCEPT/SKILL FOCUS: Structure & Function

INSTRUCT: Elicit from students that the main idea of the article is to provide information that details how imperfections in the human and animal world can be responsible for excellence in biological functioning. Present the graphic organizer, *Amazing Imperfections*, and tell students that they will be using information from the article to evaluate examples of such improved performances.

ASSESS: Reassemble the class and have partners share their answers from the graphic organizers. Ask students to volunteer examples of their own "imperfections" that they may have grown to view positively.

EXTEND

Science Direct students to reread pages 39–40 to review how the ability of organisms to adapt is crucial to survival in the animal kingdom. Have students use books and the internet to find other examples from the natural world to share with the class.

Amazing Imperfections

Use information from the article “Imperfectly Perfect” to describe how variations in biology helped lead to excellence.

Athlete	Variations in Structure (Atypical Body Structure)	Improved Function
Michael Phelps		
Simone Biles		
Usain Bolt		