

## Instructional Recipe

### How Do Fractal Patterns Found in Primitive Cultures Around the World Act as a Window into the Study of Complex Mathematics?

Grade 9-12

Subject: Mathematics

Cross Curricular Connection: World History Studies

Education Service Center Region 20

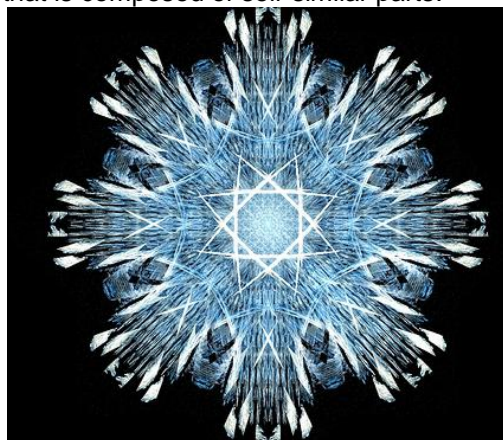


#### Step 1 – Ask

##### Objectives:

Students will use sequences and series as well as tools and technology to recognize and analyze patterns and geometric sequences and series to solve real-life problems.

**Introduction:** The primitive cultures of Africa have used fractals for centuries in their everyday life, religion, and art. Could the complex mathematics for fractals have come from repeated centuries of trial and error by these African cultures? Modern man has learned that he can create an object of art by utilizing a mathematical formula that repeats over and over, where each step results from the previous step. In other words, it is a repeated process or an iteration. Fractals are known as art by formula. From this concept art is created...art in nature, art in civilization, and art in mathematics. This concept of transformations with translations and dilations is known more commonly as a fractal. The definition of a fractal is a geometric figure that is composed of self-similar parts.



Fractal 404

Photo from [http://www.flickr.com/photos/apophysys\\_rocks/263018980/in/photostream](http://www.flickr.com/photos/apophysys_rocks/263018980/in/photostream)

##### Ask:

- ★ What is a fractal?
- ★ What are the characteristics of a fractal?
- ★ Are fractals indigenous to African culture or do they reflect contact with other cultures?
- ★ Why did the Western world only recently discover fractals in 1977 when African primitive tribes have been using them for centuries?
- ★ How could primitive cultures have known about repeated iterations when computers and calculators were not yet invented?
- ★ What technology tools use repeated iterations?
- ★ What is the difference between finite and infinite?
- ★ What is the difference between discrete and continuous?

##### Vocabulary:

- ★ Fractals or Sierpinski's Triangle, or Recursion
- ★ Recursive iterations, or Infinite and finite
- ★ Zulu Kraals, or Shaka Zulu, or Owari bead game, or Maiden Spirit Mask

##### TEKS:

###### Mathematics TEKS:

111.35.P4.A-B

###### Mathematics TEKS:

111.35.P4.A-B

(P.4) 111.34.G5.B,C

111.34.G11.A

111.36.M9.A

The student uses sequences and series as well as tools and technology to represent, analyze, and solve real-life problems. The student is expected to: (A) represent patterns using arithmetic and geometric sequences and series; (B) use arithmetic, geometric, and other sequences and series to solve real-life problems.

##### Cross-Curricular TEKS

113.33.20(A)(B)

###### World History Studies

The student understands the relationship between the arts and the times during which they were created. The student is expected to:

- (A) identify significant examples of art and architecture that demonstrate an artistic ideal or visual principle from selected cultures;
- (B) analyze examples of how art, architecture, literature, music, and drama reflect the history of cultures in which they are produced

###### Technology Application

###### TEKS: 126.24. Desktop Publishing(1) Foundations.

The student demonstrates knowledge and appropriate use of hardware components, software programs, and their connections.

## Step 2 – Investigate

[Click here for internet links/URLs](#)

### Online Subscription Resources:

- ★ **Search strategies:** (math and fractals), (fractals and primitive cultures), (African cultures and fractals), (Sierpinski's triangle and fractals), (Fractals or Sierpinski's Triangle, or Recursion)
- ★ [A Look At Math + Culture: Discovering An Instinctive Use Of Fractals In African Villages](#) By: Sessa, Sam. Baltimore Sun, The (MD), 04/25/2008; (AN 2W62W62178996969)
- ★ [African Fractals \(Book\)](#). Preview By: Read, Dwight W.. Visual Anthropology, Apr/May2004, Vol. 17 Issue 2, p199-203, 5p; DOI: 10.1080/08949460490457100; (AN 14095703)
- ★ "Shaka." [Encyclopædia Britannica](#). 2008. Encyclopædia Britannica Online School Edition. <<http://school.eb.com/eb/article-9067085>>.

### Additional Websites:

**Mathematics Links:** [Why Study Fractals?](#) ; [Sierpinski's Triangle](#) ; [Physics Fractals](#); [Geometry from Africa](#)

**African Culture Links:** [African Architecture Fractals](#) ; [African Tribal Leader](#); [Owari Bead Game](#); [African Kingdoms](#); [Maiden Spirit Mask](#); [Savanna kraals and compounds](#); [Zulu Wisdom](#); [Zulu Military Structure](#)

### Books:

Gerdes, Paulus. *Geometry From Africa*. 1. Washington, DC: Mathematical Association of America, 1999.

## Step 3 – Create

[Click here for internet links/URLs](#)

- ★ **Listen** to Dr. Ron Eglash's lecture on [African Primitive Cultures and Fractals](#).
  - ✚ Try to find the pattern that created the whole as Professor Eglash has illustrated, find the seed-shape and the iteration (the pattern) that created the whole in the African primitive cultures. Could these complex mathematics come from repeated centuries of trial and error? (Study the picture of the [Zulu Cattle Enclosure](#).)
- ★ **Explore** the [African Culture Links](#) in [Step 2](#): Ponder these questions:
  - ✚ Did other cultures introduce fractals to Africa or did the Africans develop them independently with no outside influence?
  - ✚ Do we see Islamic art patterns in primitive African art?
- ★ **Research** specific examples of fractals in African culture and explain why those examples are fractals and the role they play in the civilization.
- ★ **Create:** Math students will create a Sierpinski's Triangle which will teach them the concept of repeated iterations, this in turn allows them to understand the design and development of the fractal.
  - ✚ To create a [Sierpinski's Triangle](#), the student will need to begin with an equilateral triangle and then break it up into four equilateral triangles by connecting the midpoints of the sides. Remove the middle triangle.
  - ✚ Repeat the same process with the remaining triangles. This activity will help students understand the concept of iteration and allow them to recognize true fractals.

### Technology Link -

*Math Connection:* Students can use this simulation to create their own [Sierpinski's Triangle](#).  
*African Culture Connection:* [Dr. Ron Eglash on You Tube](#): [Transcript for Dr. Eglash lecture](#):

#### Step 4 – Discuss

[Click here for internet links/URLs](#)

- ★ Students will participate in an [inner-outer circle](#) pre-writing exercise. This strategy focuses on listening to the views of others and responding to them. The pre-writing exercise will focus on establishing and recording arguments that would support one of two ideas:
  - ✚ the fractal was developed independently, or
  - ✚ the fractal was the result of some diffused ideas from other cultures.
- ★ Students will follow the rules of an inner-outer circle discussion:
  - ✚ listen to the views of others and respond to them.
  - ✚ contemplate multiple views on a controversial issue.
  - ✚ develop oral speaking skills and impromptu responses in a group discussion.
  - ✚ develop skills in supporting one's opinion with facts and examples.
  - ✚ write an editorial or position paper as a way to prepare for the inner-outer circle debate.
  
- ★ Students will follow the guidelines as outlined in the [inner-outer circle guideline sheet](#).

#### 🔗 Technology Link –

[Inner-outer circle](#) Description Template.  
[Discussion Scoring Rubric](#) for Inner-outer circle

#### Step 5 – Reflect

[Click here for internet links/URLs](#)

##### **Culminating Activity**

- ★ Students will participate in a debate. The debate strategy focuses on listening to the views of others and responding to them.
- ★ Use the following suggested rubric to assess the students' work. Make sure that the students are familiar with the [debate rubric](#) *before* they begin preparing their project. They should refer to the rubric repeatedly to monitor their progress in creating their project.

##### **Visual Project Activity:**

Students will create an African mask, a recreation of an African village or some architecture that has a fractal design. Consider the question, "Is the design a diffusion or completely indigenous to the African primitive culture?"

##### 🔗 **Technology Link:**

For more debate ideas, wikis, blogs, and videos, go to the [International Debate Education Association](#) site:

You can also create your own rubric with your students at <http://rubistar.4teachers.org/index.php>.

## Internet Links/URLs

Articles may be located by either the accession number (AN) or the persistent URL.

### Step 2 – Investigate

- **A Look At Math + Culture: Discovering An Instinctive Use Of Fractals In African Villages** (AN 2W62W62178996969)  
<http://web.ebscohost.com/ehost/detail?vid=1&hid=6&sid=302a3526-1397-4f41-a04d-1a40a276c37c%40sessionmgr4&bdata=JnNpdGU9ZWZWhvc3QtbGl2ZQ%3d%3d#db=nfh&AN=2W62W62178996969>
- **African Fractals (Book)** (AN 14095703)  
<http://web.ebscohost.com/ehost/detail?vid=1&hid=6&sid=84ca1bdb-b773-4c74-99c3-5940eee3b3c7%40sessionmgr11&bdata=JnNpdGU9ZWZWhvc3QtbGl2ZQ%3d%3d#db=a9h&AN=14095703>
- **Shaka**  
<http://school.eb.com/eb/article-9067085>
- **Why Study Fractals?**  
<http://math.rice.edu/~lanius/fractals/WHY/>
- **Sierpinski's Triangle**  
<http://math.rice.edu/~lanius/fractals/>
- **Physics Fractals**  
<http://sprott.physics.wisc.edu/fractals.htm>
- **Geometry from Africa**  
[http://www.maa.org/mathland/mathtrek\\_11\\_29\\_99.html](http://www.maa.org/mathland/mathtrek_11_29_99.html)
- **African Architecture Fractals**  
<http://classes.yale.edu/Fractals/Panorama/Architecture/AfricanArch/AfricanArch.html>
- **African Tribal Leader**  
<http://www.britannica.com/EBchecked/topic-art/282215/34699/Leaded-bronze-ceremonial-object-thought-to-have-been-the-head#assembly=url~http%3A%2F%2Fwww.britannica.com%2FEBchecked%2Ftopic-art%2F282215%2F34700%2FMaiden-spirit-mask-symbolizing-beauty-and-peace>
- **Owari Bead Game**  
<http://www.wizzy.com/owari/>
- **African Kingdoms**  
<http://www.bbc.co.uk/worldservice/africa/features/storyofafrica/4generic3.shtml>
- **Maiden Spirit Mask**  
<http://school.eb.com/eb/art-34700/Maiden-spirit-mask-symbolizing-beauty-and-peacefulness-painted-wood-Southern>
- **Savanna kraals and compounds**  
<http://school.eb.com/eb/article-57112?query=&ct=eb>
- **Zulu Wisdom**  
<http://www.swamij.com/wisdom.htm?gclid=CM-kg4KH65QCFQJvswodCQMGSw>

- **Zulu Military Structure**  
<http://www.south-africa-tours-and-travel.com/zulu.html#THE%20MFECANE%20/%20DIFAQANE%20WAR>

**Step 3 – Create**

**Step 4 – Discuss**

**Step 5 – Reflect**

## Zulu Cattle Enclosure



**Zulu Cattle Enclosure**

Information and picture from: *History of Africa*, by Kevin Shillington, New York: St. Martin's Press. 1995 page 261.

Besides performing military duties, male and female regiments were also involved in production for the state. The men herded the king's cattle and hunted for ivory while the women cultivated the king's fields.

Regimental towns, based on the pattern of a central cattle enclosure were placed at strategic positions around the kingdom.

## INNER-OUTER CIRCLE GUIDELINES

- 1. Purpose.** The purpose of this seminar is to understand new knowledge by thinking out loud and sharing your ideas openly with other students. Cooperation can lead to greater understanding. Back up your ideas with evidence from the assigned reading(s).
- 2. Questions.** Write and answer \_\_\_\_\_ questions based on the reading(s). Ask questions that require thought. Questions should reflect your curiosity, and your questions might not have right or wrong answers. Do not write questions on the “knowledge” level. Do not write questions that can be answered in just a few words.
- 3. Grading.** This graded seminar will be worth \_\_\_\_\_ points: one-third for your written questions and answers, one-third for your discussion in the inner circle, and one-third for your notes in the outer circle.

<b>Earn positive points for:</b>	<b>Avoid negative points for:</b>
-Good thought questions (5) -Each relevant comment (1) -Evidence from the reading (2) -Bringing others into the conversation (2) -Recognizing contradictions (2) -Asking clarifying questions (1)	-Not paying attention (-2) -Distracting others (-2) -Interrupting (-2) -Irrelevant comments (-2) -Monopolizing the conversation (-3) -Personal attacks (-3)

## KEYS TO A SUCCESSFUL SEMINAR

1. Be prepared. Read the assigned reading carefully, probably more than once. Try your best to fully understand it.
2. Write thought-provoking questions. Remember to write both questions and answers. Your questions and answers will be checked at the beginning of class.
3. Keep an open mind during the discussion. Look for the strengths in other people’s ideas. Be prepared to change your point-of-view based on what you learn.
4. If several people wish to talk, raise your hand and wait quietly to be called upon. Do not raise your hand while another student is speaking.
5. Speak loudly enough for everyone in the room to hear you. Look at other students when talking. Bring the assigned reading to the discussion; you may wish to refer to it.

6. If you don't understand something, ask clarifying questions.
7. If you don't have something to say, it is OK to "pass" when asked to contribute.
8. When in the outer circle, pay close attention to the discussion, and take notes.



## Debate Rubric

Criteria	Mastery	Above Standard	Standard	Approaches Standard	Below Standard
Opening & Closing Statements	<ul style="list-style-type: none"> <li>- Extremely thorough, well-organized presentation of arguments and evidence</li> <li>- Opening statement engages the interest of audience; closing statement leaves no unanswered issues and resonates with the audience</li> </ul>	<ul style="list-style-type: none"> <li>- Well-organized and complete presentation of arguments and evidence</li> <li>- Opening statement successfully frames the issues; closing statement summarizes many arguments made in the debate</li> </ul>	<ul style="list-style-type: none"> <li>-Organized and generally complete presentation of arguments and evidence</li> <li>- Opening statement outlines or lists arguments and evidence but does not generate interest; closing statement does not reflect remarks made during debate.</li> </ul>	<ul style="list-style-type: none"> <li>-Somewhat organized presentation of arguments and evidence</li> <li>-Opening statement minimally outlines arguments; closing argument briefly restates the ideas offered in the opening statement</li> </ul>	<ul style="list-style-type: none"> <li>-Arguments are unorganized, incomplete, or completely lacking in evidence</li> <li>-Opening statement and closing statements do little more than state the position of the team</li> </ul>
Rebuttals	<ul style="list-style-type: none"> <li>- Responds to issues raised by opponents with concise, accurate, logical answers</li> <li>- Effectively challenges the arguments made by opponents with argument and evidence</li> </ul>	<ul style="list-style-type: none"> <li>- Responds to issues raised by opponents with accurate and generally concise answers</li> <li>- Challenges the arguments made by opponents; challenges are generally effective</li> </ul>	<ul style="list-style-type: none"> <li>- Responds to most of the issues raised by opponents with generally accurate answers</li> <li>- Offers arguments, but no evidence, to counter the arguments made by opponents</li> </ul>	<ul style="list-style-type: none"> <li>-Seems to be caught off-guard by opponents; offers tentative, somewhat accurate, but possibly vague or illogical responses</li> <li>-Attempts to challenge arguments of opponents</li> </ul>	<ul style="list-style-type: none"> <li>-Is unable to respond to issues raised by opponents in a meaningful or accurate way</li> </ul>
Effective use of historical evidence / content knowledge	<ul style="list-style-type: none"> <li>-Demonstrates a sophisticated understanding of the issues, events and facts relevant to the topic</li> <li>-Demonstrates thorough and accurate understanding of details as well as the ability to make original connections and interpretations</li> </ul>	<ul style="list-style-type: none"> <li>- Demonstrates a sophisticated understanding of the issues, events and facts relevant to the topic</li> <li>-Demonstrates thorough and accurate understanding of details as well as the ability to make original connections and interpretations</li> </ul>	<ul style="list-style-type: none"> <li>-Demonstrates an basic and accurate understanding of the issues, events and facts relevant to the topic.</li> <li>-Demonstrates the ability to make basic connections between facts and concepts</li> </ul>	<ul style="list-style-type: none"> <li>-Demonstrates a generally accurate understanding of relevant issues, events and facts, but may exhibit minor confusion or misunderstandings</li> <li>seem to understand general ideas, but do not support their ideas with relevant facts; OR, seem to understand facts but are unable to connect them into coherent arguments</li> </ul>	<ul style="list-style-type: none"> <li>-Demonstrates an inadequate understanding of the history content relevant to the topic</li> <li>-Supports statements with vague or irrelevant information, or no information at all</li> </ul>
Use of persuasive appeals	<ul style="list-style-type: none"> <li>Makes deliberate and effective use of logical, emotional and ethical appeals in order to persuade justices</li> </ul>	<ul style="list-style-type: none"> <li>Uses logical, emotional and ethical appeals to enhance effectiveness of argument</li> </ul>	<ul style="list-style-type: none"> <li>Uses some appeals to make argument more persuasive, but may not include a mix of logical, emotional and ethical appeals</li> </ul>	<ul style="list-style-type: none"> <li>Makes minimal use of persuasive appeals</li> </ul>	<ul style="list-style-type: none"> <li>Does not use persuasive rhetoric</li> </ul>
Language Use	<ul style="list-style-type: none"> <li>- Uses language that is stylistically sophisticated and appropriate for the court</li> <li>- Uses literary devices to enhance the argument</li> </ul>	<ul style="list-style-type: none"> <li>- Uses language that is appropriate to the court</li> <li>- Uses literary devices to add interest</li> </ul>	<ul style="list-style-type: none"> <li>- Uses language that is appropriate to the court</li> <li>- Attempts to use literary devices to add interest</li> </ul>	<ul style="list-style-type: none"> <li>-Generally uses language that is appropriate to the court</li> <li>-Uses basic but clear language</li> </ul>	<ul style="list-style-type: none"> <li>-Uses colloquial, overly simplistic language</li> <li>-Uses language and syntax that is unclear</li> </ul>
Performance	<ul style="list-style-type: none"> <li>Exhibits confidence, energy, and passion in the course of the hearing</li> <li>- Maintains respectful tone</li> <li>- Accesses preparation materials with ease</li> </ul>	<ul style="list-style-type: none"> <li>- Exhibits confidence and energy in the course of the hearing</li> <li>-Maintains respectful tone</li> <li>- Uses preparation materials effectively</li> </ul>	<ul style="list-style-type: none"> <li>- Appears nervous, yet somewhat confident, -</li> <li>Maintains respectful tone</li> <li>- Use of preparation materials does not distract</li> </ul>	<ul style="list-style-type: none"> <li>-Lacks confidence</li> <li>-Maintains respectful tone</li> <li>- Use of preparation materials distracts from quality of performance</li> </ul>	<ul style="list-style-type: none"> <li>-Demonstrates little or no preparation</li> <li>-Fails to maintain respectful tone</li> </ul>