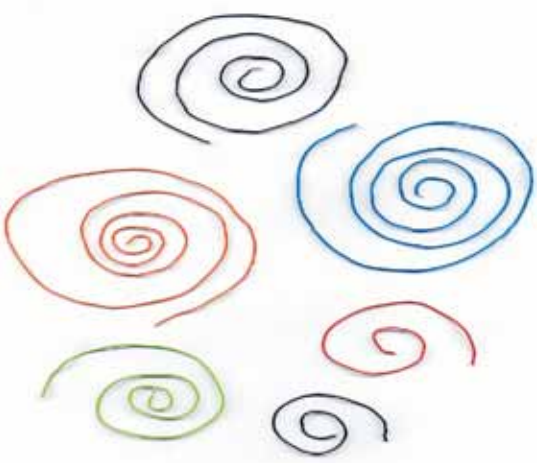
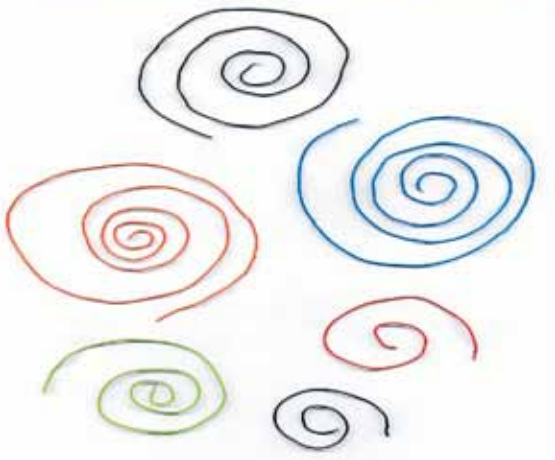
Africa meets Africa

Making a Living through the Mathematics of Zulu Design

Lesson pack: 2





A note to the educator:

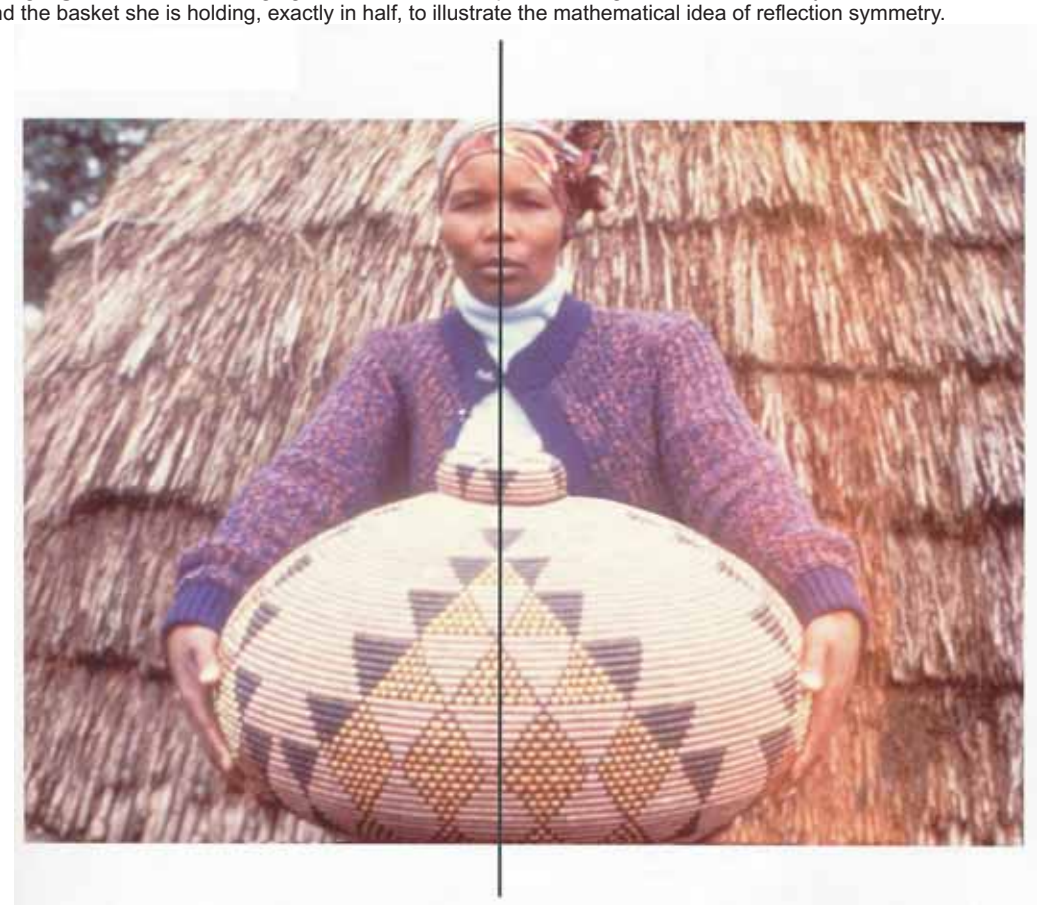
This booklet contains a set of Arts and Culture and a set of Mathematics learning materials at Grade 9 level, which are linked conceptually.

Your learners develop weaving skills from the Zulu heritage, and in doing so they work with mathematical ideas prescribed by the National Curriculum Statements (NCS).

These activities, worksheets and research tasks for learners, as well as the NCS linked educator's guidelines included, serve as example for developing further innovative materials. The book and film A*frica meets Africa: Making a Living through the Mathematics of Zulu Design* offers you primary resource material for learning materials development. Both the film and the book, with all its images in full colour, have been designed for you to illustrate your lessons in class.

Have a look at our website at www.africameetsafrica.co.za, and share your teaching ideas with educators from all over the country!

Cover: An old red and white *imbenge* (pot cover) woven in plastic and (bottom right) a wire basket woven by Elliot Mkhize.
Below: Beauty Nxgon**g**o with one of her large grass baskets. In this picture a single line divides Beauty's face and body and the basket she is holding, exactly in half, to illustrate the mathematical idea of reflection symmetry.



The things we use every day are part of our lives. We hardly think twice about them.

Take containers for example. In KwaZulu Natal many generations before us did not have the mass produced and fairly inexpensive plastic bowls, tin pots and glass bottles we use. Instead, they made containers for milk, water and beer with the clay, grass and palm leaves (*ilala)* they found around them. They found many uses for natural materials, also developing knowledge of the medicinal value of various plants. The sap of the palm tree is still used to make very tasty palm wine.

Over time particular container forms and technologies of making developed according to people's needs and social customs. In the older containers we see much of our ancestors' knowledge of the world around them reflected. As beautifully crafted objects of cultural expression, the baskets and pots offer evidence of the indigenous knowledge systems within the Zulu cultural heritage - a heritage that keeps unfolding.

The old forms are still being made and used today, but in new ways. In the 1970's, in the rural Hlabisa area, master weavers started using their knowledge of natural plant dyes to give the strands of *ilala* they weave with, a range of subtle colours. The many colours led them to weave complex patterns into the old basket forms, like Beauty Ngxongo's *isichumo* (left) on the inside cover. Compare these to the natural brown colour of *ilala* in the older basket (above right). Basket's like Beauty's are sold in the city for their beauty rather than as containers. In the city traditional *ilala* and grass weaving techniques have also been explored by weavers who use electric wiring with plastic coating in many bright colours. They have adapted the basic shallow *imbenge* (pot cover) form to make large flat baskets, like Elliot Mkhize's, that you see on the front cover of this booklet, bottom right. With these baskets, weavers have entered the urban interior design and the tourist market, in the process gaining knowledge of the free market system.

In a contemporary Zulu basket, therefore, many aspects of our world and many kinds of skills and knowledge are interwoven. Young herd boys while away hours in the veld by working grass into twine. In some schools learners weave complex geometric patterns into the baskets they weave.

This lesson pack helps you to use the remarkable thinking and making skills of the master basket weavers as an exciting new and yet culturally familiar learning tool in the classroom.

This Lesson Pack shows you how to bring indigenous weaving skills into your classroom within the Arts and Culture Learning Area. We help you guide your learners as they discover the skills of master and local weavers. In this way you also explore the indigenous knowledge and skills within your community. Part 2 of Lesson Pack 2 explores the idea that when they weave regular patterns, your learners are doing geometry with their hands! Five NCS linked Mathematics worksheets on polygons, tessellations and four types of symmetry show that understanding Mathematics can be much easier if we relate it to the things around us.

Part 1: Educator's guide: Arts and Culture: Zulu Weaving

Our methodology: The key activity in this Lessons Pack guides learners step by step as they weave the spiral shape with which many weavers start a basket. Inexpensive strips of newspaper and plastic are used here, but the mat can be woven in *ilala* or wire. Learners are shown how to weave triangular shapes into their mat with a second colour. Part 2 of this booklet offers a series of Mathematics worksheets which take the design skill of recognizing and working with shapes further. Learners explore the principles of Geometry and mathematical symmetries by looking carefully at beadwork and baskets from the Zulu heritage. With a worksheet guiding research tasks, learners explore the idea that objects of cultural expression hold evidence of indigenous knowledge (IKS).

<table>
<tr><th colspan="2">LESSON PLAN AND OVERVIEW FOR ARTS AND CULTURE, GRADE 9.</th></tr>
<tr><td>Critical and Developmental Learning Outcomes and Assessment Standards</td><td>Critical and Developmental Outcomes:
Learners will:
CO 1 Identify and solve problems and make decisions using critical and creative thinking
CO 7 Demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.
CO 3 Organise and manage themselves and their activities responsibly and effectively</td></tr>
<tr><td rowspan="4">Arts and Culture Learning Outcomes and Assessment Standards

Integration recommended with Learning Outcomes from HSS (History) EMS and Technology</td><td>LO 1: Creating, interpreting and presenting
The learner will be able to create, interpret and present work in each of the art forms
AS: Visual Arts: Creates art, craft and design works that:
Demonstrate the confident use of elements of design.
AS: Additional: Creates artworks that demonstrate
• Use of conventional or experimental processes and techniques, with attention to appropriate choice of materials
• Exploration and representation of specific patterns and design motifs which feature in South African history.
• Selects, prepares and mounts own artworks (including labeling) for public presentation</td></tr>
<tr><td>LO 2: Reflecting. The learner will be able to reflect critically and creatively on artistic and cultural processes, products and styles in past and present contexts
AS: Composite: Identifies sources of cultural information such as artists from communities, libraries, museums and the internet. Analyses the interplay between global and local culture, how cultures affect one another and undergo change.
AS: Visual Arts: Investigates and explains the influences and circumstances shaping the development of a South African artist.</td></tr>
<tr><td>LO 3: The learner will be able to demonstrate personal and interpersonal skills though individual and group participation in Arts and Culture activities.
AS: Composite: Shows willingness to explore new cultural ideas and recognize stereotypes</td></tr>
<tr><td>LO 4: Expressing and Communicating: The learner will be able to use multiple forms of communication and expression in Arts and Culture
AS: Visual Arts: Explains how art reflects cultures, lifestyles, beliefs and fashion</td></tr>
<tr><td>Teaching and assessment contexts</td><td>Learners are introduced to the cultural context of Zulu weaving and pottery (30 to 45 minutes)
Learners weave a place mat. Step by step instructions are provided (2 hours.)
They complete a worksheet as guided research task (home assessment task)</td></tr>
<tr><td>Research focus</td><td>The learner worksheet guides research in sources of cultural information</td></tr>
<tr><td>Forms of assessment</td><td>Class discussion on the cultural context of Zulu weaving, including pottery - a group assessment by the educator. The completed piece of weaving and worksheets assessed individually by the educator (see assessment grid provided). Exhibitions of learner work can be held at Teachers' Centres. Prizes sponsored by the Shuttleworth Foundation will be awarded to educators for developing innovative learning materials related to this project.</td></tr>
<tr><td>Recommended references</td><td>1.The resource books and films Africa meets Africa: The Power to Speak and Making a living though the Mathematics of Zulu Design. See the website www.africameetsafrica.co.za.
2. Ulundi Museum, Killie Campbell Collection, African Arts Centre and others listed on the Africa meets Africa website.</td></tr>
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Lesson 1: Introducing Zulu weaving: Time: Suggested 45 minutes
This lesson relates to all the Arts and Culture Learning Outcomes set out in the lesson plan and overview.
There are several ways to introduce Zulu pottery and weaving to your learners. Try to use as many of the following as you can.

- Invite a local weaver or pot maker in your community into your classroom, or someone who makes and sells pots and beadwork in your city. Ask him or her to bring some of their work and to talk about it. If your school is near a rural market, a cultural history museum or craft centre, you could take your class on an outing and speak to weavers there. Museums, craft centres and shops are recommended in the Africa meets Africa resource book.
- Show all of Part 1 (if you have not done so for Lesson Pack 1) or the section on pottery and weaving in the *Africa meets Africa* film titled *Things to Use*. Point out that the making and use of both pots and baskets are often linked to meaningful social ceremonies such as the beer ceremony. Bring baskets and pots to class or show learners the range of pots and woven baskets illustrated in the *Africa meets Africa* resource book. Mention the various forms of baskets and pots by name and function. Explain how weavers have developed their techniques, materials and colours over time. Turn baskets over to show how the weaving process started with either a square knot, or with a coil of grass. Discuss pot coiling and firing techniques. You will find all the information you need to prepare your lesson on page 14 to page 25 of the Africa meets Africa resource book, and in the film.
- Now use actual baskets and pots to point out the elements of visual art and design: shape, form, line, texture, colour, positive and negative shapes. Encourage the learners to handle the baskets and pots and to seek out the elements of design in them.
- Allow enough time for the learners to touch and look at the baskets and to share the knowledge and experience of weaving and pottery they have. Assess their prior learning about weaving and pottery.

The beer drinking ceremony

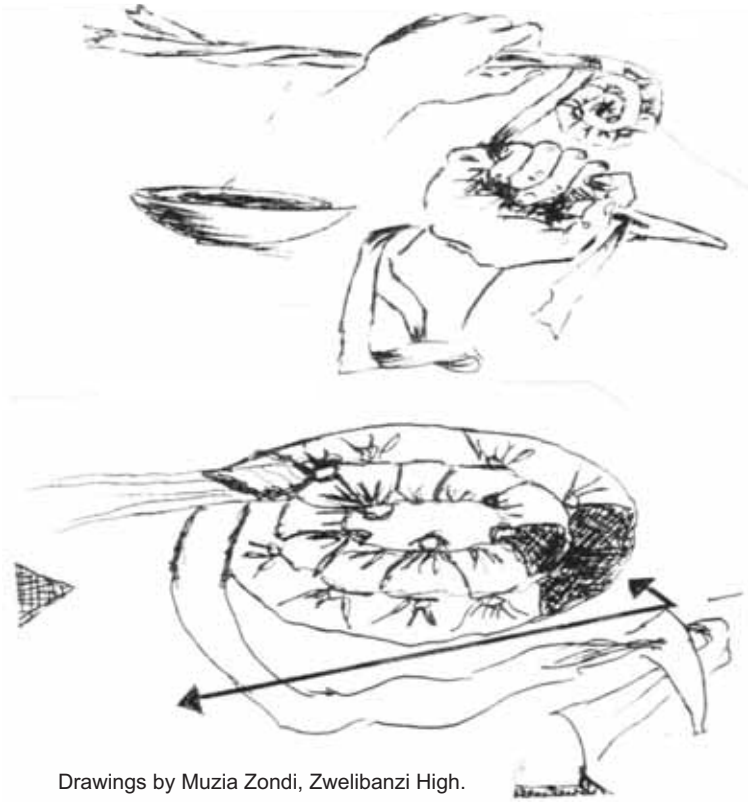
An old *uphiso*

Asolinah Mncube's pot with
an *imbenge* as potcover

Lesson 2: **Weaving a mat:** Suggested time: Two hours. During Lesson 1 the learners will have familiarized themselves with the shapes most often used in Zulu weaving design, such as triangles, diamond shapes, the rounded form of baskets and the spiral to be found at the bottom of a coiled basket. Make a copy of the activity sheets on the next two pages for each learner to work from as you demonstrate how to coil a mat. Explain that this is one of the most popular techniques professional weavers use. Encourage the learners to help one another, as LO 3 suggests. This activity is challenging and will give learners a sense of how skillful professional weavers must be to develop highly complex designs into a coiled basket. Experiment with materials: Prepare strips of newspaper and plastic as suggested, or experiment with the same shredded palm leaf strands that the weavers use. You could also try weaving with electric wire. The learners are required to present and exhibit their mats and the beadwork they produced for Lesson Pack 1, labeled with their name and the name of their school. Encourage them as a group to find an original display venue at school and to organize a special event as exhibition opening. Assess the woven placemats and their presentation according to the assessment grid provided.

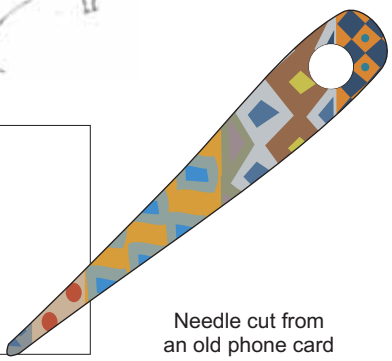
Lesson 3: A guided research task:
The worksheet to follow the weaving activity has been designed as a guided research task. It also serves to help you assess learners' understanding of the elements of design and weaving technique. Arts and Culture Learning Outcomes 2, 3 and 4 are addressed directly in the worksheet. It also guides the learners' thinking about IKS and towards Part 2 of this Lesson Pack, which links their understanding of design to mathematical concepts of geometry and symmetry

Lesson 2: Learner activity sheet: Weaving a place mat with coiled waste material.



Drawings by Muzia Zondi, Zwelibanzi High.

You will need:
An old newspaper.
Two plastic bags in contrasting colours, cut into strips that are one cm wide.
A piece of hard plastic, such as an old phone card, out of which you will cut a flat narrow needle with a sharp point.
Cut a hole in one end of the needle, large enough to thread the strip of plastic through.



Needle cut from an old phone card

Vocabulary:
Rope: a long strip of rolled and folded newspaper, your basic weaving material.
Coil: the spiral shape that you weave.
Overlap: to wrap your plastic strip over two rows of rope next to one another in a coil.
Stitch: when you thread the plastic through a hole.
A knot: created between the ribs of a coil by overlapping.

Step 1: Preparing your basic weaving material

- Roll a sheet of newspaper over tightly until you have a long, thin rope. If the weather is hot and dry, you can sprinkle water onto the newspaper to make it more pliable. It should be about one cm in width. The rolled newspaper (which we call the *rope*) is the core material your mat will be made of. The plastic strips you prepared will be folded over the newspaper. Thread one end of the plastic strip into the hole of the needle.

Step 2: Getting started

- Leave one cm of newspaper rope bare and start folding a strip of plastic (in white, silver or your lighter colour) tightly around the rope. Start by laying two cm of the plastic parallel to the paper rope and then rolling it over the paper from right to left and away from you. Carry on until you have a strip of covered rope about five cm long.
- Make sure that the strips of plastic are tightly wrapped so that the newspaper inside does not show through.

Step 3: Creating a coil:

- Now bend the wrapped piece in on itself so that it forms an elongated U shape, lying horizontally on its side, the open end facing left. As you continue working, make sure that you leave a small hole (aperture) in the centre, at the fold. The one end of the U shape (with unwrapped newspaper protruding) should now be lying parallel to where the as yet unwrapped part of your rope starts - the long end that you will continue weaving with. See Fig 1.

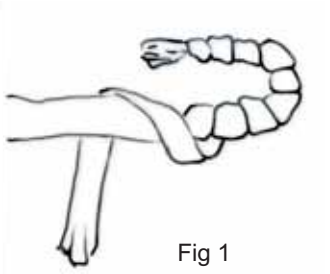


Fig 1

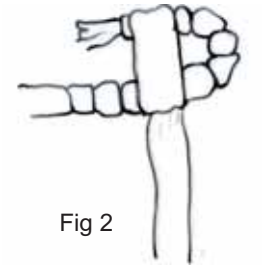


Fig 2

Fig 3

- Wrap your long plastic strip over the top leg of the U and wind it over the back to the bottom. Bring it through to the front and overlap by taking it to the top of the U again. See Figs 2 and 3.

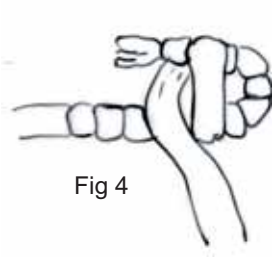


Fig 4

- Now place the plastic between the two legs of the U. See Fig 4.

Fig 5

Fig 6

- Fold the end of the plastic strip towards the right, across the *overlap* you have created, and into the central hole at the curve of the U. Thread though to the back. You have now made your first knot. See Figs 5 and 6.

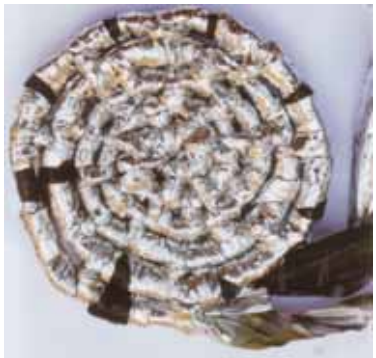
Step 4: Weaving a triangular design in a contrasting colour into your mat (our example is a black triangle on silver ground):

- When you have reached the fourth coil in your placemat, start enlarging it by rolling the silver plastic *five* times around the paper rope instead of four, and then knotting.
- Once you have created a strong coil right around in this way, introduce a triangular design in black

Follow these three steps:

1. Introduce a strip of black (or your darker shade) of plastic by holding the end parallel to the newspaper rope. Now weave the silver plastic in by rolling it twice around the newspaper rope and over the black plastic. At the inside of the coil, overlap the silver over the black, from right to left. The silver strip will now be on your left and the black on your right.
2. Roll the black once over the paper coil. Then overlap again at the bottom, this time the silver over black, and roll the white three times around the paper coil. Hold the black plastic parallel to the paper coil so that you weave the silver over it. Then make your knot. Carry on in this way until you have an entire coil with one strip of black. The black is the starting point of your triangle.
3. Now introduce two strips of black plastic and then progressively more and more in each coil, until you have woven a pointed triangle.

Note: As the newspaper coil and the black or white plastic runs out, weave more material in by laying the new end down horizontally to overlap with the old one and roll over it.



A note on evaluation and assessment:

During your lessons, and once they have been concluded, it is important to spend time observing and thinking about what is happening in your classroom. You are evaluating many aspects of the lesson, including your own performance and that of the learners. By reflecting continually on particularly successful or problematic learning experiences that have taken place in your classroom, you will start thinking in new ways and be able to improve on your lessons.

As your thinking and teaching ideas develop, use the Africa meets Africa book and film resources and website as primary research material to develop a range of NCS learning materials. The Africa meets Africa Project would be most interested to hear about your teaching and learning ideas and your experiences in the classroom. Do contact us on email at helene@africameetsafrica.co.za, or at Johannesburg fax number (011) 622 7871.

By discussing your ideas and classroom experiences with your colleagues at school and with your subject advisors, you develop your own critical thinking skills, as Outcomes Based Education encourages all life long learners to do. By using the Africa meets Africa resource material creatively, you will spend time looking back on your teaching and then acting on your own critical reflection to arrive at new understandings. This in turn will inform the decisions you make to solve learning problems. Problems seldom exist in isolation, after all.

The following assessment table offers you a broad framework for evaluating learner performance.
It can also be expanded as you add individual comments and observations.

Arts and Culture: Grade 9	**Assessment sheet for the weaving activity**			
Learner's name:				
School:				
District:	**Educator:**			
Assessment Rubric: **1- Totally inadequate. 2- Acceptable.** **3- Good with limitations. 4- Outstanding**	**1**	**2**	**3**	**4**
Overall mastering of technique				
Neatness of weaving				
Good use of time				
Economic use of materials				
Level of participation and contribution to class discussion on local weaving traditions				
Presentation and display: Clarity Originality				
Note your observations on level of involvement, on interesting contributions made to class discussions or additional pieces made by the learner.				

Lesson 3: A guided research task.

Weaving new solutions

Zulu baskets to think with

An Arts and Culture research task for Grade 9 learners

Name: **School:**

1. Look closely at the two baskets, left and below. This red and white *imbenge,* woven in plastic, inspired Laurentia Dlamini's design of the *isichumo* woven in *ilala,* below. In weaving her round basket, she has interpreted the same triangular and diamond shapes in new variations and in slightly different relationships to one another. Can you see the *imbenge's* three central leaf-like shapes reinterpreted in Laurentia's *isichumo?* How do the triangular shapes fit together in her basket? What has the shallower *imbenge's* central circle become on the larger basket? How many more colours has she dyed to weave with?

Write down your answers to these questions, as well as any other examples you can see of how Laurentia has innovated with the basic design elements of shape, line, form, colour and texture.

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2. The basket (right) has been woven in three colours. Triangles fit tightly together like a puzzle. One sees the pattern of triangles because of the contrast of regular white and black triangles, or brown and black. Do you see the white triangles as positive shapes and the black as negative shapes, or do you see the whites as negative shapes and the black as positive? And the black and brown?

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Which other geometric shapes fit together as perfectly as these triangles do, leaving no blank spaces in between? Would squares and rectangles work? Would circles and ovals? Give a reason for your answer, or make a drawing to illustrate what you mean.

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3. Reuben Ndwandwe's designs are also based on triangle and diamond shapes, inspired by the shape of leaves and the Zulu shield. He combines these skilfully in different combinations and patterns. By counting his knots and stitches (notice the rich textured effect of his technique of overstitching) Reuben works out new combinations of shapes and colours in each basket. Count and write down how many large triangles you see in this basket, and how many smaller ones fit into them. Name the triangles by their colours. Can you guess how many triangles there are on the other side of this picture of the basket?

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Reuben's *izinkhamba* are always perfectly regular and symmetrical. He never works out his design before he starts. 'I count as I work' he says. ' My eye has a measurement.' Write down in your own words what you think he means by 'my eye is a measurement.'

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4. Do research and write an essay on one of the master weavers or potters introduced in the *Africa meets Africa* book and film, and also talk to a weaver or potter in your own community or city. Build your research around the questions below, also adding your own:

- Who first taught you to weave (make pots)? Which traditional forms were you taught to make?
- Were these linked to any ceremonies in your community? How are your baskets (or pots) used?
- How do you start a basket? With a spiral or a square knot? Are your pots coiled?
- How do you decorate and burnish them? What firing technology do you use?
- Have you adapted the traditional forms and design knowledge you were taught?
- How did this come about? What inspired you? Do you use new materials, techniques?

  Note: Look for more sources of cultural information at rural markets, museums (such as the Killie Campbell Collection and Ulundi museum and centres like Durban African Arts Centre.)

5. Another source of cultural information is the object itself, like a basket or pot, as cultural expression. It shows evidence of indigenous knowledge and influences from other cultures and times. Economic changes and technological advances also influence the materials used to make it with. Read about how grass weavers started using their knowledge of natural dyes (on page 19), and about how urban weavers would *scooby scoop* with *dooby* (electrical cable) to weave with instead of *ilala* and grass (on page 24). Then think about to the following questions. Write a paragraph in answer to one of them.

Zodwa Maphumulo (left) has woven figures in traditional Zulu clothing into her wire basket, showing a pot for *utshwala*, a hut and cattle. Opposite these figures she has placed others in contemporary clothing generated by Western styles. Why do you think, has she shown these figures opposite one another in the same basket? What cultural information does it hold for us about the present? What kind of market, do you think, will buy this basket - urban, rural, tourist?

Zodwa was taught by the first great wire weaver, Elliot Mkhize. Elliot says the complex patterns in his baskets are all different, but that he works with a basic plan 'like a computer file in my head.' The shapes and designs are all 'straight' or 'geometrical', he says, because he counts his knots in each colour as he weaves. When we look at baskets and weave our own, do we recognize the shapes, patterns and symmetry in their design through the language of art, or do you think we are also responding to mathematical ideas, like geometry? What kind of thinking might be involved in weaving these baskets?

Part 2: Educator's guide:
Thinking geometrically about Zulu designs

The following lessons focus on geometry and concepts of symmetry and link into Part 2 of *Africa meets Africa: Making a Living through the Mathematics of Zulu Design.* In the case of Worksheet 5 in this Lesson pack, the material provided is expanded upon in the *Africa meets Africa* book resource from page 44 onwards. The resource book also offers support learning material on other areas of Mathematics: Numbers (including natural numbers, integers, irrational numbers and series - see Lesson pack 1), Polygons, Tilings (Tessellations) and Symmetry. Part two of the film offers you ten minutes of viewing on each one of the four sections that you can play to the learners in class. Mathematician Dr Chonat Getz looks at examples of beadwork and weaving, exploring abstract mathematical ideas in a concrete way. You will find source material in the book and film suitable for teaching Mathematics from Grade 7 to Grade 12 level.

LESSON PLAN AND OVERVIEW FOR MATHEMATICS, GRADE 9.	
Learning Outcomes and Assessment Standards	LO3: SPACE AND SHAPE *The learner will be able to describe and represent characteristics and relationships between two-dimensional shapes and three-dimensional objects in a variety of orientations and positions.* We know this when the Grade 9 learner • Recognises, visualises and names geometric figures and solids in natural and cultural forms and geometric settings, including regular and irregular polygons • Uses transformations, congruence and similarity to investigate, describe and justify (alone and/or as a member of a group or team) properties of geometric figures and solids.
Teaching, Learning and Assessment Contexts	The material consists of five worksheets which link two-dimensional shapes and transformations to patterns found on beadwork and baskets. Each worksheet focuses on a different geometric concept. The focus of each worksheet is as follows: WORKSHEET 1 Recognising and naming polygons WORKSHEET 2 Sides and angles of polygons WORKSHEET 3 Tessellations (Tilings) WORKSHEET 4 Reflection symmetry and Rotational symmetry WORKSHEET 5 Geometric transformations Answers to each worksheet are given at the end of this pack.
Suggested time for each worksheet	WORKSHEET 1 1 hour WORKSHEET 2 ½ hour WORKSHEET 3 1 hour WORKSHEET 4 1 hour WORKSHEET 5 1 ½ hours
Focus of the Worksheets	The focus of these worksheets is • To ensure that the learners can name polygons correctly. • To assist the learners to recognise the different transformations that can be used to create patterns. • To build an awareness of the geometry that can be recognized in traditional Zulu design knowledge and in the making of baskets and beadwork.
Structure of the Lessons	INTRODUCTION • Spend about 5 minutes introducing the topic to the learners. Where possible, have baskets and pieces of beadwork in class to show or refer learners to the pictures of baskets and beadwork in the *Africa meets Africa* book and film resource. BODY OF THE LESSON • The learners need to know the terminology used in the worksheets, so spend time on this with the learners to make sure they are familiar with it. • Encourage the learners to work with their groups on each activity, to discuss the tasks together and reach consensus on the answers. • They can write their answers on the worksheets or in their mathematics books. CONCLUSION • It is important for you to bring the class to a conclusion at the end of the lesson. • Ask two or three groups to report back on their answers. Encourage the rest of the class to discuss the answers. With each lesson a different groups reports back.
Forms of Assessment	• Learners work together on the tasks with the members of their group, and hence peer assessment is used. • Groups report back on their findings to the rest of the class. The class should then discuss the contribution of each group. • Where learners don't finish the work in class, they can be tasked to complete the work for homework

WORKSHEET 1 RECOGNISING AND NAMING POLYGONS

An ukhamba (round, lidded basket) made by Reuben Ndwandewe

An isichumo (pear-shaped basket with lid) made by Beauty Ngxongo

As you can see from the above photographs, polygons are often used in basket designs.

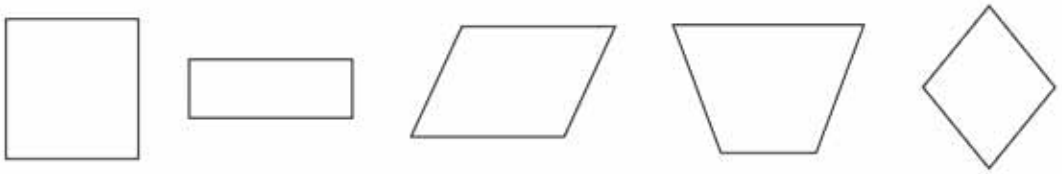
What is a polygon?
A polygon is a plane closed figure whose sides are straight lines.

NOTE:

- A ***plane*** figure is a two-dimensional figure.
- The sides of a ***closed*** shape join up and do not cross each other.

Polygons are given different names according to the number of sides they have.

- A polygon with four sides is called a ***quadrilateral***.



A ***square*** is a quadrilateral

A ***rectangle*** is a quadrilateral

A ***parallelogram*** is a quadrilateral

A ***trapezium*** is a quadrilateral

A ***rhombus*** is a quadrilateral

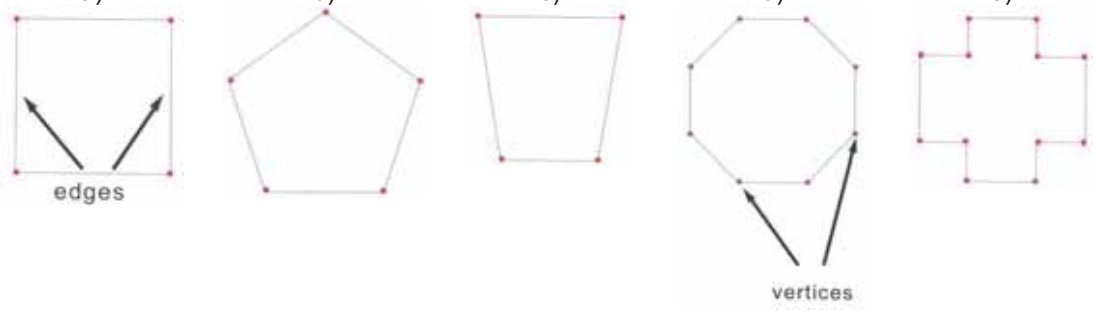
In the same way:

- A polygon with three sides is called a ***triangle***.
- A polygon with five sides is called a ***pentagon*** (penta-gon).
- A polygon with six sides is called a ***hexagon*** (hexa-gon).
- A polygon with seven sides is called a ***heptagon*** (hepta-gon).
- A polygon with eight sides is called an ***octagon*** (octa-gon).
- A polygon with nine sides is called a ***nonagon*** (nona-gon).
- A polygon with ten sides is called a ***decagon*** (deca-gon).
- A polygon with eleven sides is called a ***hendecagon*** (hen-deca-gon).
- A polygon with twelve sides is called a ***dodecagon*** (do-deca-gon).

NOTE

- The sides of a polygon are sometimes called ***edges***.
- The points where the sides meet are called ***vertices***.

a) b) c) d) e)



1) Name each of the above polygons according to the number of sides it has.

a) .....

b) .....

c) .....

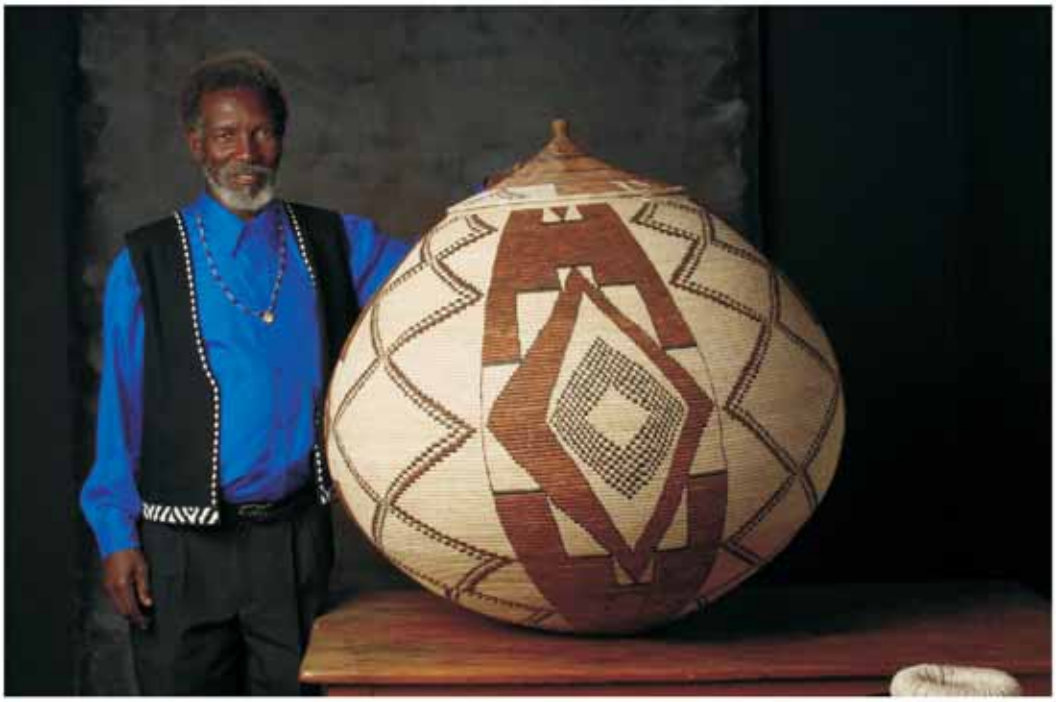
d) .....

e) .....

2) Study the picture of the *isichumo* (pear-shaped basket with a lid).

Write down the names of the different quadrilaterals that were used to make the patterns on this basket.

3) This large *ukhamba* was made by Vina Ndwandwe.
Write down the names of the different polygons you can see on the centre panel of this *ukhamba*.

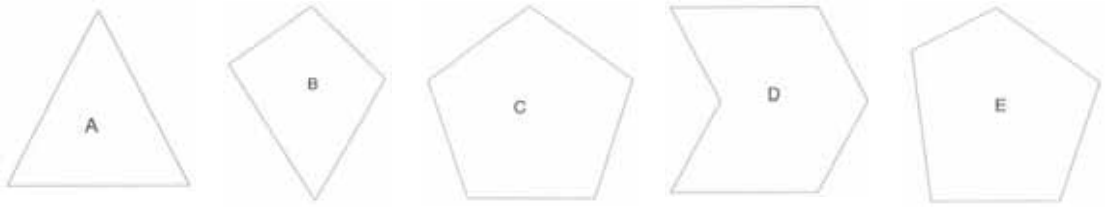


4) Make a list of all the different polygons that you can see in the pattern on this basket.

5) Name the blue and purple polygons on this mat according to the number of sides each one has.

WORKSHEET 2 SIDES AND ANGLES OF POLYGONS

1) Count the number of vertices and the number of sides of each of the following polygons. Write your answers on the following table.



a)

Shape	A	B	C	D	E
Number of vertices					
Number of sides					

b) Write down what you notice about the number of vertices and sides of any polygon.

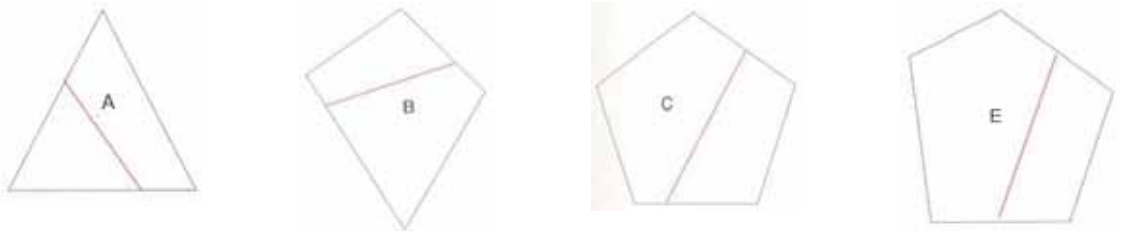
CONCAVE AND CONVEX POLYGONS

All polygons are either ***concave*** or ***convex***.

A polygon is ***convex*** if
- Every angle in the polygon is less than 180°, OR
- Every line joining a point on one side to a point on any other side lies entirely inside the polygon

Example:
Which of the four polygons above are convex?

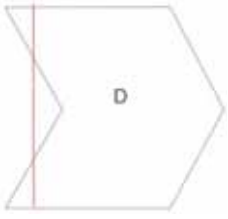
Solution:
A, B, C and E are convex, firstly because every one of their interior angles is less than 180°, and secondly because no matter which 2 sides you join, the line joining them will always lie *inside* the polygon.



A polygon is ***concave*** if
- one of the interior angles is greater than 180°,

OR
- you can find one line joining two of the sides of the polygon which do not lie entirely inside the polygon.

Example:
Of the five polygons in Question 1, polygon D is concave.
We know this because
- one of the interior angles of polygon D is a convex angle (i.e. is greater than 180°)
- at least one of the lines joining two of the sides does not lie completely inside the polygon.

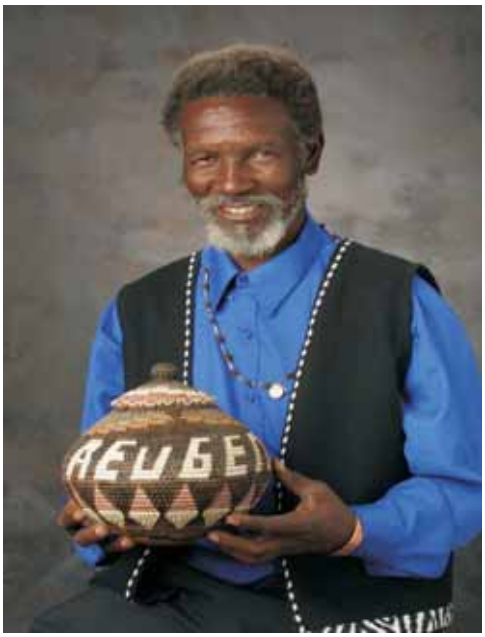


2) Study this picture of an *ukhamba*

One of the designs on this *izimchumo* has 16-sides. Is this 16-sided design convex or concave?

Another one of the designs is a 4-sided polygon (quadrilateral). Is this quadrilateral convex or concave?

3) Reuben Ndwandwe wove his name on the outside of this *ukhamba*.



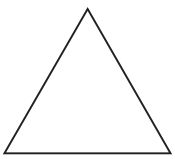
Study the E, the U and the B on the *ukhamba*. Are they convex or concave?

REGULAR POLYGONS

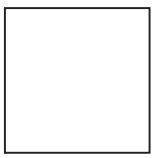
A ***regular*** polygon is one in which

- all the sides are equal,
  AND
- all the interior angles are equal.

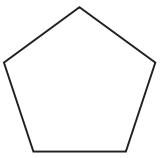
This means that all regular polygons are both ***equiangular*** (all angles are equal in size) and ***equilateral*** (all sides are equal in length).



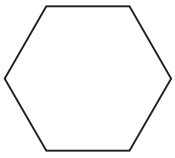
An equilateral triangle is a regular triangle



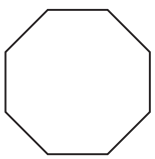
A square is a regular quadrilateral



A regular pentagon



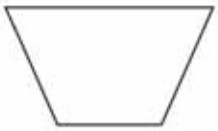
A regular hexagon



A regular octagon

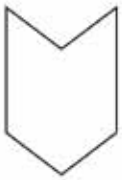
The following polygons are ***not*** regular polygons

A triangle that is not regular



Quadrilateral

Pentagon



Hexagon

Octagon

4) Look at this picture of beaded anklets (*izingusha)*

a) How many regular quadrilaterals do you see that are green?

b) How many regular quadrilaterals do you see that are red?

WORKSHEET 3 TESSELLATIONS (TILINGS)

We often see patterns around us that consist of repeating patterns of geometric shapes. Here are some examples:

- We see patterns in fabrics, or carved and painted on the walls of buildings.
- In nature, the surface of the skin or the stalks of a plant reveal intricate patterns of geometric shapes.
- Artists and architects often work by subdividing space in ways that are pleasing to the eye.

When creating designs, there are many different ways that geometric patterns can be used to cover the entire plane.

- An excellent way to cover or tile a plane surface is by using polygons.
- We can arrange the polygons to fill up the plane so that there are no gaps and without overlapping.

Such tilings, also known as ***tessellations***, ***pavings*** or ***mosaics***, have existed for thousands of years.

Beautiful examples of tiling patterns are found in Zulu beadwork and basketry.

The pattern on this basket consists of different sized triangles.

This waistcoat is tiled with triangles of different sizes

1) a) Name the polygon that was used to make the pattern in this rope belt.

b) Name the polygon that was used to make the pattern on this *ukhamba*

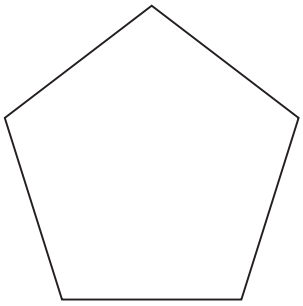
c) This Shembe beaded apron (*ubeshwana)* from the SBAAC is 16 cm wide and 25,5 cm long.

i) Name the polygon that was used to make the pattern on this *ubeshwana*,

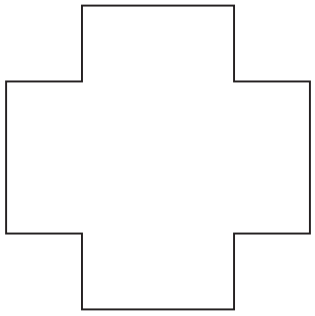
ii) Is this polygon convex or concave?

2) Make at least 6 copies of each of the following polygons, and investigate which ones tessellate.

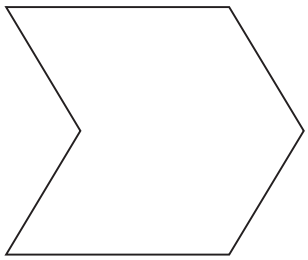
a)



b)



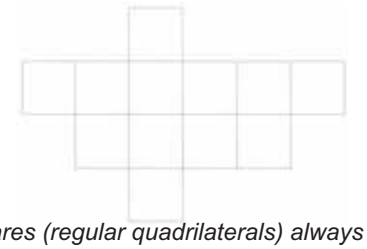
c)



3) Give a reason why shapes tessellate

<u>TILINGS WITH *REGULAR* POLYGONS</u>

Suppose you want to tile with regular polygons.
The patterns that you have studied so far show us that it is possible to do so with equilateral triangles and with squares.



Squares (regular quadrilaterals) always tessellate

Equilateral triangles (regular triangles) always tessellate

The only other regular polygon that tessellates is the regular hexagon

WORKSHEET 4 REFLECTION SYMMETRY AND ROTATIONAL SYMMETRY

Two-dimensional or plane shapes can have two kinds of symmetry:

i) Line or reflection symmetry
ii) Rotational symmetry.

Beauty Ngxongo holds one of her baskets.
The basket and Beauty's face each have one line of symmetry.
We say that they have reflection symmetry.

REFLECTION SYMMETRY

A pattern or a figure has line or reflection symmetry if the pattern on the left hand side of a line of symmetry is the mirror image of the pattern on the other side. (A *mirror image* of something is its picture in the mirror.)

The piece of wire shows the line of symmetry of this double beaded apron (ubeshwana) from the SBAAC. If we folded this ubeshwana along the line shown by the piece of wire, we would find that the one half of the pattern would lie exactly on top of the other half of the pattern.

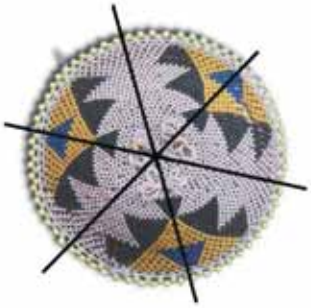
- The *amashwana* below have reflection symmetry. The black lines are lines of reflection.

This amashwana has one vertical line of symmetry

The individual designs within this amashwana each have lines of symmetry.

- We find reflection symmetry in the *imbenge* (flat open baskets) and *izinchumo* (pear-shaped baskets with lids) shown below.

This imbenge has 2 lines of symmetry



This imbenge has 3 lines of symmetry

This izichumo has 4 lines of symmetry

ROTATIONAL SYMMETRY

A rotation is a turn.

A shape has rotational symmetry if it co-incides with itself after being rotated (turned) about a point through an angle of less than 180°. ("co-incides with" means "is the same as")

Order of rotational symmetry

The order of rotational symmetry is found by counting the number of times that a shape or pattern co-incides with itself when rotated through 360°.

Example:

- If a shape co-incides with itself twice (two-times) when rotated through 360°, we say that it has ***order 2 rotational symmetry***.
- If a shape co-incides with itself four-times when rotated through 360°, we say that is has ***order 4 rotational symmetry***.

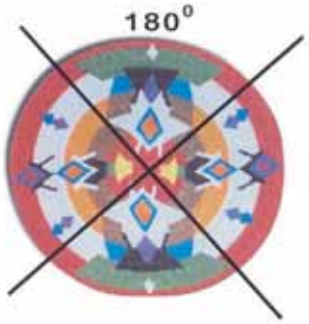
Angle of rotational symmetry

The angle of rotational symmetry is found by calculating ***360° ÷ order of rotational symmetry***

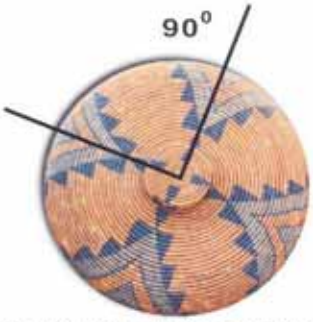
Example

- If a shape has order 2 rotational symmetry, its ***angle of rotational symmetry = (360° ÷ 2) = 180°***.
- If a shape has order 4 rotational symmetry, its ***angle of rotational symmetry = (360° ÷ 4) = 90°***

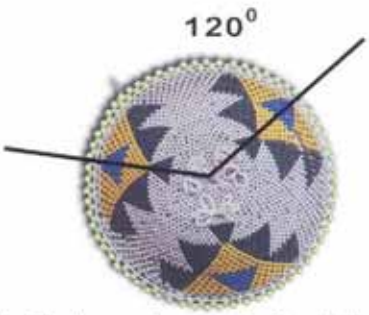
Let's look at these photographs of baskets with rotational symmetry.



This izimbenge has order 2 rotational symmetry
Its angle of rotational symmetry = (360° ÷ 2) = 180°



This izinkhamba has order 4 rotational symmetry.
Its angle of rotational symmetry = (360° ÷ 4) = 90°



This izimbenge has order 3 rotational symmetry
Its angle of rotational symmetry = (360° ÷ 3) = 120°

Study the photographs of the *izimbenge* (flat open baskets) below.

a) Draw in the lines of reflection (if any) on the *izimbenge*.
b) Calculate the order and angle of rotation symmetry (if any).
c) Complete the following table.

Imbenge	Number of lines of reflection	Order of rotational symmetry	Angle of rotational symmetry
1			
2			
3			
4			
5			
6			


1


2

3



4

5



6

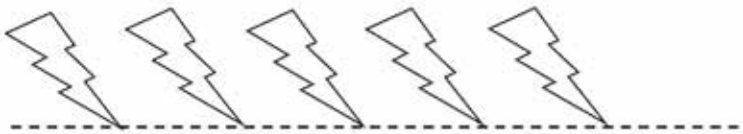
WORKSHEET 5 GEOMETRIC TRANSFORMATIONS

TRANSFORMATIONS

- To transform something is to change it in some way.
- A transformation is what brings about the change.

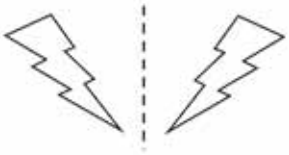
There are many kinds of geometric transformations. Here are three:

i) TRANSLATION
When a shape is transformed by *sliding* it to a new position and without turning it, it is said to be translated.



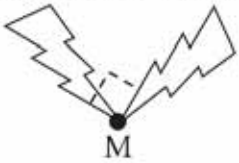
A pattern has translation symmetry if you can repeat the pattern precisely by sliding.

ii) REFLECTION
A reflection is a transformation which has the same effect as holding the pattern up to a mirror.
When a shape is transformed by *flipping it* around a line of symmetry, it is said to be reflected.



The effect of reflection on any object is to produce an image of the same shape and size but in the opposite sense.

iii) ROTATION
A rotation is a transformation which moves points or shapes a certain angle around a centre of rotation.



A rotation is defined when its centre, the angle of rotation and the direction of the turn is given.

The hendacogon (11-sided polygon) has been rotated 90° in a clockwise direction around the centre of rotation, M.

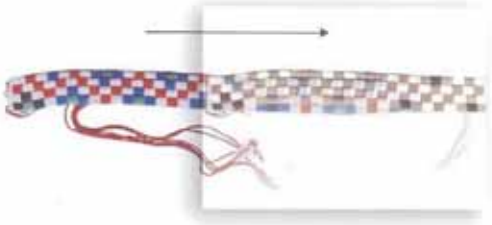
STEPS TO GO THROUGH IN ORDER TO FIND OUT WHETHER A PATTERN HAS BEEN CREATED USING EITHER TRANSLATION, REFLECTION OR ROTATION.

As can be seen in the diagrams on page 44 of ***Africa meets Africa, Making a Living Through the Mathematics of Zulu*** *Design, and Part 2 of the film* ***Things to Think With*** *where Dr Chonat Getz explains these concepts further, tracing paper can be used to find out which of the three listed transformations has been used to create a pattern.*

1) Start off with a repeated pattern.
2) Trace this pattern.
3) Place the tracing paper on top of the pattern so that it fits exactly on top of the original pattern (i.e. super-impose the tracing on top of the original pattern).
4) Move the tracing paper in one of the three following ways:
   a) Slide the tracing paper along the pattern. If the patterns co-incide exactly, the pattern is formed by *translation*.
   b) Lift the tracing paper. Rotate the tracing paper through 180°. If the patterns co-incide exactly, the pattern is formed through *reflection*.
   c) Put a pin through the centre of the pattern. Rotate the tracing paper. If the patterns co-incide exactly, the pattern is formed through *rotation*.

Example 1:
Rope belts (*umtsha*) are worn by married women in Nongoma.

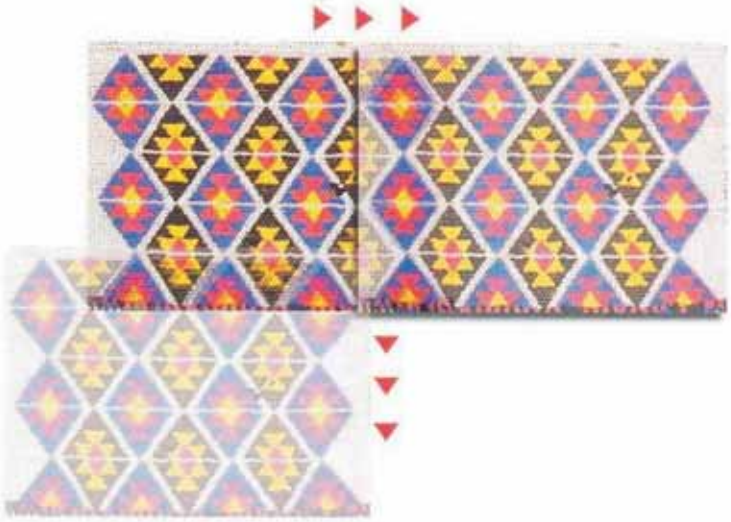
- If you look at the pattern on this rope belt, you can see how it has been repeated by sliding it in a straight line from right to left or left to right.



- This pattern also has lines of reflection. If you fold the belt along the line drawn on the diagram, both sides of the pattern will co-incide.

Example 2:
This picture is of an *ubeshwana* (Zulu beaded apron).

- If you look at the red arrows on the picture, you can see that the design has been translated in two directions horizontally and vertically



- The pattern also has lines of reflection.
  - If you fold the beaded apron along any vertical line on the diagram, both sides of the pattern will co-incide. In other words each vertical pattern has a vertical line of reflection.
  - If you fold the beaded apron along any one of the horizontal lines on the pattern, both sides of the pattern will co-incide. Each horizontal pattern has a horizontal line of reflection.
- Rotate the pattern around any of the yellow diamonds or around any of the red diamonds by placing a pin through one of the diamonds. You will see that the pattern has order 2 rotational symmetry or 180° rotational symmetry.

Study the following photographs of beadwork.

- Trace the patterns.
- Move the tracings in order to find out whether the patterns on the beadwork have been formed by
  - Translation
  - Reflection
  - Rotation
- Answer the questions on the table for each of the designs.

	Design 1	Design 2	Design 3	Design 4	Design 5
1) a) Could the pattern be formed by translation?					
b) In how many directions can the pattern be translated?					
2) a) Could the pattern be formed by reflection?					
b) Does it have a vertical line of reflection?					
c) Does it have a horizontal line of reflection?					
3) a) Was the pattern formed by rotation?					
b) If so, what is the order of rotation?					
c) If so, what is the angle of rotation?					

1

2

3

4

5

ANSWERS

WORKSHEET 1 – RECOGNISING AND NAMING POLYGONS

1. a) Quadrilateral
   b) Pentagon
   c) Quadrilateral
   d) Octagon
   e) Dodecagon
2. 3-sided polygons (triangles), 4-sided polygons (quadrilaterals/diamonds/rhombuses)
3. 4-sided polygons (quadrilaterals) and 16-sided polygons
4. 4-sided polygons (quadrilateral/diamonds/rhombus) and 28-sided polygons
5. 3-sided polygons (triangles), 5-sided polygons (pentagons), 6-sided polygons (hexagons)

WORKSHEET 2 SIDES AND ANGLES OF POLYGONS

1. a)

Shape	A	B	C	D	E
Number of vertices	3	4	5	6	5
Number of sides	3	4	5	6	5

   b) All polygons have the same number of vertices and sides.
2. 16-sided polygons – concave
   4-sided polygons – convex
3. E – concave
   U – concave
   B – concave
4. a) 5 green regular quadrilaterals/squares
   b) 5 red regular quadrilaterals/squares

WORKSHEET 3 TESSELLATIONS (TILINGS)

1. a) Rectangle
   b) Hexagons
   c) i) 12-sided polygon or dodecagon
      ii) concave
2. a) Does not tessellate
   b) Does tessellate
   c) Does tessellate
3. Shapes tessellate when they fit together without any gaps and without overlaps. In order to fit together, the angles at a point must add up to 360°.

WORKSHEET 4 – REFLECTION SYMMETRY AND ROTATIONAL SYMMETRY

Imbenge	Number of lines of reflection	Order of rotational symmetry	Angle of rotational symmetry
1	0	40	360° ÷ 40 = 9°
2	0	14	360° ÷ 14 = 25,7°
3	2	2	360° ÷ 2 = 180°
4	0	–	–
5	2	2	360° ÷ 2 = 180°
6	8	4	360° ÷ 4 = 90°

WORKSHEET 5 – GEOMETRIC TRANSFORMATIONS

	Design 1	Design 2	Design 3	Design 4	Design 5
1) a) Could the pattern be formed by translation?	Yes	No	Yes	Yes	Yes
b) In how many directions can the pattern be translated?	2	-	1	1	1
2) a) Could the pattern be formed by reflection?	Yes	Yes	Yes	Yes	Yes
b) Does it have a vertical line of reflection?	Yes	Yes	Yes	Yes	Yes
c) Does it have a horizontal line of reflection?	No	Yes	No	No	No
3) a) Was the pattern formed by rotation?	No	Yes	Yes	Yes	No
b) If so, what is the order of rotation?	-	2	2	2	-
c) If so, what is the angle of rotation?	-	180°	180°	180°	-

Back cover: Mkheti Mhlongo (11 years old) and his sister Chamakile Mhlongo (22) with baskets they have woven. They were taught to weave by their mother.

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