Linking Mathematics and Culture to Teach Geometry Concepts

Vincent Snipes and Pamela Moses

Introduction

Throughout history, mathematics has been used by different peoples in various ways. Arithmetic and geometry were utilized to meet the everyday needs of the people. The Egyptians used geometry to construct pyramids for burial purposes (Burton, 1999). The study of mathematics used by different peoples has evolved into what is now called ethnomathematics.

For this article, *ethnomathematics* will be defined as how peoples of various cultures use mathematics in their everyday lives. Furthermore, culture means peoples' language, place, traditions, and ways of organizing, interpreting, conceptualizing, and giving meaning to physical and social worlds (Ascher, 1991 p.2). Also, it is important to note that cultural groups are not limited to just racial or ethnic groups. Examples of cultural groups include high school mathematics teachers, accountants, and computer scientists to name a few. All of these groups have their own language, traditions, and ways of interpreting and conceptualizing situations.

Ethnomathematics in the Classroom

Ethnomathematics activities, which link mathematics and culture, are very beneficial to students. Students can learn about different peoples utilize mathematics within their cultures and about non-Western cultures and subcultures within the United States. These activities create an opportunity for teachers to integrate mathematics with other disciplines such as social studies, English, and art, which result in the previously mentioned opportunities for students.

Ethnomathematics activities can be performed with all types of students, from Pre-K to12th grade, and in any type of mathematics classroom, from the academically gifted setting to the standard setting. These activities may stimulate interest about people of various cultures, other than the students' cultures. The topic of the activity that will be shared is "Finding the Center of a Rectangular Box Top."

Activity "Finding the Center of a Rectangular Box Top"

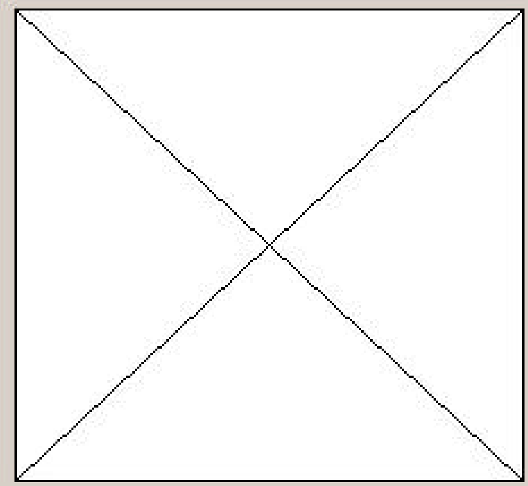
This ethnomathematics activity relates to a group of South African carpenters and their use of geometry in their everyday lives. The activity could be implemented in a third thru sixth grade classroom when students are learning geometry concepts such as length, width, and diagonals or are studying African countries in social studies. Background information can be given about South Africa, mathematics used in South Africa, and a detailed discussion specifically related to geometry. Moreover, this activity reflects almost all of the concepts in the NCTM *Standards and Principle* (2000).

Millroy (1992) studied a group of carpenters in Cape Town, South Africa to learn how they utilized mathematics in their everyday job duties. These carpenters stopped all formal mathematics training from the ages of 12 to 16 years old and did not consider their work to have much to do with "real" mathematics.

One day the researcher observed one of the carpenters finding the center of a box lid, so that a star design could be placed at the center of a piece of furniture. The scenario of the carpenter finding the center of the box lid is as follows:

The carpenter took a box lid and drew diagonals **(See figure 1).** He measured diagonally across the frame from corner to corner and recorded the length. He then measured the length diagonally between the other two corners. According to the carpenter, if the lengths are slightly different, then the cupboard or table frame is not a square. (Millroy, 1992).

Figure 1



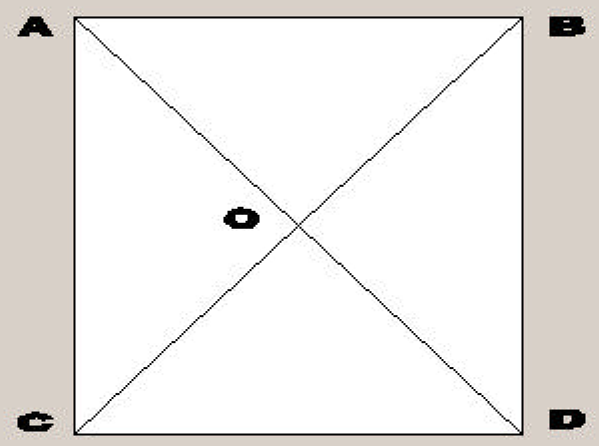
The carpenters referred to all rectangular shapes as "squares." This is an incorrect statement mathematically and should be pointed out to the students. All squares are rectangles, but not all rectangles are squares. The carpenters measure both parts of each diagonal. If all four parts are the same length, then the table frame is a rectangle. The intersection of the two diagonals is the "center" of the box. The center of a rectangle is defined as a point inside the rectangle equidistant from the four corners (vertices). The researcher asked the carpenter why this method of finding the center worked, and the carpenter replied, "Because it is the center" (Millroy ,1992). Many times the carpenters gave explanations similar to this when asked why things were done a certain way.

This group of carpenters has learned to find the center of a box lid through everyday job experiences and not from geometry principles learned in school. What this means is that these carpenters were taught certain processes to follow to perform job tasks, but they can not tell you the specific geometric principles that enable them to be successful with their job tasks. There are three geometry principles that the carpenters understand that enable them to correctly find the "center" of a box (Millroy, 1992). First, the opposite sides of a rectangle are equivalent in length. Secondly, the lengths of the diagonals of a rectangle are equal, which is not the case for other parallelograms. Thirdly, the diagonals of a rectangle bisect each other, which allows the carpenters to find the "center" from the point of intersection of the diagonals. From the point of intersection of the diagonals, it is the same distance to each one of the corners or vertices, which is why we can call that point the "center." With other parallelograms that are not rectangles, the intersection of the diagonals does not produce a "center." Since the non-rectangular parallelograms have diagonals that are not congruent, then the distance from the point of intersection to each of the 4 corners or vertices would not be equal; therefore, that point would not be a true "center" by definition.

"Finding the Center of a Rectangular Box Top" was performed with a group of 20 elementary school students **(See class activity at the end of the article)**. Instead of using actual box tops, sheets of paper with a rectangle on them were utilized. This activity was designed to allow the students to discover various properties of the rectangle, make conjectures, and share and discuss their own mathematical connections and findings. When performing this activity, the teacher should not tell the students that the quadrilateral is a rectangle or tell any other properties of the provided figure. It is important for the teacher to show an illustration to the students for each step that required drawing and labeling; otherwise, the class would not have a uniform figure **(See figure 2)**.

Most of the students had no problems measuring the line segments in inches, but a few had problems writing their measurements as a mixed number. Most of the students already knew that the opposite sides of a rectangle are the same length, but students were instructed to measure the sides of the rectangle to verify that opposite sides of a rectangle are the same length. Students were dissuaded from stating, “it looks the same length” as an answer for this activity. Some students conjectured that the diagonals of a rectangle are the same length. After the students measured the length of each diagonal, they discovered that the diagonals are the same length, provided that their diagonals were drawn relatively straight.

Figure 2

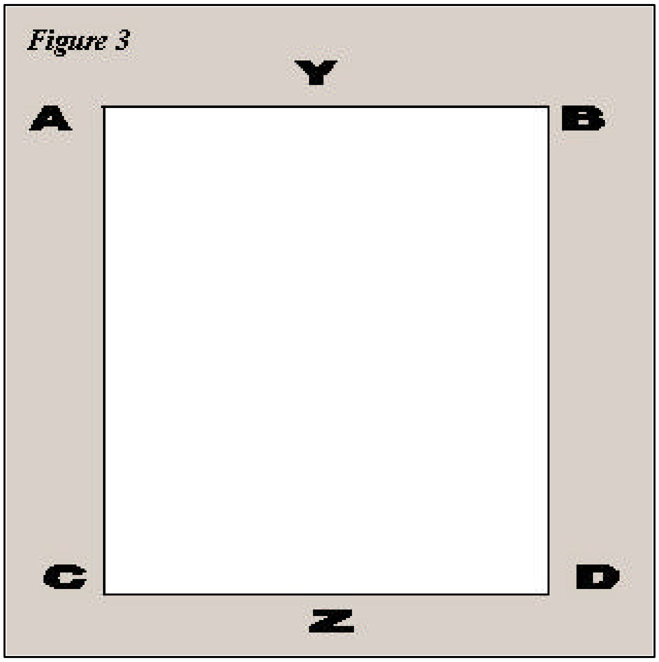


When it was time to measure the parts of the diagonal, two students said that the four parts should all be the same length. Their rationale was that each diagonal was divided into two parts, so both parts of the diagonal should be the same length, which they based this on the appearance of the figure. One girl said that since the diagonals were the same length, then all four segments OA, OB, OC, and OD should be the same length. The students’ measurements verified that these four segments were congruent. From our earlier discussion about the South African carpenters, some students realized that point O was the center of the rectangle, which is the point inside the rectangle equidistant from the 4 vertices.

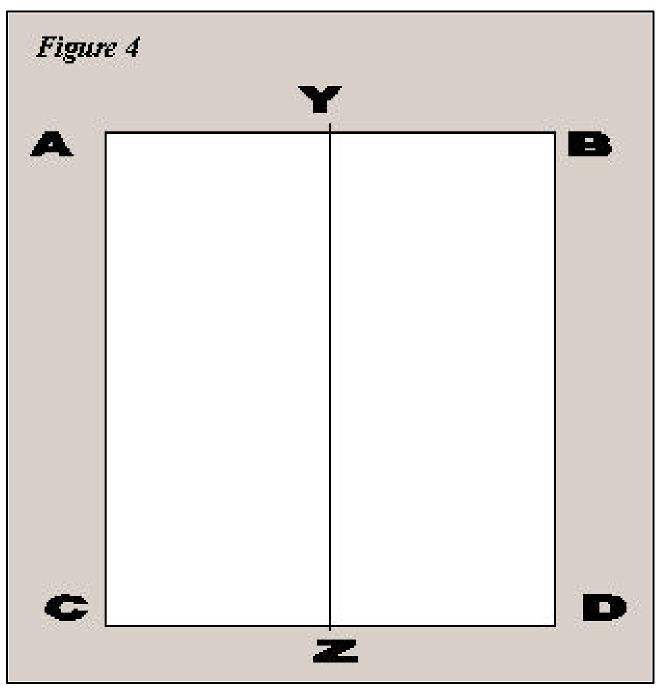
The students also had the opportunity to communicate with other students. After all measurements are taken, the students are instructed to share their findings with other classmates and discuss their own mathematical connections. Some of the students were really excited after completing the activity because they felt like they could design houses and furniture tops like the South African carpenters did.

The activity the students completed focused on students at the 5th grade level. Modifications can be made to this lesson to assist students in discovering properties of the rectangle. For example, it may be helpful to have the students circumscribe a circle around the outside of the rectangle, which touches the four vertices, and use their knowledge about the circle in relation to the diagonals. Remember, typically students have not been formally introduced to diagonals in the mathematics classroom in the fifth grade. However, many students are familiar with diagonals in everyday life by playing games such as tic-tac-toe, Connect Four, and traditional checkers. Formal introduction of diagonals in a mathematical context begins generally in the sixth grade. Since students are pretty familiar with the circle by fifth grade, this may assist them in making meaningful conjectures.

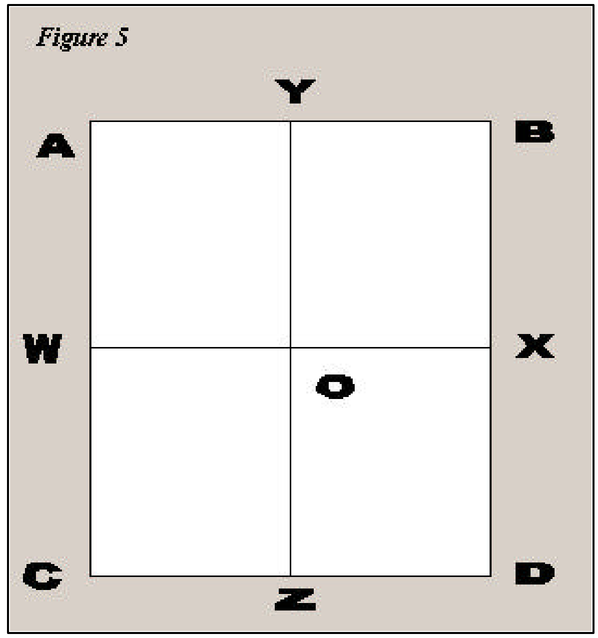
This activity illustrates how South African carpenters utilize mathematics in their everyday lives to find the center of a rectangular side of a piece of furniture. It is interesting to compare the methods used by the South African carpenters to those practiced by American carpenters. Two American carpenters were asked individually how they would proceed to place a design at the center of a rectangular side of a piece of furniture.



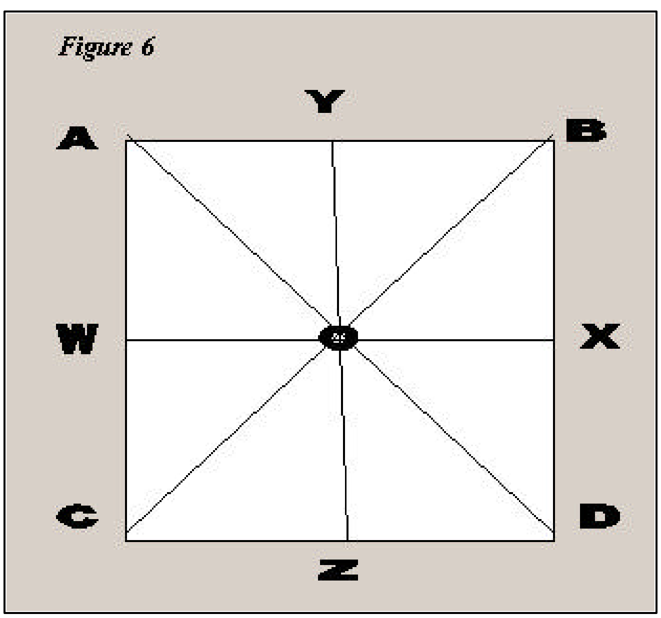
The American carpenters informed us that cabinet doors and other rectangular pieces of wood are usually ordered from catalogs and come with exact measured dimensions. Thus, when the carpenters receive the wooden boards for making furniture, they do not have to generally verify whether or not the boards are rectangles. First, they measure the length of a pair of the parallel sides (AB & CD) and mark the center of each side, points Y and Z **(Figure 3)**. Secondly, they connect the center points of each parallel side with a line segment YZ **(Figure 4)**. The American carpenters point out that segment YA is a perpendicular bisector for segments AB and CD and verify this by measuring angle BYZ and angle YZD and show me that both angles measure 90 degrees. Thirdly, the carpenters repeat the same process with the other parallel sides, segment BD and segment AC. Next, the center points of each parallel side (X) and (W) are connected with line segment WX, which is the perpendicular bisector of AC and BD



(figure 5). Finally, through years of experience, the carpenters realize that point O, the intersection of the perpendicular bisectors, is the center point of the rectangle.



From the method followed by the American carpenters, it is easy to verify that point O is the center of the rectangle. Again, let me emphasize that the center of a rectangle is defined as an interior point equidistant from the four vertices. Since point O lies on the perpendicular bisector of segments BD and AC, then point O is equidistant from the endpoints of both segments **(Figure 6)**. Thus OB=OD and OA=OC. Also, point O lies on the perpendicular bisector of segments CD and AB, and point O is equidistant from the endpoints of both these segments **(Figure 6**). Thus OB=OA and OD=OC. The lengths of the four segments are equal, which makes point O the center of the rectangle.



The South African carpenters and American carpenters both found the center of a rectangle, but they utilized different methods. The South African carpenters centered their approach around their knowledge of diagonals, and the American carpenters approached the task by building upon their knowledge of perpendicular bisectors. This comparison demonstrates that in other cultures individuals sometimes use different problem solving methods. This is an important concept because students must realize that there is usually more than one problem solving strategy to arrive at the correct answer.

Conclusion

Ethnomathematics, which is how a culture understands and utilizes mathematics in everyday life, is a growing field. It is comprised of interesting and informative cultural issues as well as mathematically rich information. Ways to integrate ethnomathematics in the mathematics classroom are:

1. Utilize mathematics games from different cultures like Mankala and Igba-Ita (Zaslavsky 1998).
2. Share with students how other cultures use different algorithms than those used in the United States for working problems (Ex. Different ways of multiplying, different ways to represent numerals).
3. Illustrate how other cultures view mathematics and utilize mathematics in their everyday lives.
4. Bring in guest speakers from different cultures to demonstrate to the students how they use mathematics.

Acknowledging the cultural component of mathematics will enhance our appreciation of its scope and of its potential to provide an interesting, artistic, and useful view of the world (Barton, 1996).

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<u>Class</u> <u>Activity</u> (Finding the Center of a Rectangular Box Top)

Objective: To let the students discover various properties of a rectangle

Grade level: 5th Grade

Estimated time: 45 minutes

Materials: Shoe box top or a sheet of paper with a rectangle drawn on it; ruler; pencil

Directions:

1. Flatten the edges of your box top.

2. Label the four corners of the rectangle. Use A, B, C, and D. Make sure that everyone has his or her rectangle labeled the same way.

3. Use your ruler as a straightedge to draw in diagonals on the box top. Where the diagonals intersect, label that point O.

4. Measure and record the length of each diagonal and each side. AB=________ BD=_______

   CD=_______ AC=________ AD=_______ BC=________

5. Measure and record the length of both parts of each diagonal. AO=______
   BO=_______CO=_______ DO=________

6. Make a list of things that you discovered about your box top. ___________________

   ____

   ____

7. Find a partner and share your list with your partner.

8. Share your discoveries with the entire class.

<u>Further Reading:</u> Read *Afro-Bets: Book of Shapes* by Margery Brown to identify rectangles and discuss how they are encountered in our everyday lives.

The following figures are full size duplicatable copies for classroom use.

Figure 1

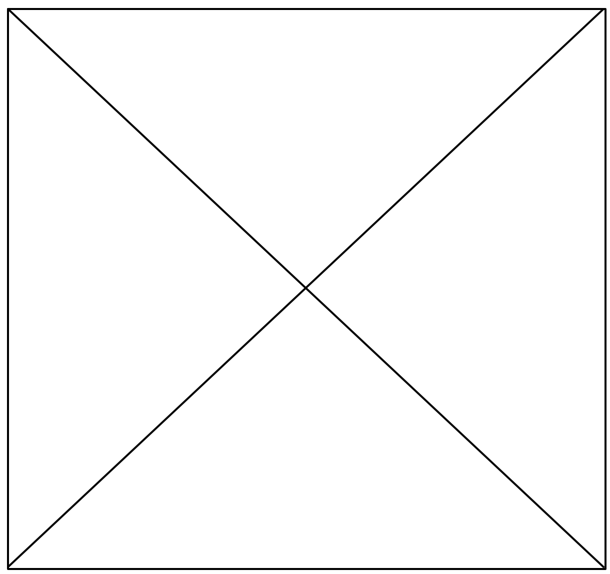

Figure 2

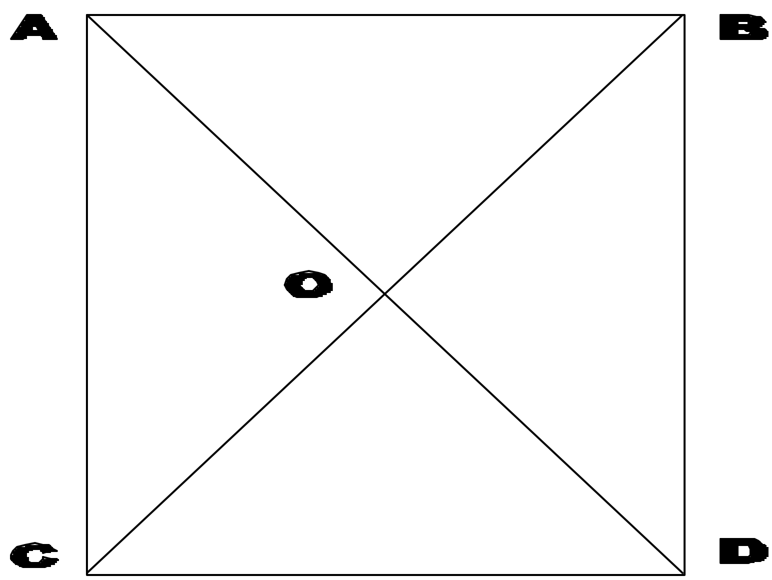

Figure 3

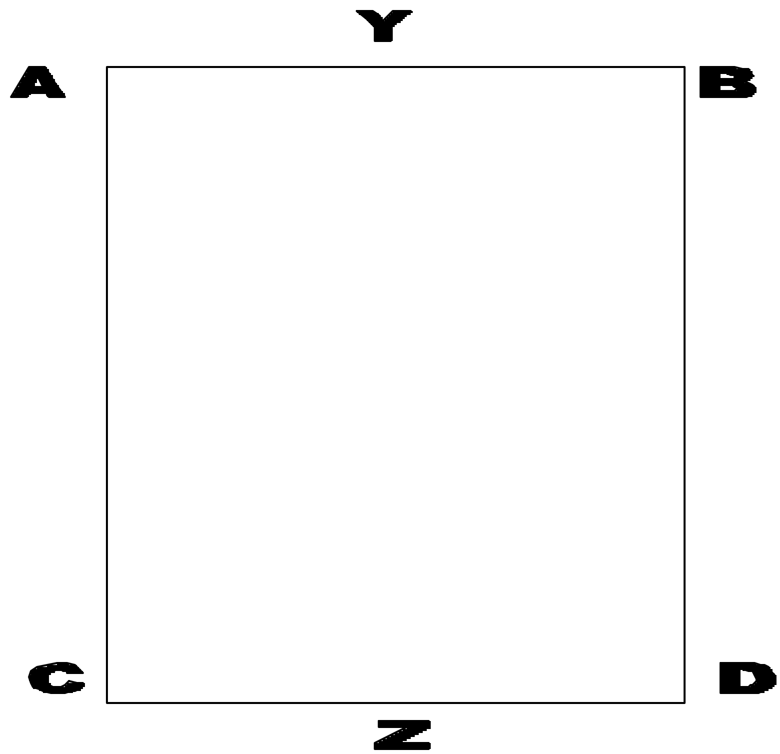

Figure 4

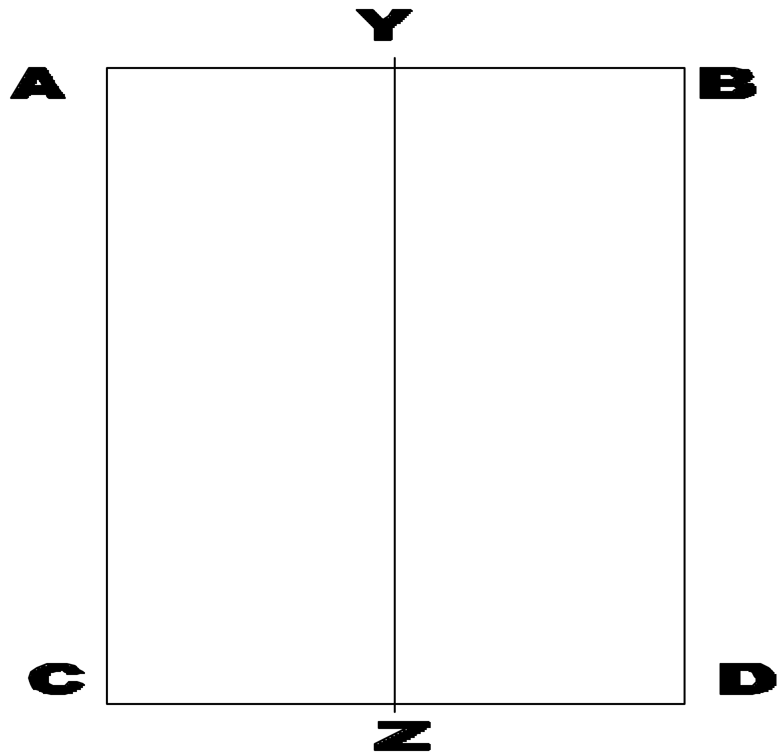

Figure 5

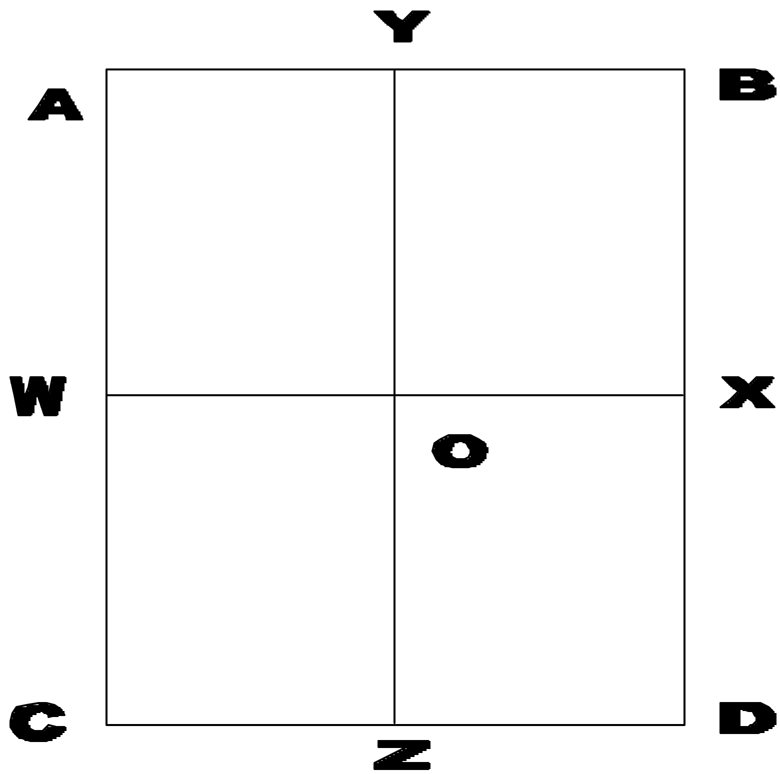

Figure 6