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RESEARCH ARTICLE

ETHNOMATHEMATICS IN BEDOUIN SOCIETY (GEOMETRY IN BEDOUIN EMBROIDERY)

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ABSTRACT

In this essay we will present the ethnomathematics of the Bedouin society in the south of Israel, and in particular the ethnomathematics manifested in the folkloric embroidery of Bedouin women. The purpose of this essay is to show how Bedouin women knew mathematics intuitively and used unique cultural values and elements in their daily lives, which contain and reflect a variety of didactical mathematical aspects, concepts, and attributes. In this essay we will show how Bedouin women knew mathematics through their embroidery work. The data presented in this essay is based on research we conducted among the Bedouin population and particularly with Bedouin women, with the aim of searching for and collecting ethnomathematics knowledge in Bedouin society. This goal was derived from our need to experiment with the ethnomathematical approach in math instruction in order to make the subject easier and more accessible to our students, and to increase their desire to study it. In the future, at a more advanced stage, we intend to integrate it in the curriculum.

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INTRODUCTION

In light of the numerous changes that have occurred in the structure of Bedouin society in Israel and the cultural customs of this population as a result of the process of modernization, many of the traditional socio-cultural characteristics and values have disappeared. For example, one of the basic characteristics of traditional Bedouin life was living in a tent and roaming the land. One can argue that today, in Israel, such a way of life no longer exists, as the Bedouins now reside in permanent homes. Nevertheless, despite the numerous changes in their way of life, the Bedouins have managed to preserve to some degree several of their traditional social and cultural values and practices. One of these practices is the sewing and embroidery skills of Bedouin women, which were passed informally from mother to daughter, from one generation to another, until very recently. The embroidery traditionally practiced by Bedouin women included numerous shapes and objects, such as flowers, plants, geometric shapes, numbers, round letters, line types, and animals all of which were hand-embroidered very precisely, using various methods and colors, several types of cloths, needles, and a special white net. This essay details these tools and the way they embodied ethno-mathematical knowledge that was used to consistently embroider precise geometric shapes.

The importance of developing a curriculum that integrates cultural values: Following the development of the ethno mathematical trend as an educational-cultural field, several proposals were suggested and numerous attempts were made to develop curricula with multicultural mathematical ideas that include traditional cultural values, traditions, symbols, and mechanisms for the purpose of aiding the instruction of mathematical subjects. This trend testifies to the importance and centrality of ethno mathematics, which appears now not only as a matter of enrichment or the property of a certain society of power, but as a matter that requires an overall effort to develop. Therefore, cultural values must be utilized in mathematical education and instruction, out of solidarity and respect for all cultures as such, while preserving their future existence (Shirley, 2001). According to D'Ambrosio (2002), educators are responsible for the learning process and therefore they must develop informal curricula that refer to the reality in which the student lives, while integrating traditional values in their cultural-educational context in the mathematical instruction and learning process. As he stated: "Education must impart respect of culture and take into account cultural values. This matter requires much more than is offered in the regular curriculum. The situation of math is particularly grave. It has no relation to the experience of children. We need more mathematical content that creates interest" (pp. 3–5).

Teaching mathematics without cultural context on the pretext that it is abstract and universal is the reason for the failure of students in this subject. On the other hand, when students are exposed to various cultural links and reflect upon them together, they develop a desire to learn and their self-confidence grows. A similar result was found in a research we conducted and that included the development and implementation of an ethno mathematical curriculum among two groups of Bedouin students in Israel (Amit& Abu Qouder, 2016). "Comparisons between the experimental group (75) and the control group (70) showed that studying the integrated curriculum improved the students' self-perception and motivation, but had almost no effect on achievements in school tests that were conducted immediately after the experiment. The experiment had an extra social impact, changing students' attitudes to their own culture and the tribe's older generation." (Amit& Abu Qouder, 2016).

Teaching math in a completely abstract, symbolic, and meaningless manner that is remote from cultural aspects is not merely ineffective; it is actually harmful to the students, society, math itself, and future generations. As educators we must encourage children to see what they are aiming for; not what we are aiming for. The numbers and symbols that we use with children are meaningless to them, and their meaning goes beyond what we intend or note. Children have their own priorities regarding symbols, which in some cases turn into strong feelings and adamant decisions. Math teachers and educators usually ignore these issues or fail to understand how culture is related to the students and their learning process (Fasheh, 1982). Through ethno mathematics, which is linked to human life, learners can be more active in solving problems because they are related to their lives (D'Ambrosio, 1987). However, much of the curricula used by teachers do not correspond to the social and cultural reality of the students and therefore they do not cooperate (D'Ambrosio, 2001). Not only that but If students view mathematics as a prestigious and social value, the question of whether they are present in their culture or not can have a significant impact on them And imagine that culture, and by itself. In other words, see their culture completely separate from one of the greatest human achievements may cause them Feel that they and / or their families are somewhat inferior, and perhaps not worthy or able to learn mathematics. (Amit& Abu Qouder, 2017).

Teaching math without cultural context on the pretext that it is perfect, abstract, and universal is the reason for students' declining achievements and their failure (Gilmer, 1990). To remedy this situation, we must find ways to help students learn about their cultural mathematics. When students are exposed to different mathematical cultural values and reflect upon them together they discover that they know more than they thought they knew when they were judging themselves by the formal, traditional mathematics. Furthermore, in this way they develop a desire to learn and their self-confidence grows. Also, ethno mathematics helps them solve more complex problems (Powell &Frankenstein, 1997). Implementing situations from the local culture in the classroom is one way in which to assist students in seeing the relevancy of math to their culture, and subsequently use this link to assist in teaching math. According to D'Ambrosio (2002), educators are responsible for the learning process and therefore they must develop informal curricula that refer to the reality in which the student lives, while integrating traditional values in their cultural-educational context in the mathematical instruction and learning process. As he stated: Education must impart respect of culture and take into account cultural values. This matter requires much more than is offered in the regular curriculum. The situation of math is particularly grave. It has no relation to the experience of children. We need more mathematical content that creates interest (pp. 3–5). The development of ethno mathematics is a long-term project due to the numerous changes occurring in society, which entail the replacement of old structures with new ones. Therefore we must focus not only on attempts to develop formal curricula; we must also develop proposals and means that can serve ethno mathematics in order to develop anthropological structures related to ethno mathematics. The biggest challenge facing educators and math teachers is finding the correct way to impart mathematical rules and content in an effective, enjoyable, and successful manner that will enable students to learn and master modern mathematics. Ethno mathematics curricula can be one way to achieve this goal. In this light the effectiveness of math education and its effect on student achievements is high on the agenda of numerous countries (Keitel, Damero, Bishop, & Gerdes, 1989), which is one reason why numerous researchers have developed and implemented ethno mathematics curricula. Studies that have been conducted on such curricula testify to its effectiveness in various aspect of math education.

For instance, similar results were found in a research conducted by the authors (Amit& Abu Qouder, 2016) among a Bedouin population in Israel. This study included the development and implementation of an ethno mathematics curriculum based on integrating Bedouin cultural values and elements for an especially constructed learning unit on the subject of units of measurement. Four 7th grade classes two classes in the experiment and two as a control were the research population. Findings showed a clear improvement for the experimental group in various outcomes such as motivation and self-conception, which were at higher levels after the implementation of the ethno mathematics program compared to before. For the control group, these values did not change between the two measurements and in fact slightly dropped. The study also affected the students positions toward their culture and the adults in their society, making these positions more positive. However, the findings showed no effect on the math achievements of the students. In addition, several researchers developed and implemented a theoretical structure to analyze student's lack of desire to participate in a cultural course for teachers (Verner, Massarwe & Bshouty, 2013). Participants were pre-service and in-service teachers, Arabs and Jews, religious and secular, who studied geometry through inquiry into geometric ornaments drawn from diverse cultures, and acquired knowledge and skills in multicultural education. The methodology of engagement structures recently proposed by Goldin et al. (2011) was used to analyze the emotional behaviors in the course. The research findings showed that engagement structures were a powerful tool for examining the student's lack of motivation to study math. The constructivist ethno mathematical approach highlighted the structures that matched our instructional goals and diminished those related to students' feelings of dissatisfaction and inequity. The researchers suggested a new engagement structure "Acknowledge my culture" that nurtures math education. Findings also showed that the participants perceived this type of learning as a meaningful experience that, contrary to other learning methods, enhances their positive feelings toward other students and teachers and contributed to a lively discourse among them and raised their level of motivation.

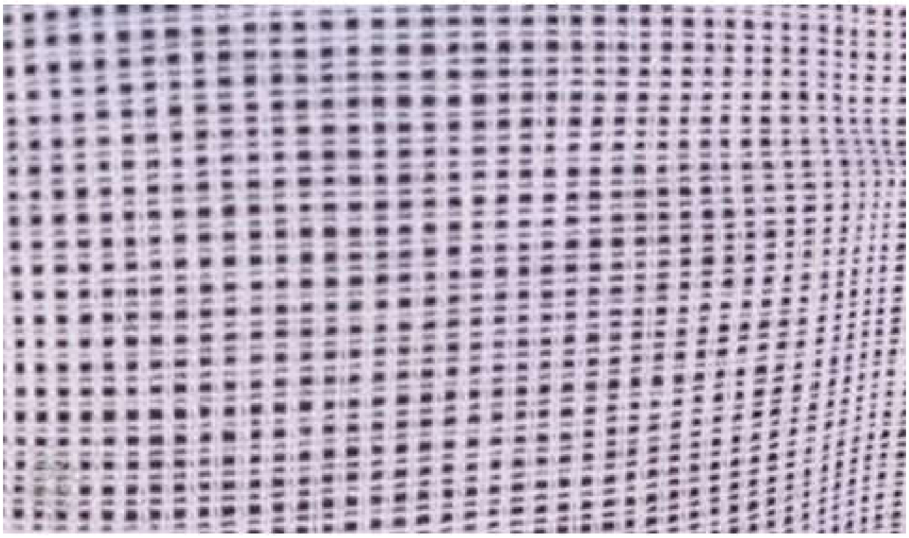

Fig. 1. The Bedouin Mirka

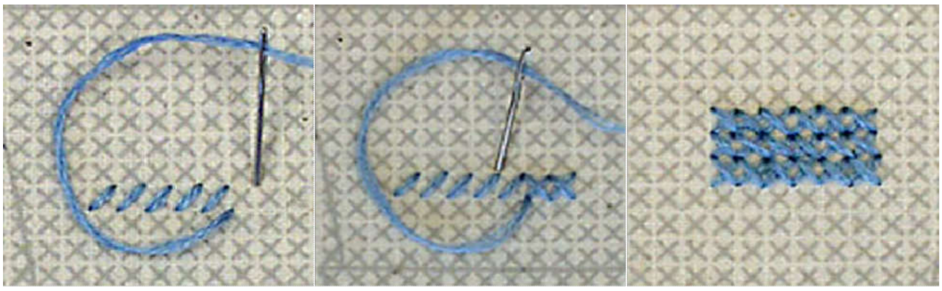

Fig. 2.The common "X method" of embroidery

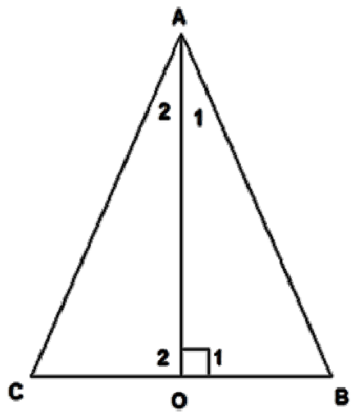

Fig. 3.Properties of an isosceles triangle (AC=AB; AO is the altitude; OB=OC)

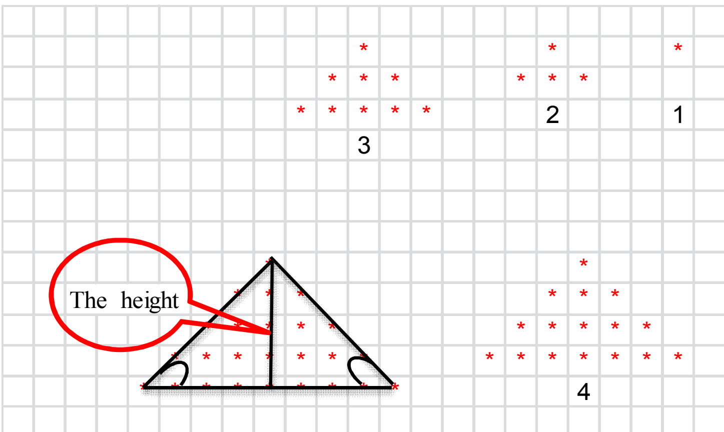

Fig. 4. Counting method for embroidering an isosceles triangle

Fig. 5. An isosceles triangle as embroidered on a Bedouin dress

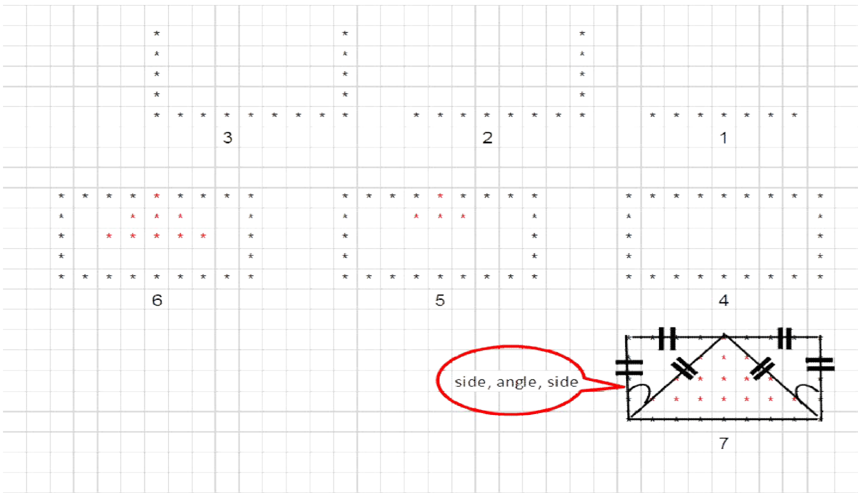

Fig. 6. Using a rectangle to embroider an isosceles triangle

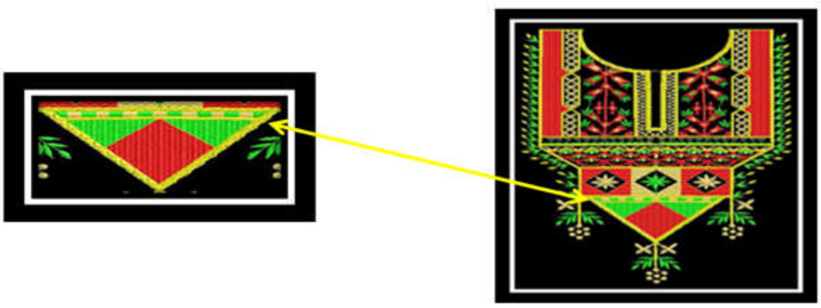

Fig. 7. An isosceles triangle embroidered within a rectangle on a Bedouin dress

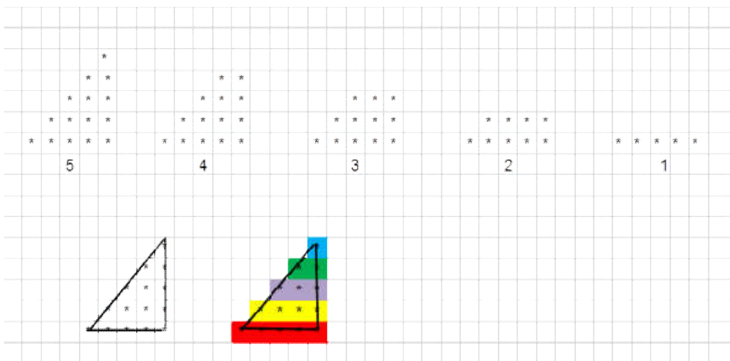

Fig.8.Traditional Bedouin method of embroidering a right triangle

Fig. 9. The right triangle embroidered on a Bedouin dress.

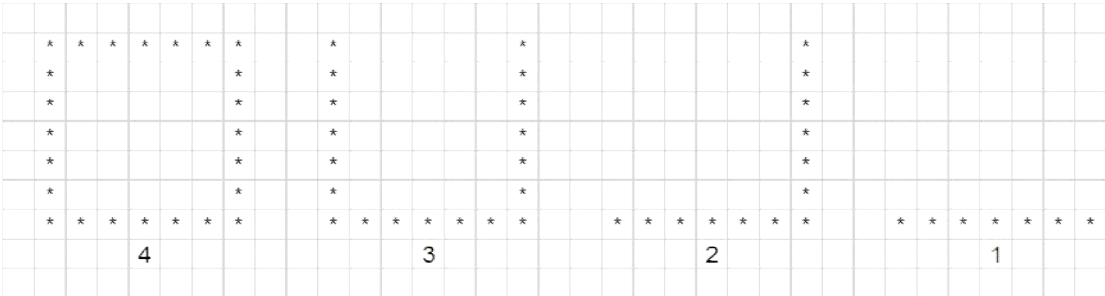

Fig. 10.Traditional Bedouin method for embroidering a square

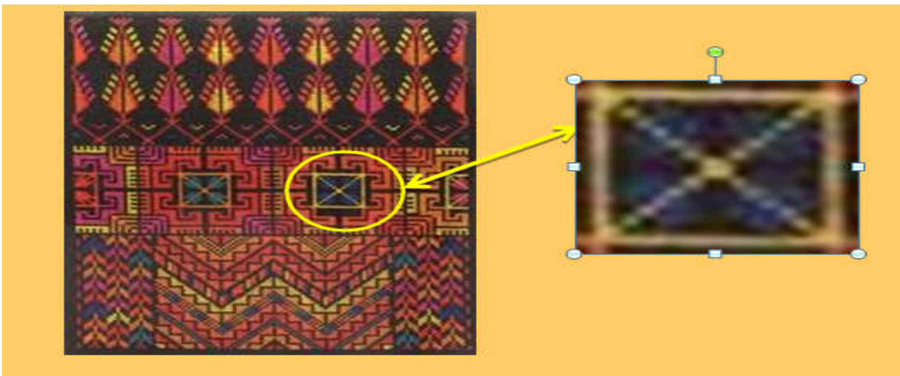

Fig. 11. A square embroidered on a Bedouin dress.

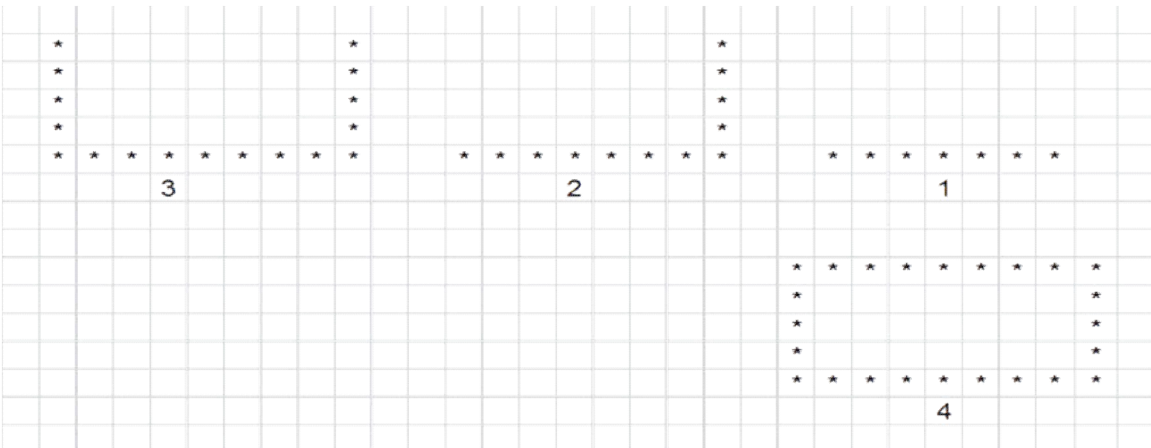

Fig. 12. Traditional Bedouin method of embroidering a rectangle

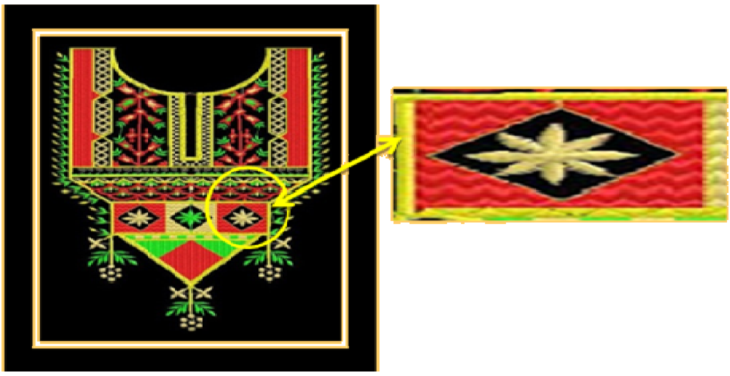

Fig. 13. A rectangle embroidered on a Bedouin dress

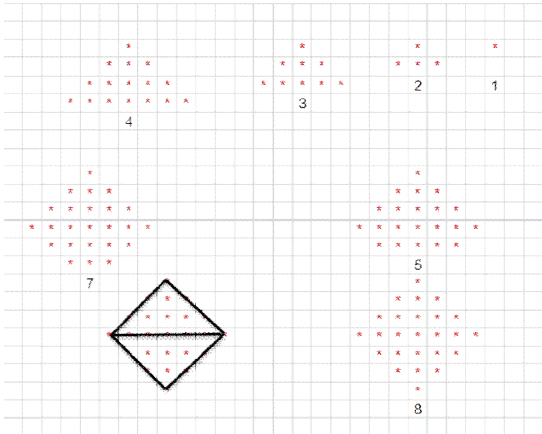

Fig. 14. Traditional Bedouin method of embroidering a rhombus

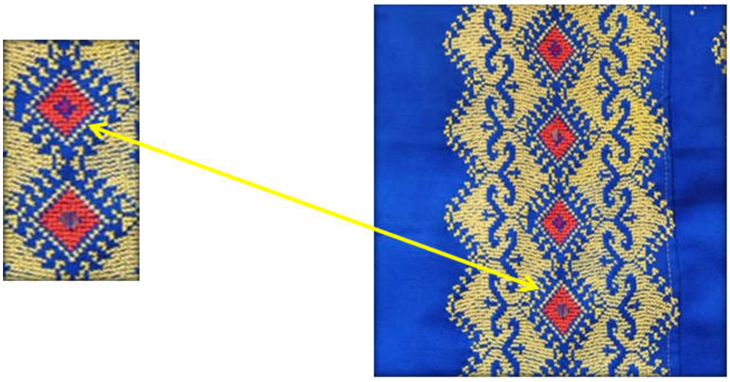

Fig. 15. A rhombus embroidered on a Bedouin dress

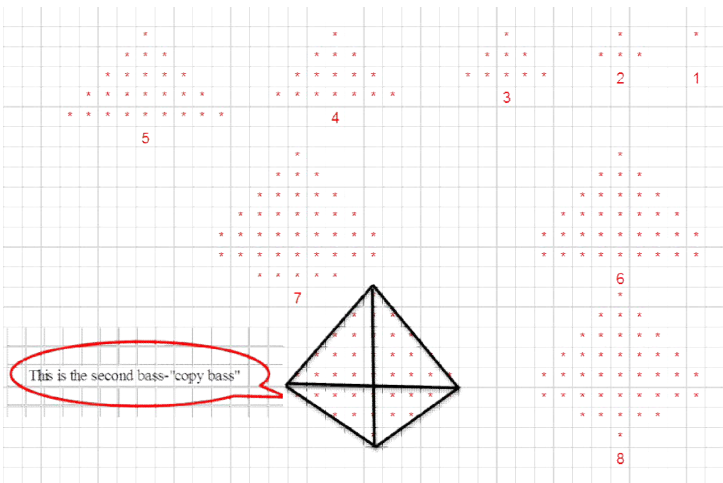

Fig. 16.Traditional Bedouin method of embroidering a kite

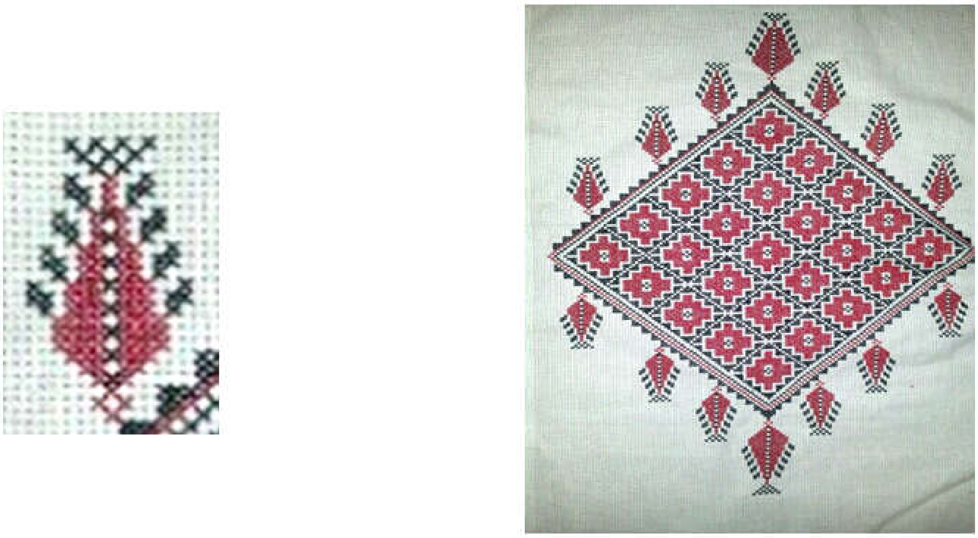

Fig. 17. A kite embroidered on a Bedouin dress

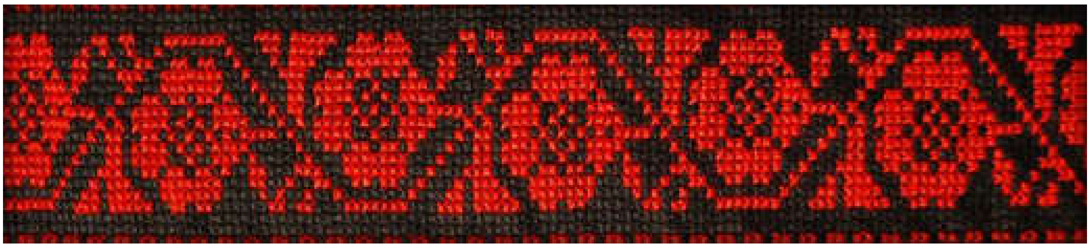

Fig. 18. A zigzag line embroidered on a Bedouin dress

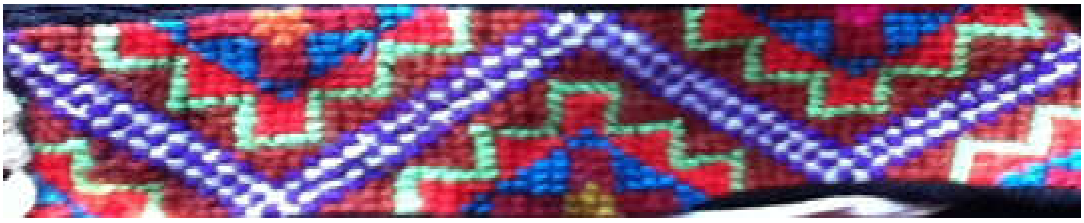

Fig. 19. A zigzag line embroidered on a Bedouin dress

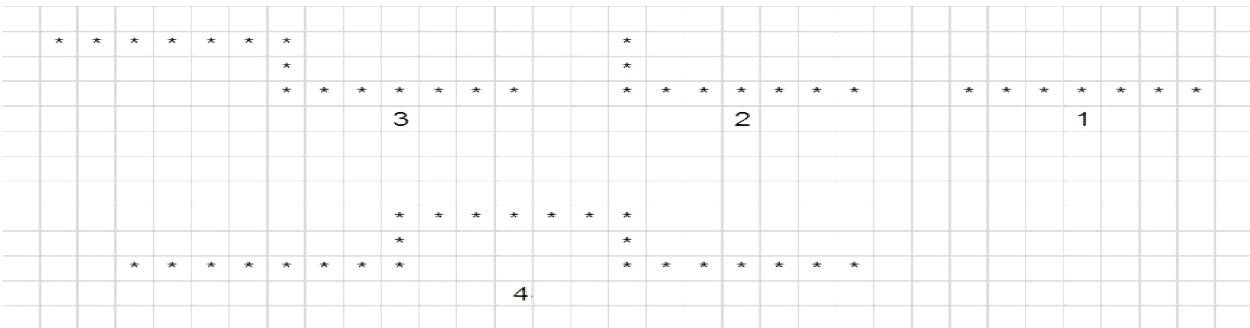

Fig.20. Traditional Bedouin method of embroidering a kite

Studies show that knowledge based on faith and affiliation to a group leads to cultural coexistence and inner peace (Amit, Fried & Abu-Naja, 2008), which in turn improve the students' self-conception and achievements.

Bedouin Embroidery: General Technique

Bedouin women used the following main tools in their embroidery:

- Choosing the type, color, and amount of desired cloth
- Choosing the type, color, and amount of threads
- A white checkered net, which is called "a mirka" in Arabic
- Scissors

Traditional Bedouin embroidery begins with the selection of the type, color, and amount of fabric to be embroidered, and the type, color, and quantity of threads. Scissors are also used and most importantly, the "mirka" (see fig. 1), which is a white

Fig.21. Curves embroidered on Bedouin dress

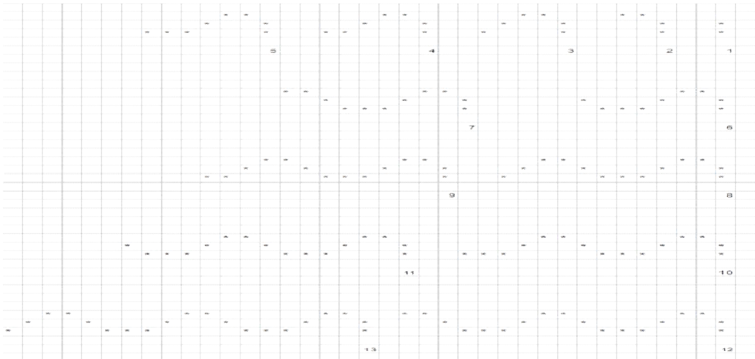

Fig. 22.Traditional Bedouin method of embroidering a Curves.

Fig. 23.The top of a Bedouin dress uses slide symmetry

fabric net with different sized openings that is attached to the cloth (and later gently removed) and that assists the embroiderer in planning and executing complex shapes. The most commonly used method of embroidery by Bedouin women is the “X method”, in which small dots are created by stitching X shapes on the cloth. This method can be applied in two ways. In one method, the embroiderer moves from left to right on the “mirka” net: Beginning with one square on the mirka, the embroiderer makes a diagonal stitch from the bottom to the top of the square (/). Then she returns and makes a second diagonal stitch in the same square, this time moving from right to left and from top to bottom (\), thereby forming an X in one square. The second method consists also of stitching from left to right, but diagonal stitches from the bottom up are created in several squares at once, and then the X’s are completed by stitching the diagonal in the reverse direction, from right to left and from the top to the bottom, as shown in figure 2.

Geometry in Bedouin embroidery: After examining the basic methods and tools used in Bedouin embroidery, we will now proceed to examine several geometric shapes that appear in Bedouin embroidery, including the isosceles triangle, the right triangle, the square, rectangle, rhombus, and kite shapes, as well as types of lines and the general concept of symmetry. In each case, the mathematical properties of these shapes will be presented, and then we will describe how they are executed by Bedouin women, using traditional knowledge.

Embroidering the isosceles triangle: The various properties of the isosceles triangle can be used to prove that the triangle in Bedouin woman embroidery is indeed an isosceles triangle. One such property is that in an isosceles triangle, the altitude bisects both the base and the angle of the apex and is also perpendicular to the base. Further, in an isosceles triangle, the base angles are equal, as shown in figure 3.

How Bedouin women traditionally embroidered the isosceles triangle: First method: In order to embroider the shape of an isosceles triangle, the Bedouin woman uses acounting method in which an odd number of squares are stitched one beneath the other, beginning with the apex. For example, if the embroiderer desires to create a triangle from 16stitches, she begins with one stitch at the apex of the triangle. Then embroiders three stitches and then five stitches. Finally, she finishes by embroidering a line of seven stitches, which forms the base of the triangle.

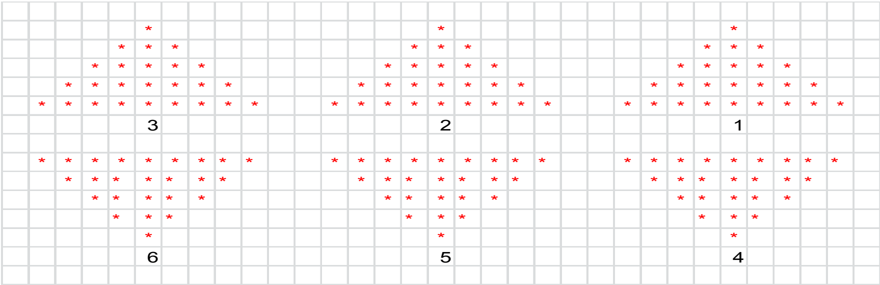

Fig. 24.Traditional Bedouin method of embroidering slide symmetry

Fig. 25.The top of a Bedouin dress uses reflective symmetry.

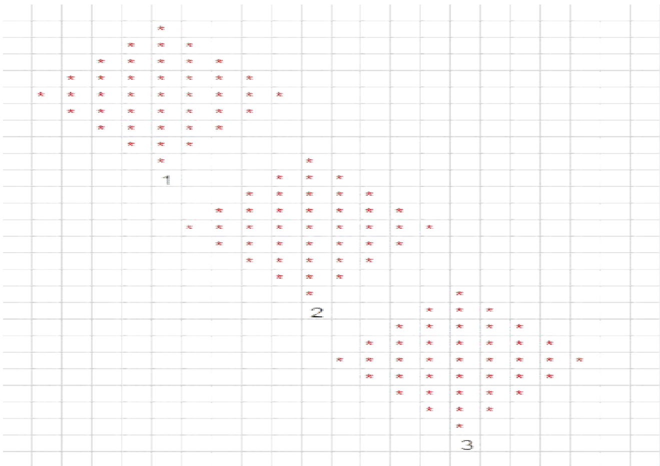

Fig. 26.Traditional Bedouin method of embroidering a reflective symmetry

Fig. 27.The top of a Bedouin dress uses rotational symmetry

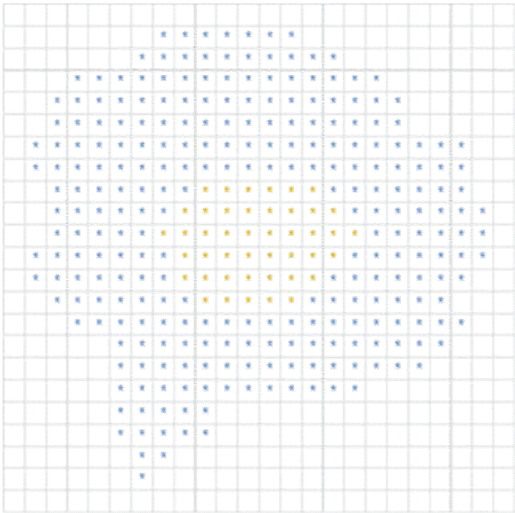

Fig. 28. **Traditional Bedouin method of embroidering a rotational symmetry**

The result is an isosceles triangle as defined above and as shown graphically in figure 4. Figure 5 shows such an isosceles triangle in an actual Bedouin dress.

How Bedouin women traditionally embroidered the isosceles triangle: Second method: The second method through which Bedouin women embroider an isosceles triangle is based on two stages: embroidering a rectangle and then a triangle. The rectangle is embroidered by first using an odd number of stitches in a horizontal line. For example, the embroiderer may create a horizontal line of seven stitches (see fig. 6, step 1), after which she returns to the right side of the line and embroiders five stitches in a vertical line (step 2). As a third step, she moves to the left of the horizontal line and embroiders five stitches in another vertical line (step 3).Finally, she returns to the top of the first vertical line on the right and embroiders a line of seven stitches from right to left, thereby closing the rectangle (step 4). In the second stage, an isosceles triangle is embroidered within the rectangle shape. First, the embroiderer determines the middle point of the horizontal line of the rectangle that she has embroidered. Then from this middle point, which is the apex of the triangle, stitches are embroidered downwards, towards the base of the rectangle, beginning with three stitches, five stitches, and finally seven stitches, which form the base of the triangle, right on top the base of the rectangle. Notably, if a line would be drawn from the apex of this triangle, it would be the middle and the height of this triangle, in other words, this is an isosceles triangle. In addition, two congruent triangles are created by this isosceles triangle, since two sides and the angle between them are equal, as shown in figure 6, step 7.Figure 7 shows an example of this method on a Bedouin dress.

The right triangle: Mathematical properties: A right triangle is a triangle in which one angle is a right angle, that is, a 90^0 angle.

How Bedouin women traditionally embroidered aright triangle: In order to embroider a right triangle, Bedouin women use a descending numerical series. The embroiderer starts from the base of the triangle and finishes at the apex, with the number of stitches decreasing in each line and moving in the same direction. As shown in figure8,for example, the embroiderer may start with five stitches that form from the base of the triangle and then proceed to stitch a shorter line of four stitches above the base and so on until the apex, which will consist of one stitch only. Figure 9 shows the right triangle on a Bedouin dress.

The Square: The properties of a square: A square is a regular quadrilateral that has four equal sides and four equal angles of 90^0.

How Bedouin women traditiona llyembroidered a square: In order to embroider asquare, Bedouin women begin with any number of stitches, whether odd or even, in a horizontal line. For example, and as shown in figure10, an embroiderer could begin with a horizontal line made of six stitches, and then embroider a vertical, 6-stitch line on the right side of the horizontal line. The second vertical 6-stitch line on the left would follow, and then, finally, the embroiderer returns to the first vertical line on the right and embroiders a horizontal line of six stitches from one vertical line to the other, thereby completing the square. When Bedouin women embroider a square, they are concerned with using an equal number of stitches on all sides. Therefore, we can argue that the Bedouin cultural method of embroidering a square applies the two basic properties of the square shape: first, that all the sides in the square are equal, and second, that all angles are right angles. Figure 11 shows such a square embroidered on a dress.

The rectangle: The properties of a rectangle: A rectangle has four sides and four angles; the angles are all right angles and the length of the pairs of sides opposite each other are equal.

How Bedouin woman traditionally embroidered a rectangle: In order to embroider a rectangle, Bedouin woman begin by embroidering any number of stitches, whether odd or even, in a horizontal line. For example, as shown in figure 12, one may begin with a horizontal line made of seven stitches (step 1). After this, the embroiderer returns to the beginning of the right side of the line and embroiders five stitches in a vertical line. Then the embroiderer embroiders an identical vertical line on the left of the initial horizontal line, and finally, she embroiders a horizontal line between the two vertical lines, thereby completing the rectangle. When Bedouin woman embroider a rectangle they are concerned with using an equal number of squares (i.e., stitches on the mirka), in each opposite line that they embroider, and with ensuring that the length of the two vertical lines differs from the length of the horizontal line by at least one square. Thus, the traditional method that Bedouin women use to embroider a rectangle applies the two properties of the rectangle shape: First, that the lengths of the pairs of sides opposite each other are equal, and

The Rhombus: The properties of a rhombus: All sides have equal length; all the opposite sides of the rhombus are parallel and all the opposite angles are equal; the diagonals of a rhombus bisect each other at right angles, creating four right triangles within the rhombus.

How Bedouin women traditionally embroidered a rhombus In order to embroider the rhombus shape, Bedouin women employ the method of counting the number of squarestheyem broider on the “mirka” in order to determine the desired lengths of the sides and the overall size of the rhombus. Bedouin women embroider the rhombus in two steps (see figure 14). In the first step, an isosceles triangle is embroidered as described above (see p. 7).In the second step, after completing the first triangle, the exact same triangle is embroidered on the base of the first triangle. The embroider starts this second triangle by embroidering five stitches on the base of the first triangle. Following this, three stitches are embroidered and the triangle is completed with one stitch that is actually the apex of the new, second triangle. As shown in figure 14, the diagonals of the embroidered rhombus divide it into four equal, right triangles, which is one of properties of the rhombus. Fig. 15 shows a rhombus embroidered on a dress.

Kites: The properties of a kite: A kite is a quadrilateral with two sets of distinct, adjacent, congruent sides. The diagonal that goes through the vertex angles is the angle bisector for both angles, and the non-vertex angles of a kite are congruent.

How Bedouin women traditionally embroidered kites: Bedouin women use two steps to embroider the kite shape. In the first stepan isosceles triangle is embroidered as explained above (see p. 7).In the second step, a second triangle is embroidered by copying the base of the first triangle in the row adjacent to it, as shown in figure16, step 6.While the base of the two triangles is identical, the rest of the second triangle is embroidered with fewer stitches. Thus, as seen in fig 16, the base of the two triangles has nine stitches but the next rows in the second triangle consist of fewer stitches; in this case five stitches are used in the second row instead of seven in the first triangle. To complete the second triangle, the embroiderer adds stitches in an unorganized series, to ensure that the second triangle is of a different size from the first triangle. Thus, since the Bedouin woman embroiders two triangles of different sizes, with each triangle embroidered in the opposite direction to the other, she has embroidered a kite. Figure 17 shows this shape on a dress.

Lines in Bedouin embroidery

The zigzag line: Azigzag is a line that is a combination of straight diagonal, vertical, and horizontal lines.

How Bedouin woman traditionally embroidered a zigzag line: In order to embroider a broken line, Bedouin women embroider a diagonal of a certain number of stitches. Then the embroiderer rises and falls in different directions using the needle and thread according to the shape she wants. This activity continues until she embroiders the desired shape of the line. An example of such a line is shown in figure 18 and figure1.

The curve: A curve (also called a curved line in older texts) is, generally speaking, an object similar to a line but that need not be straight. Thus, a curve is a generalization of a line, in that its curvature is not necessarily zero.

How Bedouin woman traditionally embroidered a curve
Embroidering a curve is the same as embroidering a zigzag except that in this case the embroiderer does not create angles when she changes direction. Figure 21 shows an example of such curves.

Symmetry in Bedouin embroidery: Traditional Bedouin embroidery employs three types of symmetry: slide symmetry, reflective symmetry, and rotational symmetry. These will be discussed and explained in the following.

Slide symmetry: This is the method by which some form is copied or "translated" by mirroring the form without tilting, flipping, or resizing. Also called translation symmetry.

How Bedouin woman traditionally employed slide symmetry in embroidery: In this type of embroidery, the embroiderer begins with one shape that she wishes to repeat. Then she moves several spaces and embroiders the same shape. This pattern is repeated with the embroiderer taking care to preserve the same distance between copies of the same shape, and the same direction and size of each copy.

Examples of this type of symmetry are shown in figure 23.

Reflective symmetry: In this type of symmetry, a form is copied along an axis line, so that the two forms, the original and the copy, mirror each other exactly in space, as shown in abstract in figure 25on a Bedouin dress.
Rotational symmetry: In this type of symmetry, the copied form is rotated with respect to the original form with one point, which called the rotational point, serving as a joint axis for all the rotated copies.
How Bedouin woman traditionally employed rotational symmetry in embroidery: In rotational symmetry Bedouin women use the odd or even counting method. They begin with one central stitch and then stitch around it in an expanding circle.

DISCUSSION

A different look: Simple math: One of the topics included in my ethno mathematics doctoral research program which was supervised by Prof: A mit Miriam, among the Bedouin population in the south of the Israel was Bedouin embroidery and its mathematical-cultural values, which are expressed in a variety of geometric shapes and mathematical rules. In order to identify and collect the mathematical-cultural knowledge that is embedded and expressed in Bedouin culture, a general search was conducted within this population. The search process was based on personal interviews with older women with experience in the field of embroidery. Interviews were recorded with video, transcribed, and analyzed. The data collected permits several conclusions as follows:

- The shapes embroidered in the dresses of Bedouin women reflect the personal status of the embroiderer (girl, adult, single woman, and married woman), and her psychological situation (in love, depressed, sad, happy, and so on).
- The size of the embroidered shapes in the Bedouin fabric, their color the amount of decoration, and the type of fabric used bear a socio-cultural message that depends on the personal social situation of the embroiderer. Thus, the shapes, colors, clothes, and the amount of ornaments used in the dress of a Bedouin girl are different from those used in the dresses of older women. For example, girls' embroidery uses shapes such as squares, triangles, small flowers, stars, and many circles, which are embroidered in bright colors (especially the color red) and adorned with excessive decoration.
- All types of Bedouin embroidery reflect specific cultural values and customs of Bedouin society. In addition, it is possible to say that each type of embroidery has a "terms of use" or a "usage situation." In other words, each type of embroidery reflects a message that indicates a certain

cultural value that is recognized by the members of society.

- The general strategy used by Bedouin women in embroidery is the counting method that is based on the counting of embroidered squares in the "mirka", the special white net that is designed especially for embroidery. By using this method, Bedouin women determine the size and circumference of the embroidered shape. This means that the size and the embroidered shape depend on the number of squares used in the "mirka".
- Bedouin women have no connection or awareness of the definitions, laws, and mathematical properties of the variousgeometricshapes that they employ in their embroidery. The awareness and ability of Bedouin women to discern geometric shapes in embroidery is based on—and limited to—their ability to distinguish the external appearance of the shape.
- Since Bedouin women have no awareness of the mathematical operations, their work can be described as "spontaneous" work, which is easy to perform and based on (1) planning and implementing the desired shape by counting the number of embroidered squares used to form each shape, which then serves as a means of measuring and determining the extent and area of each shape, and (2) different techniques of repetition, such as symmetry, that are used to embroider various shapes.

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