EXPLORING INFORMAL MATHEMATICS OF CRAFTSMEN IN THE DESIGNING TRADITION OF 'XYSTA' AT PYRGI OF CHIOS

CHAROULA STATHOPOULOU

The research presented in this article has a socio-psychological approach (Lave, 1988; Millroy, 1988; Lave and Wenger, 1991; Millroy, 1992; Pozzi, Noss and Hoyles, 1998). Vital and Skovsmose (1977, pp. 134-137) call this the third of four (historical anthropology; pure anthropological approach; socio-psychological approach and ethnomathematics and mathematics education) main strands in ethnomathematics. The method was that of ethnography in that the dominant characteristic was observation (not quite participant observation). The research concerns *xysta*, a constructing-designing tradition for the facades of houses at Pyrgi, a village on Chios (an Aegean island). The main intent of the research was to explore mathematical ideas, usually implicit, that are used by the traditional craftsmen in their work.

The village and the habitants

Pyrgi village is located to the north of Chios island. It is one of the medieval villages of Chios characterized by the fact that it has remained almost the same during the last six to seven centuries. Although the settlement has expanded around the edges, the main part of the village continues to be the same as the old one.

The houses are constructed of stones and usually have 3 or 4 floors. The streets continue to be as narrow as they were in the past, when the inhabitants had to protect themselves from pirates. The continuous threat, in the old days, made the inhabitants construct buildings and streets in this way.

Although Pyrgi is not the only medieval village in Chios, it is the most famous. What differentiates this village from all the others in Greece is the tradition to construct designs, mostly geometrical patterns, on the house facades. The time when this practice started is not known, but, through old photos and documents, Xyda (2000, p. 41) places the *xysta* tradition earlier than 1850. At this time, there were only a few facades decorated with *xysta*, mostly on the central buildings or buildings with high status. In any case, plaster was expensive, so the people who had the ability to have plaster-coated houses, a necessary condition for construction of *xysta*, were the richest and so were their houses.

Nowadays, although *xysta* have gone through several stages of evolution regarding the kind of patterns, size and colours, they remain a main element of the identity of the people. I noticed this through discussions with many inhabitants:

CS: Why do you like to have *xysta* at your house?

A: Because I'm Pyrgouis [habitant of Pyrgi]. Jesus Christ was born in the crib and the crib is what he remembers. (80-year-old man)

Many other inhabitants answered the question about their interest in *xysta* in a similar way, saying that they like *xysta* because "they are their tradition". In other cases, the tourist trade was emphasized: "The *xysta* are a means of promotion for Pyrgi; the place is famous because of its *xysta*".

This tradition remains alive (see Figures 15 and16). Although the inhabitants now use mainly bricks for building, they still decorate their houses' facades with *xysta*. These facades are constructed only by traditional craftsmen who learnt this technique by apprenticeship.

Entering the community

After having visited Pyrgi a few times as a tourist, I decided that the study of *xysta* was of interest for my ethnomathematics research. This special tradition was important not only as construction and design, but also for the mathematical ideas involved.

On the first day on which I visited Pyrgi, as a researcher, in the summer of 2005, I attempted to enter the community by visiting the places the men of the community use to drink coffee (*cafenio* = Greek café). The way the village is constructed results in the whole social life being inside the village, largely in the main square.

I met some kind and helpful inhabitants of Pyrgi who did their best to facilitate my research. On this first visit, I explained the reason of my visit. After a short time, I was in the middle of an intense discussion: everybody was trying to give any available information regarding *xysta*. In some cases, strong arguments were aroused among them. In these discussions, I heard several versions of the origin of *xysta*, the time this tradition started, and the influences on the designs. Some argued that the origin was from the East (Turkey), while others from the East (Italy). Among others I had the chance to meet Elias, a 70-year-old man, who willingly accompanied me to some old, local houses that had *xysta* on their facades. He informed me about the tradition of *xysta*, the time for construction and the material used.

After that we returned to the *cafenio*, where I continued the conversation with the inhabitants of Pyrgi. There I also met George Zervoudis, who used to be a craftsman specialising in *xysta* construction.

Observing the construction of 'xysta'

After Elias had introduced me to George, we had a conversation about several issues concerning the tradition of *xysta*. As he stated to me in this conversation, he as apprentice and the group of his teacher-technician had constructed the majority of *xysta* in Pyrgi. Among other things we discussed the way a craftsman makes *xysta*. In order to show me how geometrical figures are constructed he borrowed the geometrical tools, a pair of compasses and a ruler, from a student who lived close to the *cafenio* (see Figure 1).

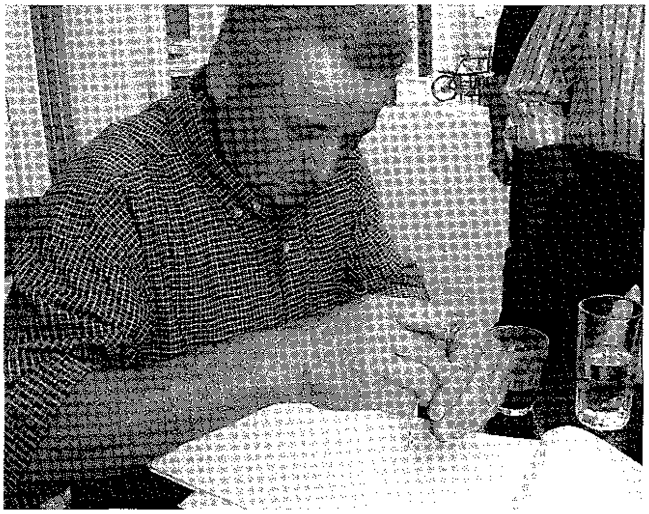

Figure 1: The craftsman designing patterns

This procedure was difficult for him as he was not used to using these kinds of tools. So, he proposed meeting me the next day when he would have the tools he uses at his disposal. The next day he came with a colleague and we moved to a sandy place. There they tried to show me how they construct the figures. Again the attempt was not successful because the material was different from the plaster on which they usually work. The main problem was the fact that I could not photograph the designs they made on the sand. So, they kindly offered to construct some patterns outside a building on which they were working, even though, at this time, they were not constructing xysta. Unfortunately, during this period, no construction of xysta was in progress.

The next day I visited the place they were working. They interrupted their work and gave me the chance to observe the total procedure of xysta construction. They decided to do it on an internal wall of the storeroom in which they were working.

First of all they prepared the material (see Figure 2). They used sand and cement for the blend of the plaster that is used in the first layer and lime for the second layer. In Figure 3 we can see the tools used for xysta construction: a pair of dividers (to act as compasses), a lath (a small piece of wood, a parallelepiped, used as a ruler) and a fork. The two craftsmen, after they had prepared the plaster, firstly put a layer on the wall and immediately the lime upon this layer. All this procedure must be done quickly since the plaster has to be fresh to make the xysta.

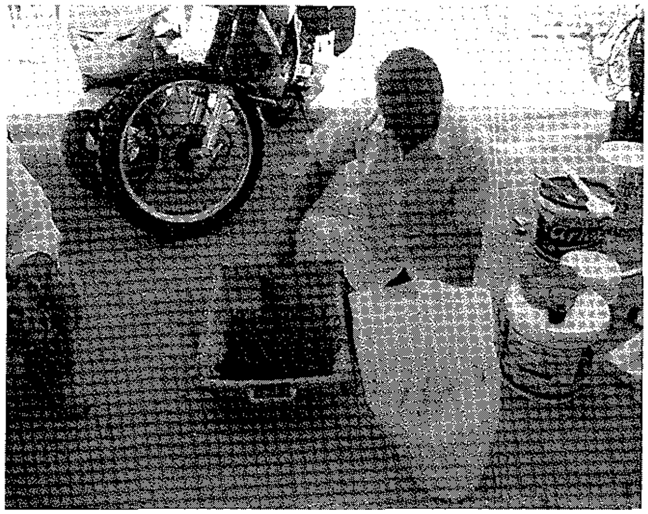

Figure 2: The preparation of the material

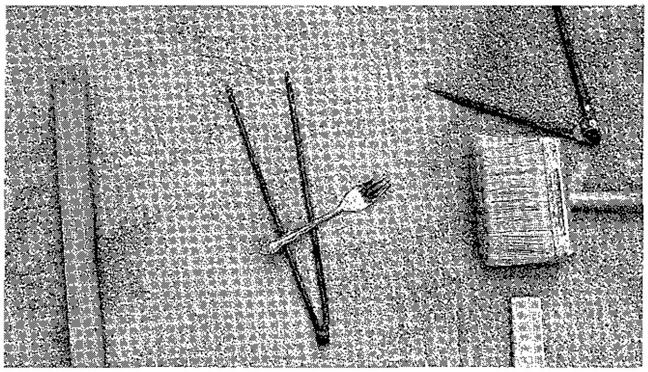

Figure 3: The tools used by craftsmen

There are two kinds of characteristic patterns: circular and rectangular.

The procedure for the construction of the circular pattern: Using the lath they drew a horizontal line on the surface that was plastered. Then they determined two points on this surface at the same distance from the original line. These points were determined by the dividers used vertically to this line keeping the same span. In my question, "Why do you mark two points?", the answer was, "If we didn't do that the line possibly would go higher or lower", meaning that it could not be parallel to the one already traced.

After they had drawn the two zones of parallel lines - their width was the width of the lath -, they tried to determine the centre of a circle they were going to construct using the dividers like this: they firstly considered a point that had the same distance from both lines and they measured the distance by using the dividers, putting it vertical to the lines. Then they traced two concentric circles (see Figure 6).

The radius of the internal circle was used for the partition of the perimeter into six equal arcs that corresponded to six equal chords; every one also equal to the radius of the circle. They separated the circle into six equal arcs using the dividers as follows: at the first step they chose a random point of the circle as centre and a same-radius circle was traced. They made the new circle keeping only its part that was internal to the original circle. Then, using one of the two intersecting points of the circle, traced a new circle on the

Figure 4: The craftsmen tracing the first horizontal line.

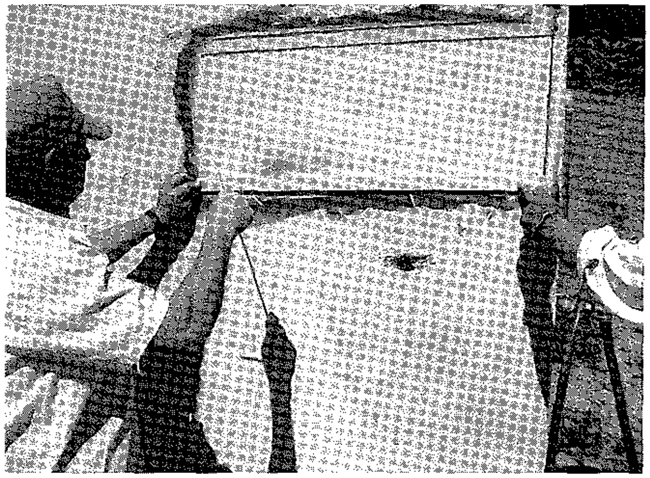

Figure 5: The craftsmen tracing parallel lines

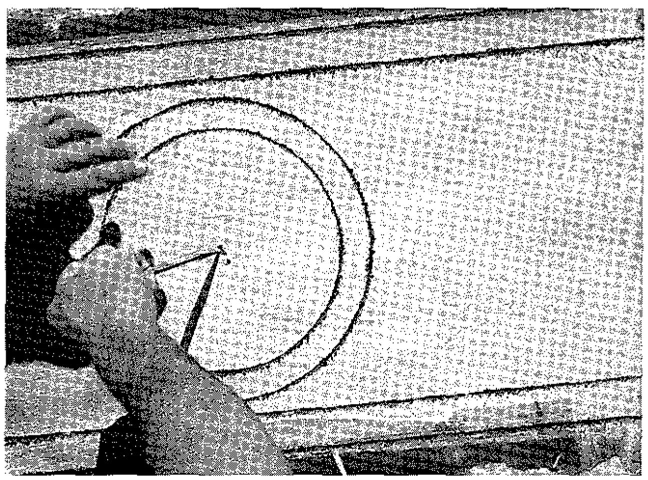

Figure 6: The craftsmen tracing two concentric circles.

same radius. Continuing in the same way, using both tips of the dividers, until the last point coincided with the first (see Figures 7 and 8).

I had the following conversation with George about the construction of these patterns and the way they sectioned the circle into six equal parts:

CS: How do you know that these will be six equal parts?

George: It will be. I, as a craftsman, have learnt this

In Figure 9, the craftsman is scratching part of the design with a fork and the pattern is finished (see Figure 10). This pattern is called *fegaria* by the craftsmen

In Figure 11, a border, consisting of a semi-circle with a short radius, was constructed. When I asked them, "How did you calculate the correct radius?", they answered that they select one by chance and when they are close to the end, by eye, they see if it must be increased or shortened. In the final form, the differences in the radii are inconsiderable and not visible.

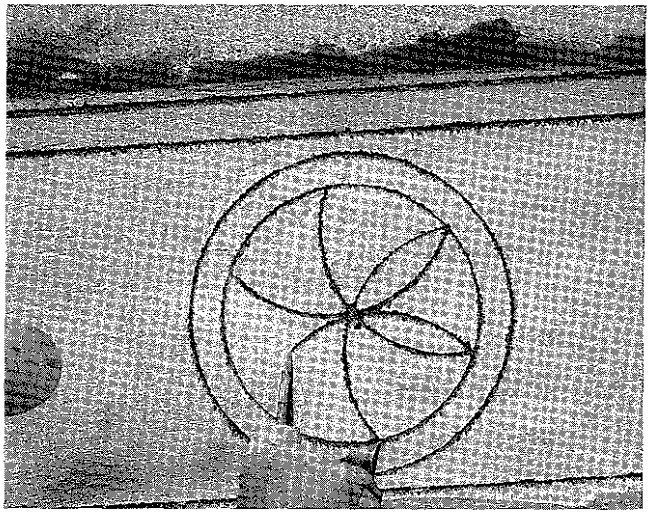

Figure 7: Tracing a 'margarita'.

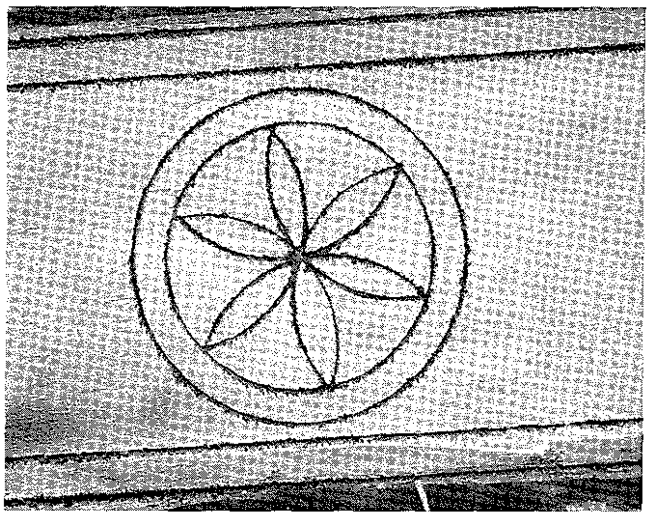

Figure 8: A complete 'margarita'.

The procedure for the construction of the rectangular pattern: In order to construct the two patterns, they separated the zone of the two parallel lines in two parts with the lath and the dividers. They used the dividers in the same way as above to determine the line that keeps equal distances from the two original zones of the parallel lines. On these two parallel straight lines they sectioned two times equal parts of straight lines in such a way that the two sides were vertical to the two horizontal lines and constructed the two rectangles (see Figure 12). After they had made the two parts, they decided to construct two different patterns. For the higher

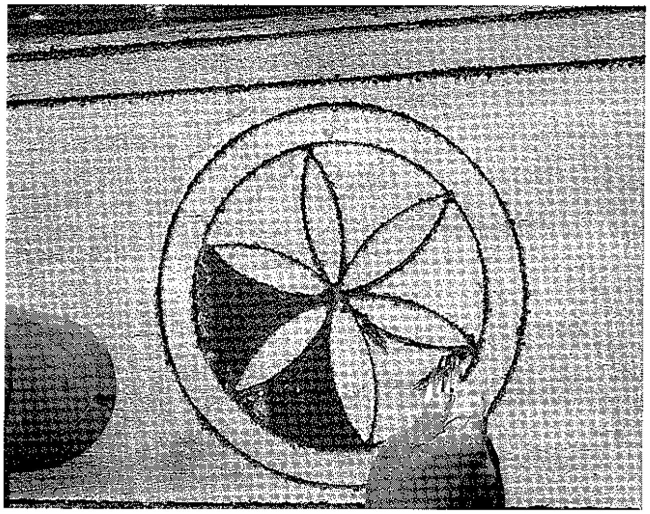

Figure 9: The procedure of scratching with a fork

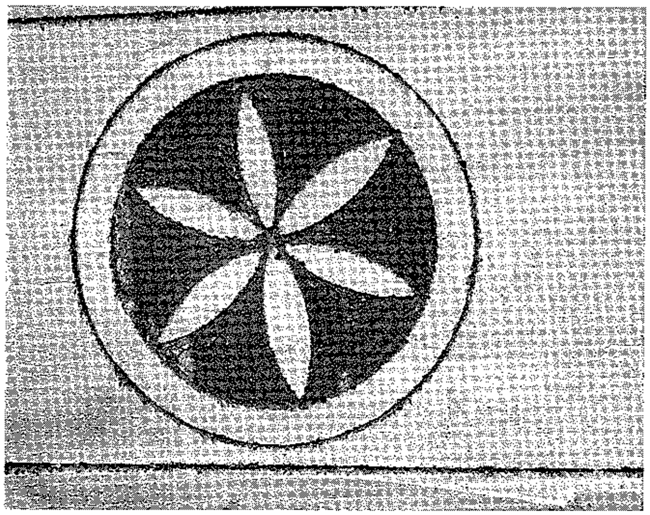

Figure 10: The 'margarita' after scratching

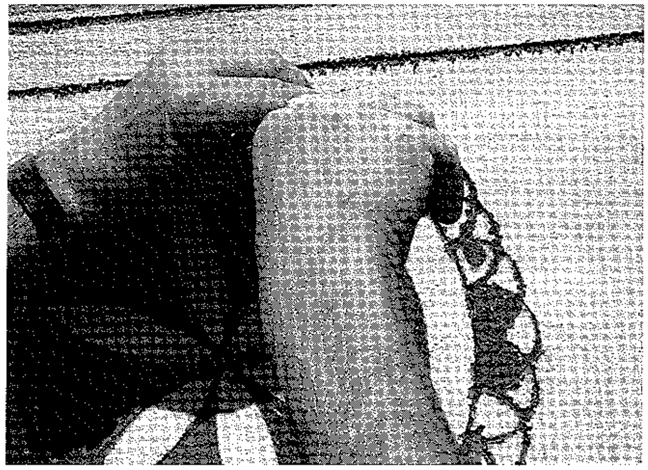

Figure 11: The construction of a border.

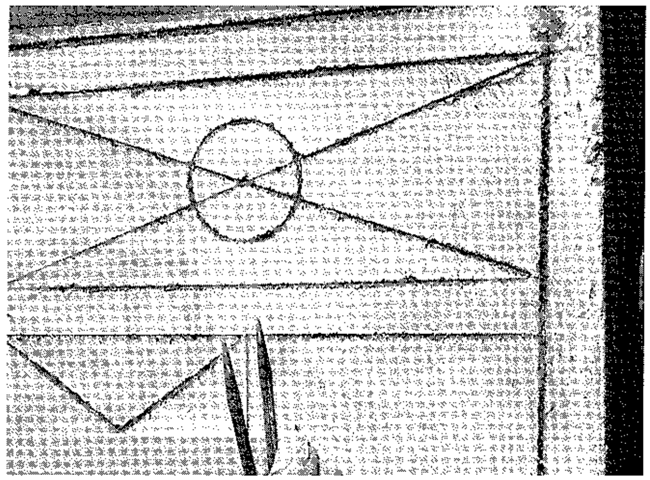

Figure 12: The construction of the two rectangles

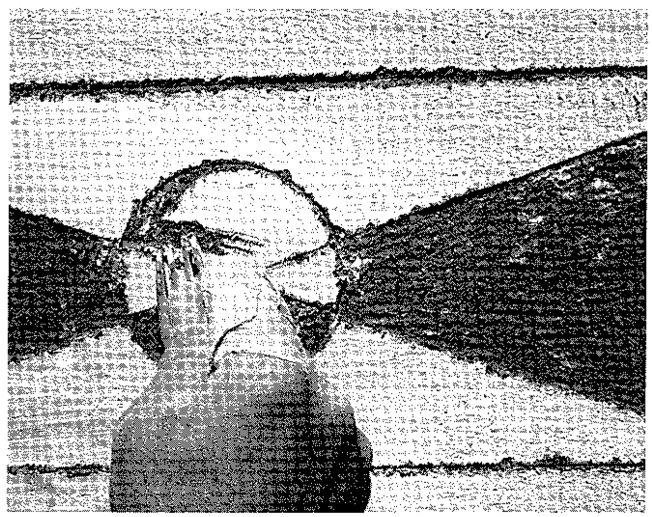

Figure 13: Scratching the upper rectangle

figure (see Figure 13), they used the dividers and measured two equal line segments on the two parallel straight lines. In this way, they constructed a rectangle. Tracing its diagonals they determined its centre. This centre was used as the centre of a circle on the inside of the rectangle (see Figure 13)

During the construction of this figure we had the following discussion:

CS: How do you know that this is the centre of the rectangle?

Craftsmen: Since I put the lath from one angle to the opposite and then I did the same for the other pair of opposite angles ... I find a point that is exactly in the middle.

CS: And how could we know that this is, indeed, the middle?

Craftsmen: Look, it happens, let's say, practically. We don't consider finding it mathematically, this is so practically

Then they constructed an equal rectangle lower than the first one, which was bisected into two equal rectangular figures Tracing the diagonals of these two figures, and after scratching, the pattern (see Figure 14) was revealed.

As we can also see in Figure 14, when they constructed another pattern next to this one, a rhombus appeared:

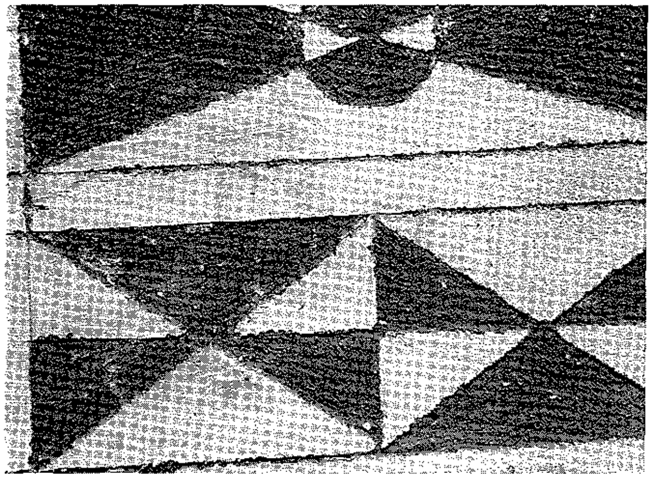

Figure 14: The complete pattern with the two rectangles.

CS: This one is a rhombus! Why did it become a rhombus?

Craftsmen: Exactly, it happens to be a rhombus. This is the pattern, in this case a rhombus comes about in the middle and it continues on this side ... If you continue on this wall, two or three or more meters, the rhombus will continue until the wall ends. We, as craftsmen, don't care why, we found them like this. Even though we were interested in why, ... we didn't ask [he means the craftsman who had taught him] how this rhombus will come about ... and what will happen, why it comes in this way ... But even if we could ask, maybe he didn't know the answer. At that time, the people didn't know so many 'letters'.

Searching out the mathematical ideas

As we observed, in the first step the craftsmen constructed two parallel straight lines. For this, they had used the dividers twice vertically with the same span (radius) from the first line's two points. Obviously these two points determined the position of the parallel line since two points of it were the same distance from the other.

Through our discussion about the way they constructed these two parallel lines, two important mathematical ideas seemed to be conceived by them, albeit unconsciously: for the construction of a line two points are needed and for constructing a parallel straight line to a given one two points that keep equal distance from it determine the position of the parallel line. This cognition may not be conscious, but what Vergnaud calls "a theorem in action" (Vergnaud, 1985; Nunes, 1996, p. 74).

In the determination of any point that keeps equal distance from the two parallel lines they used the dividers. Its determination, even approximately, had sufficient accuracy. This practice of "using my eye" is not accepted in a school context, but for these several groups of craftsmen constituted a traditional practice. Similar practices are referred to by Millroy (1992) in her study of carpenters.

Interesting mathematical ideas are included in the construction of the circular pattern. The craftsmen used as a measure the circle's radius in order to section the circle into six equal parts. First of all, the six arcs are equal as they correspond to equal chords in the same circle. Furthermore, their measure is 60 degrees since its corresponding central angle is 360/6 degrees and it is known that equal angles at the centre correspond to equal arcs. So, the last section of the circles they traced was the same as the first (see Figures 7 and 8). The two craftsmen were certain that these sections were equal although they could not prove it. Their certainty was derived from their trust of the craftsman beside whom they were working as apprentices.

For the construction of the two rectangles, they traced two vertical lines on the zone of parallel lines that they had already made. In this procedure, the properties of parallelograms as well as of rectangles were applied. They then determined the centre of the rectangle as the intersection of its two diagonals. They were certain that the point of intersection of the diagonals was the centre of the rectangle.

This point has one more property - it is a centre of symmetry. The notion of symmetry appears in the majority of *xysta* patterns, as we can see not only in these they constructed but also in *xysta* that already existed on house facades (see Figures 15 and 16).

In the figures they constructed, the notion of symmetry may be the main mathematical idea. Particularly, in the circular figure, apart from the centre of symmetry (the centre of the circle) there are six axes of symmetry; the three diameters that join the points of circles section and the three that join the middle of the arcs. Also, in the rectangle (see Figures 13 and 14) there are two axes of symmetry; horizontal and vertical. In the lower rectangle (see Figure 14) there is one vertical axis of symmetry for each of the two rectangles. Furthermore, the second rectangle is the result of a rotation by an angle of 180 degrees.

If we imagine these patterns repeating, in order to cover a whole wall, translation would be the dominant mathematical idea (see Figures 13, 14 and 16).

Some concluding comments

As Gerdes (2005) notes, many peoples are not referred to in the mathematics history books. This does not mean that these peoples have not produced mathematical ideas, only that their ideas have not (as yet) been recognised, understood or analysed by professional mathematicians and historians of mathematical knowledge. In this respect, the role of ethnomathematics as a research area resides in contributing studies that begin with the recognition of mathematical ideas of these peoples and to value their knowledge in diverse ways, including the use of this knowledge as a starting point in mathematics education.

It seems, from the particular activity of the two traditional craftsmen, that they use interesting mathematical notions, recognized by mathematicians, although they themselves do not see these ideas as mathematics.

The craftsmen have acquired this cognition partly by partnership and partly culturally, since they live in a place where they contact *xysta* in their everyday life. In other words, we speak about situated cognition, a product of the activity, of the context and the culture.

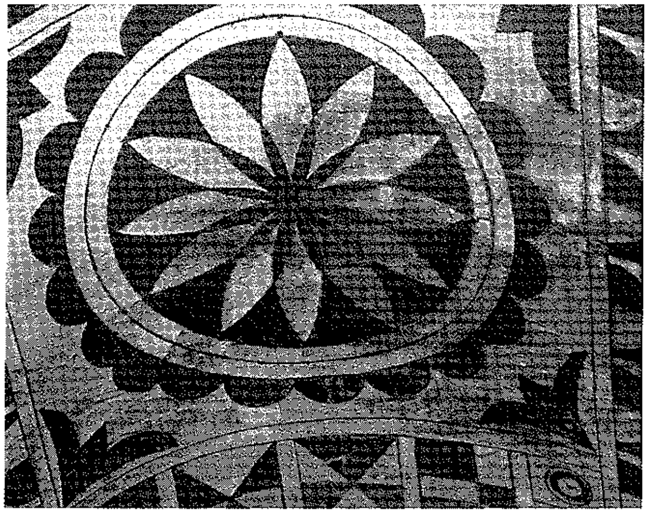
Figure 15: A pattern under an arch.

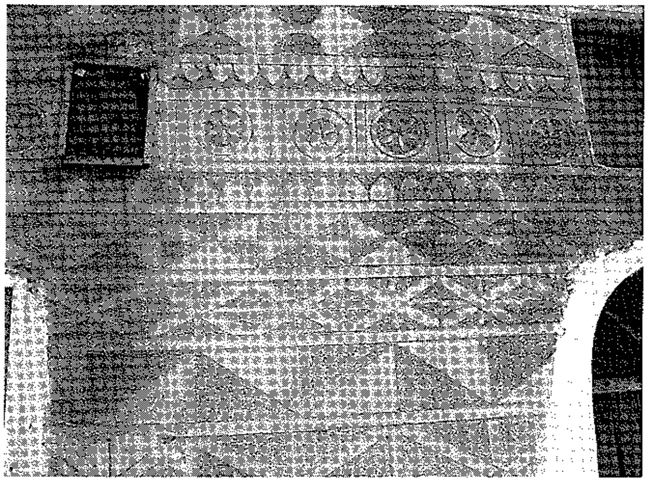
Figure 16: The external view of a house.

In this case, crafts that are constructed by traditional technicians, the role of the expert who taught them is of importance. These two craftsmen trust absolutely the methods of the expert despite not seeing completely the mathematical ideas. They are interested in using a model that works in a particular situation with particular needs and not in asking "Why?" - "We as craftsmen don't care why."

Apart from apprenticeship, a traditional way of teaching, the use of particular tools is also an interesting element. Every tool, depending on its nature, determines affordances and constraints In this case, for example, the use of dividers, in which the two ends are the same, contributes to a shorter procedure for the circular patterns On the other hand, the use of a lath (a ruler without numbers) makes the procedure less accurate.

The use of the lath as a ruler - in the notion of ancient Greek mathematicians - is an important point. The use of a ruler and compasses is connected with rigidity constructions Indeed, in ancient Greece's mathematics framework, the only constructions accepted were the ones made by these tools. The contradiction that appears here, the use of the same tools without the same rigidity, seems to be explained by the context; in ancient Greek mathematics the interest in geometrical construction was a theoretical one while in this tradition it is absolutely practical.

In formal mathematics and its teaching/learning context, the understanding of a concept is important In a context like this, it could be argued that the craftsmen ignore basic mathematical notions. But, in the context of constructing geometrical patterns for particular purposes, they manage to be effective. They based the tracing of the geometrical figures on mathematical ideas unambiguously albeit implicitly

What could be the utility of an experience like this for teaching mathematics in the classroom? Which points could help students?

First of all, this case-study supports the idea that mathematical cognition may appear in different forms, and can be produced not only in school but also in contexts that provide meaning to the people involved in it. This informal mathematical cognition has different characteristics since the purposes for which it is produced in comparison with formal cognition is also different The acceptance of this kind of cognition demands an alternative epistemology. In an everyday context, the application of any theory and the invention of working practices are both important.

But everyday cognition is not only an advantage for the technician. Students also acquire mathematical cognition, implicitly or explicitly, by involving themselves in everyday activities. So, the view of Millroy could be supported that

> We need to bring nonconventional mathematics into classrooms, to value and to build on the mathematical ideas that students already have through their experience in their homes and their communities. (1992, p. 192)

Notes

[1] *Fegari*, in the single, means 'moon' in the Greek language They used to call every pattern that has circular parts this name. As Xyda stated to me, in a personal communication, the craftsmen make these patterns in the case when the available space is not enough to develop repeating patterns.
[2] He means that the people were less educated

References

D'Ambrosio, U (1986) 'Socio-cultural bases for mathematical education , in Carss, M., *Proceedings of ICME 5*, Boston, MA, Birkhauser, pp 1-6

Gerdes, P (2004) *Geometrical aspects of Bora basketry in the Peruvian Amazon*, Maputo, Mozambique, Mozambican Ethnomathematics Research Centre, www mi sanu ac yu/vismath/gerdbook/gerdbora/, accessed August, 2006

Jacob, E (1997) 'Context and cognition: implications for educational innovators and anthropologists', *Anthropology and Education Quarterly* **28**(1), 3-21.

Lave, J. (1988) *Cognition in practice: mind, mathematics and culture in everyday life*, Cambridge, UK, Cambridge University Press

Lave, J. and Wenger, E. (1991) *Situated learning legitimate peripheral participation*, Cambridge, UK, University of Cambridge Press.

Millroy, W. (1992) 'An ethnographic study of the mathematical ideas of a group of carpenters', *Journal for Research in Mathematics Education, Monograph* **5**.

Nunes, T and Bryant, P. (1996) *Children doing mathematics*, Oxford, UK Blackwell

Pozzi, S , Noss, R and Hoyles, C (1998) 'Tools in practice, mathematics in use', *Educational Studies in Mathematics* **36**(2), 105-122

Vergnaud, G (1985) 'Concepts et schèmes dans une théorie opératoire de lareprésentation', *Psychologie française*, **30**, 245-252.

Vithal, R and Skovsmose, O (1997) 'The end of innocence: a critique of 'ethnomathematics'', *Educational Studies in Mathematics* **34**(2), 131-157.

Xyda, M (2000) *The* xysta *of Pyrgi*, Chios, Greece, Alfa pi.