



Adults Learning Mathematics

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Mathematics in Masons' Workplace

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Abstract

This paper presents masons' professional practices, which are related to mathematics. It aims to contribute to the area of adult mathematics education and to enlarge knowledge about how mathematics is used at the workplace.

Methodologically it was followed an ethnographic approach. The key informants of the study were four masons aged between 40 and 60 years old. Observations and interviews were carried out at the workplace in a civil construction setting in the Lisbon area.

Firstly we present masons' views about schooling and mathematics, as well as the importance that masons confer to mathematics in their profession. Then the paper describes and discusses three episodes observed at masons' workplace in their professional practices. As a whole these episodes illustrate how mathematical knowledge is imbedded in professional activities. Independently of schooling, masons daily and implicitly apply mathematics. It is this practical knowledge of mathematics that, after being uncovered, is for us educators of most relevance to adult-learning mathematics contexts, because not only does it connect school content and curricula to labour-market necessities, but it also makes use of adult learning experiences to support new mathematical learning.

Key words: mathematics education; adults education; masons; professional practices; mathematics in workplaces; ethnomathematics; community of practices.

Introduction

Training has been recognized as a principal mean to achieve professional development and with it to promote better social conditions. Moreover the results of research have been contributing to news ways of thinking about professional training and to recognize as indispensable in future training both the educational value of the work environment and adults' knowledge acquired through work and experience.

In addition, to the extent that alternative forms of learning processes of knowledge acquisition are at the core of adult education's pedagogy it is important to deepen the understanding of techniques and skills that adults need in their professional context and how they cope with mathematics knowledge and take advantage of it to face new problems and situation. As Wedege & Evens (2006, p.30) point out:

The subject area of adult education encompasses formal adult mathematics education as well as adults' informal mathematics learning in the communities of everyday practice, for example in the workplace.

Workplaces are, thus, part of the adults' learning experience and present rich contexts to educational investigation. Moreover, from the viewpoint of mathematics education, professional knowledge as well as cultural mathematics are nowadays both considered as sources of wisdom and inspiration in designing curricular activities and seen as important components of the pedagogy and didactics of the field. In addition, mathematics education can really determine a person's success in professional careers and job opportunities.

The research presented in this paper addresses the issue of masons' professional practices that involve mathematical knowledge. Masons, sometimes illiterate and mostly with very little formal education, build houses, and monuments that stand for centuries. In their professional activity they do calculations and reasoning, and use mathematics daily. It is this practical knowledge of mathematics that, after being uncovered, is for us educators of most relevance to adult-learning mathematics, because it might be used in of adult learning experiences to support new mathematical learning. As educational researchers we need to understand workplaces as contexts of professional practices where implicit mathematical knowledge is performed, because they help to deepen our understanding of how mathematics is used and thought in practical applications required by specific work practices. The investigation of masons' activities, where mathematical reasoning and tools processes are present gives the researcher insight and wisdom to understand the dynamics of the relationships between the knowledge applied by masons in their workplace and mathematical knowledge. Thus, the investigation presented in this paper collects and describes situations observed in masons' workplaces that illustrate the use of implicit as well as explicit mathematics. In particular, it addresses the following questions:

- In what ways do masons use mathematics in their professional activity?
- What kind of relationship exists between that professional use and formal mathematics instruction?
- What are the mathematical concepts that masons use in their professional practices?
- How and where did masons learn the mathematics that they use?

This paper aims to contribute to the area of adult mathematics education, and to enlarge knowledge about how mathematics is used at the workplace. For us, the relevance of studying masons' professional knowledge is to put it to good curricular use in the context of mathematics education either to design general courses in adults' mathematics education or to think about specific curricular vocational courses.

In addition, by investigating what masons know in practice, we intend to explore their mathematical reasoning and calculations to enlarge, strengthen, and develop their mathematical competencies. Simultaneously, with this study we hope to highlight, on the one hand, the value of masons' work, with its professional specificities, practices, social prestige, and role in society, and on the other hand, the universal component of work, its role and place in society, and its intrinsic meaning for most social groups.

Theoretical Background

The theoretical framework that guides this research derives from three major fields: ethnomathematics, adults' education and the concept of "community of practices" and its relationship to learning. Next we address which one of these fields.

Adults' Education

Adults Education is a complex subject. If in one hand the term 'adult' varies both in terms of defining age, and according to social representations, on the other hand, "adult education" is also a polysemic term that encompasses a myriad of different situations as adults are illiterate, with little formal education, with a school trajectory marked by failure and also the situations of life-long learning that increasingly tend to be part of adulthood. Thus, education and training needs in the adult world are hugely variable and dependent on each adult specific circumstances, prior training and education needs.

The field of research of Adults Education has been asserting especially after the World War II. A milestone in the development of the field was the report submitted by Gerald Bogard, in 1991, following a research project commissioned by the Council of Europe. It is not our intention to examine the report here; it is nevertheless necessary to say that it presents an innovative perspective on adult education based on both the significance of cultural learning and the value of transversal competencies. Moreover this report highlights three key aspects in the field of adult education, which are the following:

- i) The place and time of education, that discusses it as a long term process of socialization and therefore articulates pedagogy with both an institutional and social field
- ii) The appreciation of the uniqueness of the educational process that takes in consideration the diversity of adults' knowledge and the different ways of how it was acquired which is hardly harmonized with the compartmentalized situations of school subjects.
- iii) The acting role of the learner within his/her pedagogical relationship (Canario, 2008, pp. 22-26)

Although there are several trends in the area of adults education, the trend that is for us most significant is the one that highlights "the development of training integrated in the work actions" (Canario, 2008, p. 29). This trend is based on the idea that "the exercise of the work is, in itself a producer of competencies" (Canario, 2008, p. 30). That is, research has pointed out how, when the process of adult education is integrated with work actions, the valorisation of the "human factor" as a set of non-technical skills allows workers to know the overall process of production where he/she is inserts (Berger, 1991; Bogard, 1991). In addition the developed competencies have a much more complex nature, in the sense that they are not uni-disciplinary, but holistic and polyvalent and in addition it helps to develop the professional identity.

Ethnomathematics

Ethnomathematics is considered by D'Ambrósio (2002, p.9) as:

...that mathematics which is performed by cultural groups such as urban and rural communities, groups of workers, professional groups, children within a certain age,

indigenous societies, and many other groups that identify themselves by common goals and traditions.

Thus, Ethnomathematics not only provides a valuable framework for researching mathematical activity from all over the world, but also offers the possibility to study and analyse the mathematics of professional groups such as masons. Moreover, it also affords for discussing and reflecting upon its findings and relating them to educational practices and aims. In fact, since the 1970s, research findings from the field of ethnomathematics have demonstrated i) that different professional or cultural groups possess particular ways of approaching mathematics, ii) the social, cultural and political nature of the variables and processes involved in mathematics education, and iii) the complexity of the articulation between mathematical knowledge based in primary culture and that promoted by schools, highlighting the dissociation of formal mathematics education from daily life (Moreira, 2007).

Thus, to understand professional practices that involved mathematical knowledge provide insightful contexts that contribute to develop new perspectives about social and cultural aspects implicated in the mathematical learning processes. Moreover they reveal different ways in which the use of implicit mathematics is connected with its explicit use. In fact, since the seminal works of Carreher, & Schliemann (1993) with child vendors on the Brazilian streets who daily performed complicated mathematical calculations and the one of Abreu (1998) on the methods of production of cane sugar that shows the existence of proper mathematical procedures to measure, several studies have been focused in the mathematics practised by professional groups. In Portugal, Fernandes (2004) conducted a study focused in the mathematics of locksmiths; Costa, Nascimento & Catarino (2006) developed a study about the mathematical practices used in two traditional jobs tanoaria (barrel maker) and latoaria (tin worker), and Pardal (2008) conduct a research on masons' professional practices. In Brazil, mathematical practices of civil construction were investigated by Duarte (2003). In addition, the theoretical grounds of Ethnomathematics has been used to understand the mathematics of young adults (Fantinato, 2003)

Community of practices

Lave & Wenger (1991/1997) understand learning as intimately related to the notion of belonging to the group where it takes place. This is, membership in a community of knowledge and practice implies the attainment of the necessary knowledge attached to this community through a process of legitimate peripheral participation that enables newcomers to become members with full participation in the community. As Lave and Wenger state “learning is an integral and inseparable aspect of social practice” (1991/1997, p. 31). Thus, both the notion of belonging and identity are linked with the process of learning inside the group. As these authors argue:

Viewing learning as legitimate peripheral participation means that learning is not merely a condition for membership, but is itself an evolving form of membership. We conceive of identities as long-term, living relations between persons and their place and participation in communities of practice. Thus identity, knowing, and social membership entail one another. (Lave, & Wenger, 1991/1997, p. 53)

Moreover learning, as a component of a social practice, involves the whole person and the activity that she/he is working on – tasks, functions and comprehension do not exist separately. As the same authors point out :

Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations. To ignore this aspect of learning is to overlook the fact that learning involves the construction of identities. (1991, p.53)

“Communities of practice” (Lave & Wenger, 1991/1997; Wenger, 1998) is an important concept to understand how mathematics is present in the workplace. As communities which gather people informally based in their interest in learning and doing a common activity, although each person might have different responsibilities and functions, community of practices are not only a set of people with common interests but also a set of persons that learn, construct and manage knowledge (Wenger, 1998).

Lave & Wenger's (1991) viewpoint allows for the concept of community of practice as socially permeable, in the sense that the community accepts among its members different interests and knowledge in regard to the performed activity. As such, it not only includes a set of persons who develop a specific relationship with the culture of the group, namely because they have common goals and needs, which in order to be achieved involves the development of certain practices, but also entails “a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice” (p. 98). It is the relationship among people, their organization, and the knowledge that they produce as well as their interactions with other communities that, as a whole, constitute the community of practice.

Wenger (1998) emphasizes what he terms the three dimensions of a community of practice. They are: a mutual engagement, a joint enterprise and a shared repertoire. Practices unfold themselves in a social world where interest, powers and status are present. As Wenger states:

A community of practice is neither a haven of togetherness nor an island of intimacy insulated from political and social relations. Disagreement, challenges, and competition can be forms of participation. (1998, p. 77)

Being shared, a social practice ends by connecting people in diverse and complex forms that constitute themselves as participants in the community of practice. In order to achieve community coherence, Wenger proposes, the people in question engage in the “negotiation of a joint enterprise” (Wenger, 1998, p. 77).

Methodology

One special characteristic of ethnographic research is the long-lasting presence of the researcher at the place of investigation, to create familiarity with the “native” culture and to develop interpersonal relationships with locals. This life experience allows the researcher to move toward the comprehension of the other. In addition ethnography has been pointed out as an appropriated methodology to be used in research that aims to understand mathematics from the participants' view point (Barton, 1997) and specially to be aware of the role of the participants' workplaces in the production of mathematical meanings because of its suitability for getting proximity to the context of everyday operations (Zevenbergen, 2000). Thus, to better comprehend how mathematics emerged in masons' professional practices we decided to use an ethnographic approach to be acquainted with activities, behaviours, perspectives and masons' daily routines.

The ethnographic research demanded our continuing attention as researchers playing the role of the participant observer, with daily proximity and direct involvement in the masons' social

setting. We have to interact with them, namely to slow down their practices in order to bring into speech their realities that were intertwined with mathematics. As Bourdieu pointed out ,

The relationship between informant and anthropologist is somewhat analogous to a pedagogical relationship, in which the master must bring to the state of explicitness, for the purposes of transmission, the unconscious schemes of his practice". (1977, p. 18)

We were very consciousness about the fact that if we failed by not creating a propitious ambiance to elicitation, masons would not trying to bring into speech their explanations and we would not experience the practices and its dynamics, and get as close as possible to their rational. In other words we strongly felt how “the ethnographer is the ultimate instrument of fieldwork (Heath & Street, 2008, p. 57).

Data was collected from September 2006 to July 2007 in a civil construction setting located in the Lisbon area (Sintra). Usually we visit the setting two times a week. There were eight full-time masons at the jobsite.

Because we were acquainted with the owner of the building company, it was easy to get permission to carry out participant observation and to interact with the masons during work time. Before the beginning of fieldwork we first spoke with masons openly about the research aims and processes and about the possibility of having to tape some conversations.

The key informants were selected mainly for their predisposition to collaborate, as well as their ability to communicate with the researchers. Another important criterion was to have at least five years' experience in the trade, to ensure that they knew their profession in detail. Finally four male masons between forty and sixty years old were chosen.

We started by making informal visits to the setting and explaining our research goals to the masons. Our first aim was to meet the masons and get to know their daily routines. Later we focused our conversations on the most common routines that we, as researchers in mathematics education, recognized as involving mathematics. With this focus in mind we encouraged our key informants to talk about their professional procedures.

In this way we recorded information about several episodes that show how mathematics is embedded in masons' professional practices. The observations and interactions were done in the professional context, highlighting mathematical processes and ideas in a contextualized and interrelated way with professional activities.

Semi-structured interviews were also conducted to learn about the masons' school experience and professional trajectories, as well as their personal thoughts about mathematics. All the interviews were done in the professional setting according to the masons' availability and in accord with their job routines. With our informants' agreement the interviews were taped.

Participants' perspectives on schooling and mathematics

The data collected in this study shows that masons did not go through any kind of formal education to learn their profession. In a process of apprenticeship, newcomers in this kind of profession learn in the community of practice of their professional jobsite: the older and more knowledgeable masons demonstrate how to do the job to the newcomers, who learn by observation and imitation, starting by executing the less complex tasks. The key informants in this research have different levels of formal education- two of them completed the 6th grade, one the 4th grade and other 3th grade all of them dropped out of school during basic education (1st to 9th grade) either because their family economic status did not allow them to continue schooling, or because they wanted to be independent from their families.

The four share a similar conception of mathematics. That is, they all assert the importance of mathematics for their professional practices as well as the great importance of

mathematics for life, but they separate the mathematics that they learned in school from the mathematics they use in their professional community. More specifically, they consider school mathematics to be more difficult and “higher status” than the mathematics that they apply day-by-day.

We present our key-informants: Mario, Quim, Joao e Antonio and their views on schooling and mathematics.

Mario is 45 years old and has been a mason for thirty-one years. When he was a little boy his dream was to be a physician. However, because of his family's economic needs, early in his life he needed to look for a job. He finished his formal education in 6th grade. When he started his apprenticeship as a mason, his work was his great support. As Mario says:

I was a little boy and sometimes I felt like a fish out of water. If not for some of my companions, I would not have learned to enjoy my profession.

Mario considers school mathematics essential to his profession, but asserts that experience is even more important. Moreover, he emphasizes that he applies mathematics even without being aware of it. As Mario reports:

I was never good in mathematics. I only knew how to do to the basics, and to do divisions I need a calculator. My teacher used to say that I was a “donkey” in mathematics.

Quim, 42 years old, decided to drop out of school in 6th grade against his family's will. Quim wanted to be independent from his family, at least economically. It was a friend who spoke to him about the possibility of being a mason. In Quim's own words:

In the beginning it was not easy at all. To be an auxiliary mason is even harder than to be a mason. You have to do the hardest tasks, like carry heavy containers full of concrete.

In regard to mathematics he affirms the importance of school mathematics, although he tells us that in his profession he does calculations in a more practical and unconscious way, as he learned from his master masons. He highlights that a mason needs to know how to calculate proportions, percentages, areas and volumes, to measure angles, etc.

As he says:

The mathematics that I learned in school is much more technical and harder to apply than the mathematics that we use daily in building. The latter is so easy that we even forget that we are applying it.

Joao is 52 years old and dropped out of school in 4th grade because his mother passed way and he needed to help his family. He remembered that it was his mother who both used to instigate him to move on in school and to help him with homework. Joao started to work in civil construction when he was 13 years old. He started as an auxiliary mason auxiliary and learnt at the workplace, in the construction building itself. It was the elder and more knowledgeable masons who taught Joao the techniques of his profession and how to use them.

As Joao said:

It was not difficult to learn. I'm a smart gay and when it was possible I tried to do things

by myself.

With 16th years old Joao already dominated the techniques and possessed the necessary basic skills to move on from auxiliary mason to a full mason.

In regard to mathematics Joao considered that what he learnt during basic education was important, although experience and observation of elder masons at work were most significant. Joao agrees that mathematics is crucial in his profession and he highlights that a mason needs not only to know basic arithmetic but also how to calculate areas, perimeters, how to read, apply and compute scales, how to estimate quantities, for example of blocs and to work out budgets. However Joao highlighted that such activities are now routines for him and thus he does not remember that he are doing mathematics

Antonio is our elder key-informant and he has been a mason for 46 years. He finished 3th grade long time ago and dropped out of school because as he belonged to a large family it was necessary to care for his brothers and later on to have an income.

It was Antonio's father who suggested him to work in civil construction. The fact that he has only 3th grade does not restrain him to apply mathematical calculations and even to teach the newcomers. Antonio says that school was not necessary to learn mathematics because his life was his school. As he says, joking:

I deal with numbers even with my eyes closed.

Antonio points out that in his profession mathematics is fundamental although its learning does not require attending school because one can learn in daily situations. In fact he uses several mathematical processes and performs mental calculations to solve problems, saying with proud that:

My calculator machine is my head. And the results are always correct.

Mathematical Episodes

Throughout the fieldwork, distinct mathematical content easily emerges in masons' professional contexts, clearly showing possibilities of working out mathematics in connection to masons' real work needs, especially in the areas of Geometry and Arithmetic. Next, we will describe three episodes: "The construction of an "esquadro" (a tool used to verify that walls are perpendicular to each other); "Adapting tools" (the process followed to solve a situation using the technical tool that masons possessed); and the "Roof's inclination", (the process developed by masons to calculate the inclination of the roof necessary to build up the roof itself).

The construction of the "esquadro"

One of the masons' daily routines is to measure angles, especially right angles. In order to do this, masons often use a tile because they know that a tile contains four right angles rigorously measured. However, to build up perpendicular walls, as in rectangular rooms, and be sure that the walls will keep the right angle between them, masons need a more appropriate tool than tiles. For this purpose they construct what they name "o esquadro" (the esquadron).

To construct the "esquadro," masons use long, thin wood strips that they nail together following precise procedures. The following dialogue, recorded while our informant Mr. Antonio was making an "esquadro," describes the process of making and confirming the accuracy of the "esquadro."

R(earcher): Mr Antonio, I see that you already divided the inside of the house into smaller rooms. How do you know that this wall (internal wall) is perpendicular to the exterior wall?

Antonio: Well. I know because I made my measurements.

R: How did you take these measurements?

A: I used the “esquadro” to be sure that the wall was in “esquadria” (perpendicular).

R: How do you make an “esquadro”? Do you mind showing me?

A: Yes. Come here so I can show you.

Antonio placed two long, thin wood strips on the floor and joined two of the ends with nails, making an angle between them of roughly 90° .

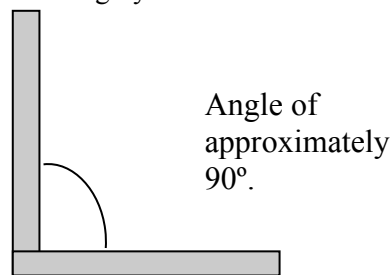


Figure 1 First step in the construction of the “esquadro”

R: You told me that the angle between the strips is 90° more or less. However, the “esquadro” needs to be a precise instrument. You need to have an angle with a rigorous measure...

A: Yes! Of course! I need to be sure that between the two strips there is a right angle. We will get there.

R: So, what is the size of the angle?

A: We know that is 90° . Now to be sure that the “esquadro” has a right angle, we measure 30cm along one strip and 40cm on the other; or, another possibility is to measure 60cm on one strip and 80cm on the other. (Fig.2)

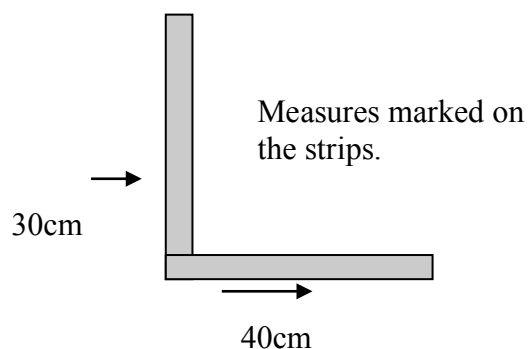


Figure 2. Second step in the construction of the “esquadro”

R: Is it finished?

A: No. Now comes the most important step.

R: Why?

A: Because now I need to measure 50cm between the first pair of marks or 1m between the second. (Fig. 3)

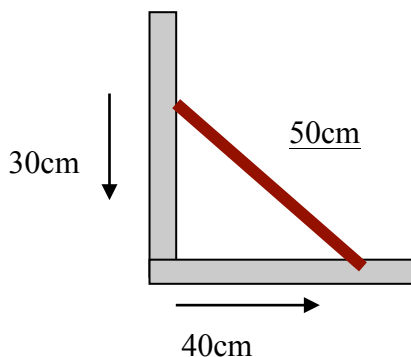


Figure 3. Final step in the construction of the “esquadro”

R: Why are you using the measures of 30cm and 40 cm, or 60cm and 80 cm?

A: Because this is my “scale” and I’m sure that with these measures, the other side of the “esquadro” will measure 0.5m or 1m, and thus I know that my “esquadro” has 90°.

R: Do you always use all these measures?

A: No! I use the measures 30cm and 40cm or the measures 60cm and 80cm, depending on what I’m doing.

R: So the “esquadro” is for measuring right angles. Can you prove that the angle in the “esquadro” is a right angle?

A: Of course I can prove it. With my calculations I have no doubts, but even so I can put a tile on the “esquadro” to prove that the angle has 90°.

The construction of the “esquadro” shows an empirical use of the Pythagorean Theorem as a way to obtain right angles. We asked Antonio where he acquired this knowledge. Antonio said that he learned it a long time ago, with experience and with the help of elder masons. When we spoke with Antonio about the Theorem of Pythagoras he was not impressed by our explanations. From Antonio’s professional point of view the Theorem of Pythagoras does not hold much interest, mainly because the professional context does not require it (Pardal, 2008; Pardal & Moreira, 2009)

Adapting tools

Frequently, to solve a problem at the workplace requires that masons reasoning about the solution in connection to a specific technical tool. The episode that we are going to describe shows this situation. This is, because Mr. Antonio’s boring machine only makes circular holes and it was necessary to perforate a hole on a surface with a quadrangular shape, Mr. Antonio faced a new problem, that he solved applying basic geometric knowledge (Pardal, 2008, pp.122-123).

R(researcher): Do you mind to show me what are you doing?

A(ntonio): I'm drawing squares to incrust the lamps in the roof.

R: How are you going to make it?

A: Then, I draw four circles inside the square.

R: Why are you drawing squares?

A: Because my boring machine is circular and I want quadrangular holes. Thus, I need to make four circles.

R: Why four?

A: I need to do a square hole with a 18cm side, but the machine has a diameter of 9cm. Thus, if I make two circles side by side I get the 18cm as the side of the square.

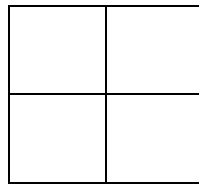


Figure 4. Square divide in four equal squares

R: Where are you going to perforate?

A: After drawing the square, I'm going to divide it in four small squares each one with 9cm side, which is the measure of the diameter of the circle of the machine

R: And then...

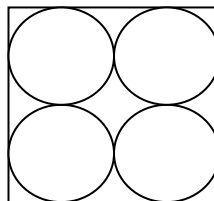


Figure 5. Circles inscribed in the square (each circle represents the perforation of the machine)

A: Then, I put the machine inside each square and I do the holes.

Calculating the roof's angle of inclination

“Roof” is a universal name for covertures. Generally the roof is constituted by the composition of inclined plans. The simplest roof is the one that has only two inclined plans. It is called the gable roof. If the roof has four inclined plans it is called a hip roof.

The function of the roof is to protect people and their belongings against exterior factors such as the snow, the rain, etc. Another additional function is the caption and distribution of water rains. The roof's inclination depends on the type of the covertures as well as on local climatic conditions. Thus, according to the angle of inclination of the plans that constitute the roof, waters rain might be more or less flew off and the heaviness of the snow more or less bearded. For example, in some places in Europe, like the Alps, roofs have a high root ridge in

order to hold better the heaviness of the snow and, therefore the angle of inclination of the roof needs to be more than 60° .



Figure 6. The interior and exterior view of the inclination of a gable roof.

In the following episode masons explain to us how they build a gable roof (Pardal, 2008, pp 106-108).

R: Do you mind to explain to me how do you build the roof Mr. Antonio?

A: Of course!

Next Antonio explains how he does the calculations to construct a 35% inclination roof.

R: How do you calculate the inclination of the roof? What does it mean a 35% inclination?

A: An inclination of 35% means that to each horizontal meter we should have 0,35m in the vertical. Thus, the roof has an inclination of 35%

R: Do you mind to explain it better?

A: Of course! If the roof measures 4m in the horizontal, and I know that for each meter in the horizontal it needs to have 0,35m in the vertical I multiply four metros by 0,35. Thus I know that its root ridge will be 1,4m ($4 \times 0,35$).

R: If the roof has 3m in horizontal and 1,5m in the vertical, what will be the inclination?

A: The solution is identical. The only difference is that in the former situation I did a multiplication in the later I should do a division.

R: So, what are you going to divide?

A: In the former situation I knew the measures of the horizontal line and the inclination, so I multiplied the two values. Now I know the root ridge's height (1,5m) and the value of the horizontal line (3m), thus, I divide the root ridge by the horizontal line ($1,5 \text{m} : 3 \text{m}$) and the inclination is 50%

R: How do you obtain 50%?

A: Well, the result of the division is 0.5. Then I multiply it by 100 to get the value of the percentage, and it is 50%.

The following image illustrates a gable roof as well as the triangle that it forms and the calculations, as we do it in mathematics education, to compute the percentage of the roof's inclination.

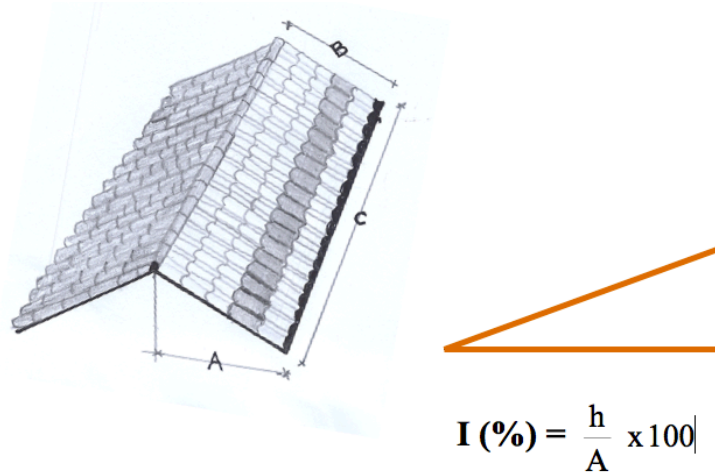


Figure 7 The roof's inclination and the process of its calculation

Discussion

As Barton (1996, p. 214) states:

Ethnomathematics is a research programme of the way in which cultural groups understand, articulate and use the concepts and practices, which we describe as mathematical, whether or not the cultural group has a concept of mathematics.

It is in some aspects certainly the case of masons. In fact, during fieldwork, we witnessed several situations where masons did not recognize that they were using mathematical knowledge, in spite of its relationships to school mathematics. That is, frequently masons apply mathematical knowledge in a practical and intuitive way, using specific strategies to solve problems, without being aware that mathematical ideas are involved.

Moreover Wedge (2002, p.25) presents five hypotheses about the mathematics used by semi-skilled workers. From mason participants' perspectives on mathematics and from the above-described episodes, we can verify these five hypotheses. Thus:

- The three above described episodes are problems "arise(d) that can only be solved by quantification" (hypotheses 1).
- In the three episodes, the situations required "relatively simple formal skills and understanding of mathematics" (hypotheses 2, p. 25)
- The use of mathematics is differently from its use in traditional teaching (hypotheses 3).
- "Workers think mathematics is important in the labor market, they do not regard mathematics as something important of personal relevance to them" (p.25) (hypotheses 4)
- Workers are not fully conscious of their mathematical activity in their daily work and, thus, of their 'mathematical' competence (hypotheses 5).

In addition Wedge & Evans, (2006, p.53) argue about the use of mathematics in the workplace:

... in the workplace what could be called the situation-context (Wedge, 1999a) throws up problems which may (or may not) require the use of mathematical ideas and

techniques. These problems result from the need to solve a working task where the numbers are to be found or constructed with the relevant units of measurement (e.g., hours, kilograms, and millimetres). It is the working requirements and functions, in a given technological context, that control and structure the process, not a narrowly defined task. Some of these problems may look like school tasks (the procedure is given in the work instruction) but the experienced worker has his/her own routines, and methods of measurement and calculation.

The episodes described above: “The construction of the esquadro”, “Adapting tools” and “The roof’s inclination” are a clear illustration of the above argument, in the sense that they are tasks carried out to solve problems posed by situations-context at the workplace and they involve numbers and measures that get meaning in the process of solving the problems. That is, it is the context itself that dictates what numbers and measures are going to be used. Moreover, calculations and reasoning present in the three episodes are similar to some word problems that one might find in mathematics textbook, however, for masons they are routine problems that obey to precise procedures and norms.

From the analysis of the first episode “The construction of the esquadro” we observe that although the Theorem of Pythagoras is taught in school, what emerges from the above dialogue is that masons have been familiar with the application of this theorem for a long time. In fact when we said to Anthony that we can use the Theorem of Pythagoras to calculate faster he noted that:

I do not know that name, but Mr. Pythagoras uses his scale and I use mine, as well as my colleagues use them.

Thus, Antonio does not know the formal name of the Theorem of Pythagoras, but he knows how to apply it in his professional context in the particular case of two Pythagorean triplets – 30, 40, 50 and 60, 80, 100. Fernandes (2004) relates a similar finding in a study about mathematical knowledge in a workshop of locksmiths. The apprentice locksmiths also use the Theorem of Pythagoras to verify if the cover of a chair is in “esquadria”—that is, if it has a rectangular shape—and they use the Pythagorean triplet 6, 8, 10.

Research conducted by Duarte (2003) in Brazil also pointed out that masons use proportions to solve math problems in the course of their work. In fact, several professional practices used by Brazilian masons are similar to the ones observed in our study. For example, to calculate the perimeter of a circumference a popular technique is to add the value of four diameters of the circumference, this is the perimeter of the square inscribed in the circumference. This way of doing the calculation does not indicate the exact value of the perimeter of the circumference but avoids the more complicated procedure of to measure the wire around the circumference.

The episode that we named Adapting tools is an example of what Bessot (2000) argues. As she says:

In the professional area being studied, the part of the device made up of technical tools determines professional practice in the same way as do the succession of actions. Mathematical knowledge is preserved in these tools, and adapted to specific situations. (Bessot, 2000, p.225)

This is, the available technology is used in association with mathematical techniques, in creative ways, to solve professional problems, expressing this professional group’s difference in approaching to specific professional situations.. In the episode described above it was the

characteristics of the technical tool combined with their mathematical empirical knowledge that they can performed with it, that determined the creative approach that masons used to solve the practical problem they faced, this is, according to different contexts masons improve their practices by figuring out new ways of using their professional technology with the support of mathematical processes that they already know.

Final Consideration

To the extent that it is necessary to perform or assume new roles in professional life it is necessary further education that includes learning specific techniques as well as social and theoretical skills. Thus, professional education requires constant lifelong learning as well as the adaptation of former learning.

In order to update professional education as well as to acquire new vocational training it is indispensable to be aware of what the particular mathematical requirements of a given profession are (Bessot, 2000). Masons' knowledge collected by means of fieldwork throughout several real episodes might constitute a set of significant materials that could provide more examples to use educational contexts. As FitzSimons notes (2009, p.350)

The different kinds of experiences brought by the learners – educational, practical and multicultural – can provide important resources for contextualizing their mathematics education, provided that the learners are willing to share them and feel confident to do so.

To study masons' practices and describe them, highlighting their mathematical process and contents, allows us to make use of their practical examples for situations in lifelong education. In this way it is possible both to construct curricula aimed at adults learning mathematics and to develop curricula suitable for labour markets.

Thus we argue that these practical applications of mathematical concepts may constitute, for us mathematics educators, material to work with in order to certify mathematical competencies in an official process.

As a final remark we highlight that educational researchers should understand, explain and propose courses where the dynamics of the relationship between mathematics and the workplace are considered as resources for cultural improvement and further mathematical competences.

Finally, it is important to say that this research does not claim to exhaust the understanding of the phenomenon in study. As in any work that attempts to mine reality, data is infinite. Humility to deeply recognize that fact is always necessary.

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