Farmers do use mathematics: the case of animal feeding

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This article presents findings from a study on the use of mathematics in the context of a farm. Ethnographic methods were used for the data collection and ethnomathematics provides the theoretical framework guiding the analysis. We present two different situations, as examples of ethnomathematics, in which the farmers make use of mathematics in daily life situations on a farm. The first situation has to do with how one of the farmers dealt with a barn as a space for feeding calves. The second situation is about the use of different objects as measuring tools.

The abundant presence of mathematics in daily life and the fact that many people do learn and use mathematics outside school and beyond the formal usages are strong points for teaching mathematics using out-of-school experiences. However, in order to do so, it is useful to identify the use of mathematical knowledge outside the formal school environment of mathematics. Mathematics knowledge is included everywhere in our everyday settings (Nunes, 1992). In this article, mathematics is regarded as the knowledge and behaviour embedded in dealing with change, structure, space and transformation complemented with what Van Oers describes as ”the observance of particular rules, the use of particular concepts and tools, the engagement with certain values,” (Van Oers, 2002, p. 72). Daily life and tasks at workplaces require mathematical knowledge, sometimes more as routines, sometimes in a more problem-oriented way. This is what FitzSimons refers to as adult numeracy, since it implies ”a practical aspect to using mathematical ideas and techniques, whether in the paid workforce or in unpaid family and community situations” (2008, pp. 9–10). According to FitzSimons, numeracy ”relies on

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common sense, and it is context-specific and context-dependent, directed towards the achievement of specific, immediate, and highly relevant goals" (2008, p. 9). As will be seen in the following section, mathematics and mathematical activities in workplaces at all levels have interested many researchers. However, we know very little about how mathematics is used at the level of farms. Most of the studies are directed towards the formulas used in a farm for economical efficiency and farm management (see Glydon, 2005; Mitchell, 2003).

Activities, such as feeding, shearing, vaccinating, preparing the animals for reproduction, or simply identifying animals, are tasks from the farmers' daily routine that may include various mathematical elements. A farm is a good example of an informal milieu in which various uses of mathematics may be present. Adults on a farm cope with the sophisticated demands of the daily practices involving many mathematical elements. Often, these practices are forgotten in the classroom, and there is no link between the reality of daily life and the formal mathematics taught in the classroom. The recognition of adult competency in mathematics, when dealing with daily practices in a rural environment, can be a strong and persuasive tool to use in adult education programmes (Tusting & Barton, 2003, FitzSimons & Wedege, 2007).

This article presents findings from a study showing that farmers use mathematics in daily activities on a cattle farm. We are interested in knowing what mathematics the farmers use in certain situations. The purpose of this article is not to make pedagogical implications derived from the use of mathematics in a farm; but to investigate a natural setting where the use of mathematics is not obvious and to emphasize the process the farmers are involved in. In this paper we analyze two different situations in which farmers make use of mathematics.

Theoretical framework

The idea of taking into account the mathematical content and procedures outside the formal environment of mathematics is not new; many others have insisted on the importance of such considerations (e.g. Angulo, 1994; Cabello, 1997; Ascher, 2004). Before people attend formal schooling, many mathematical concepts are already acquired through informal interaction with other members of the society. Butterworth (1999) refers to this kind of learning as a socio-cultural phenomenon. Accordingly, the context becomes the key for understanding the use of mathematics in everyday life (Gainsburg, 2005). Understanding the bonds between context and mathematics is the major focus of ethnomathematical enquiry; ethnomathematics being the theoretical approach which provides the foundation for this study.

Accorging to Ron Eglash (1997, p. 79) "ethnomathematics is typically defined as the study of mathematical concepts in small-scale or indigenous cultures". The concept of ethnomathematics was coined in 1977 by D'Ambrosio during a presentation for the American Association for the Advancement of Science. Over the years, the concept has been defined and developed by many researchers (for example Barton, 1996; Pompeu, 1994; Ascher, 2004 or Knijnik, 2003). Different lines of investigation have been followed. For example, Knijnik (1995) presented a more socio-political view of ethnomathematics related to the landless people in Brasil. Oliveras (1996) carried out a study about the mathematics identified in Spanish crafts emphasizing the ethno-didactics involved in the process of production. Clareto (2003) researched the space perception of school children in a small fishing community in Brasil.

D'Ambrosio defined ethnomathematics as "the mathematics which is practised among identifiable cultural groups, such as national-tribal societies, labour groups, children of a certain age bracket, professional classes, and so on" (D'Ambrosio, 1985, p.45). This definition indicates that ethnomathematics is not necessarily about new mathematical knowledge. On the contrary ethnomathematics is foremost about the use of already known mathematical knowledge. Therefore, D'Ambrosio insists on describing ethnomathematics as a "research program in the history and philosophy of mathematics, with pedagogical implications, focusing the arts techniques [tics] of explaining, understanding and coping with [mathema] different socio-cultural environments [ethno]" (D'Ambrosio, 2006, IX).

Ethnomathematics can been seen as an intersection set between cultural anthropology, formal (institutional) mathematics and mathematical modelling. Ethnomathematics utilizes mathematical modelling to solve real-life problems, and translates them into modern mathematical language system (see Orey & Rosa, 2006). Eglash (1997) locates ethnomathematics as one of the five subfields in the anthropology of mathematics with emphasis on small-scale indigenous or traditional societies.

Through the lenses of ethnomathematics, it is easier to understand the cultural dynamics within which knowledge is created. However, D'Ambrosio argues that ethnomathematics is not a folkloristic view of how other cultures or cultural groups do counting, measuring or distributing. It is not the study of rare phenomena or curiosities (D'Ambrosio, 1999). On the contrary, ethnomathematics focuses on "how the knowledge, specifically mathematical knowledge, is generated, intellectually and socially organized and diffused" (D'Ambrosio, 1999, p.52). Therefore, as a research field, it has valuable pedagogical implications.

Jama Musse Jama claims (1999) that often examples of the local culture may be used for introducing mathematical arguments. Ethnomathematics allows a good response to the problems regarding the cultural component of education. In other words, ethnomathematics takes a step further towards documenting and including social practices and procedures regarding mathematics into the formal education.

In the last decades, mathematics educators have made many efforts to include ethnomathematical ideas in the formal, institutional mathematics learning and curriculum texts. Some have seen ethnomathematics as the missing step to be added and to complete mathematics education within the framework of diversity (see Presmeg, 1998; Dickenson-Jones, 2008). One example is Luitel's and Taylor's (2007) attempt to create a culturally contextualized model of mathematics education in Nepal. The model held ethnomathematics as a theoretical reference that help students to develop their cultural capital, and the use of mathematics becomes more beneficial for learners.

Situated cognition offers another perspective of a culture's influence on mathematics learning. This is the line followed by those in ethnomathematics that study the use of mathematics by adults and students in daily life situations as opposed to the formal mathematics of school. Barton (1996) illustrated good examples of this type of research like the analysis of Saxe (1988) of Brazilian candy sellers and Carraher, Carraher and Schliemann (1985) of illiterate people in Brasil, or Lancy's (1983) work on the Kewa's counting system and calendar in Papua New Guinea.

In this article, the ethnomathematics refers to the practice and uses of mathematics in a specific context. Our understanding about ethnomathematics in this study is very near to Eglash's (1997) concept of vernacular mathematics, which he sees more or less separate from ethnomathematics, but nevertheless as a subfield of the anthropology of mathematics. Eglash refers by vernacular mathematics to the use of mathematics of those who are distinctly outside any mathematical professionalism (of either west or non-west) and would not qualify under the anthropological category of an "ancient cultural tradition". This kind of mathematics could also be called folk mathematics – mathematics that folks do (Maier, 1980).

The context that frames this study is a calf-rearing farm. Most of the time, the context modifies or even transforms the use of mathematics. From an ethnomathematical perspective, the study of the use and the practice of mathematics in a rural setting such as a farm, may lead to a better understanding and a more effective development of adult mathematics education, since ethnomathematics engages the personal experiences with the use of mathematics in everyday life. The everyday life is what Vithal and Skovsmose (1997) label as everyday settings.

Interestingly, the use of mathematics when carrying out daily routines is not always a conscious act (Wedege, 2002). However, when mathematics is purposely contextualized, it becomes more culturally relevant and thereby makes a difference to the learner and that consciousness may emerge.

Methodology

Barton (1996) defined four types of empirical methodologies that differentiate ethnomathematical research: descriptive, archaeological, mathematizing and analytical. The descriptive methodology concentrates on how mathematics is intuitively used by the members of a community in everyday life, which is exemplified in our study. The methodological approach used in this research is descriptive ethnography. The fieldworker got immersed in the context of the farm, doing, as D'Ambrosio (2004) recommends, participant observations and unstructured interviews. We chose an ethnographic approach because context is best studied through participant observation and in our study the context was expected to play a significant role. Both the ethnomathematical theory and the ethnographic approach require a holistic view of the activities being studied, with special emphasis on the context and culture.

Curiously, most of the studies in the field of ethnomathematics have been carried out in places far away from the European as well as the Nordic countries, for example Harris' (1991) study of aboriginal perspectives on space in Australia, Gerdes' study of Angolan sand drawings (1991, 1994), Zaslavsky's (1973) study of mathematical practises of African people, or Ascher's (1991) study of the Inuit, Navajos and Iroquois in North America. In addition, the studies carried out in Europe have been focused on specific classes or groups far from the rural context (e.g. Frank, 1999 or Oliveras, 1997). In this sense, mathematics education research has ignored the rural context. For that reason, the research was conducted in Europe, on a farm in Lleida, in the western part of Catalonia, Spain. Furthermore, one of the authors is a native from the area, which facilitated parts of the data collection process. Lleida is a mostly rural area whose economy is based on fruit production and animal rearing and the chosen farm is a small cattle farm in which the animals are raised as livestock for quality meat. It has a capacity for 580 calves and about 500 lambs. The farm is not industrialized and is run by three farmers: Jaume, Elena and their son Pere. All of them have some basic education but Jaume and Elena did not finish their primary studies. Jaume and Elena were our informants. The fieldworker together with the two farmers explored the mathematical content of their daily activities, as well as how they made sense of their surroundings.

The participant observations generated notes and audio recordings of the daily activities. Through the unstructured interviews with the two adult farmers, biographical data was compiled and life stories were collected. In addition, the fieldworker took photographs of their activities and daily routines as supportive visual data, that became particularly useful when recalling the different utensils and objects the farmers used in their daily activities.

The fieldworker visited the site several times and the data were collected during the spring and summer of 2004. The fieldwork on the farm consisted of 20 days of observations, which were divided into three periods (table 1). The length and goals of each visit varied.

Table 1. *Fieldwork*

Visit	Date	Days	Data collected and methods	Remarks
1st	14.2 – 17.2.2004	4 days	Photos, participant observation, written field notes.	First contact. Establishment of the situation
2nd	5.6 – 24.7.2004 Intermittent	8 days	Photos, simulated interviews, recorded field notes, participant observation.	Getting acquainted with the general context.
3rd	13.12 – 20.12.2004	8 days	Photos, acting out, shadowing and apprenticeship interviews, recorded field notes,participant observation.	Intensive period. Participant observation and detailed data, impressions.

After each period, we did a preliminary analysis of the data in order to see what else was needed, as well as to get an overview of the process. The first visit was as a period of acclimatisation. The fieldworker went to the farm premises and asked for permission for observation and she used this time as a strategy to minimise the observer effect. For the farmers it was not a problem to have her observing their daily activities and asking questions about it, since the farmers knew her because she grew up in the area. This particular situation gave the fieldworker the possibility to move freely at any time within the farm premises. During the second period of fieldwork, she collected the data by interviewing the farmers and taking notes as an observer. It was an intermittent period, because the fieldworker did not stay at the farm more than two days in a row. In the light of ethnographic theory, the first two visits helped her to collect fruitful data during the last visit. The fact that both visits were short as well as intermittent helped her entrée-adjustment to the farm routines.

The visits softened the odds of having a stranger around and provided the farmers with a more relaxed feeling towards the fieldworker. Longer acclimatisation periods could have been too invasive.

Thus, the last visit to the farm was the most productive and interesting from the data collection point of view. During this last period, the fieldworker became a participant observer and did apprenticeship interviews. She was part of the situation in specific moments, in order to come into closer interaction with the farmers, as well as to be able to understand the insights of the activity that they were executing (Spradley, 1980). She also tried to understand the daily activities of the farmers in their environment by examining the objects and physical traces left by them (e.g. tools and marks in the barns), but that was not possible without the help of Jaume.

During the first period of observation the fieldworker did a situated interview (Barth, 1994), where she asked the farmers to tell her what they did when performing their tasks on the farm. She asked in detail about their practices. Throughout the period, when the farmers showed her the farm premises in detail, she did simulated use interviews: the farmers showed her how they would do those things, which they had previously mentioned during the first situated interview. Third, she asked the farmers to show her their normal procedures – as acting out interview. However, the most fruitful interviews were the shadowing interviews and the apprenticeship interviews. During the shadowing interviews, she followed the farmers wherever they went. For the apprenticeship interviews, she asked the farmers to teach her how to do the different tasks. These interviews were a part of her participant observations, where she acted as a farmer and learned how to do most of the activities the farmers had to deal with in their everyday life.

Some of the challenges encountered when applying the various techniques related to the methodology were due to the fieldworker's inexperience as an ethnographer. For example, in a couple of occasions, when interviewing and discussing with the farmers during an activity, her physical position was disturbing their movements. She had to learn to choose the right spot for her observation. Also, while speaking to the farmers, she at times got in the way of their discourses. However, this turned out to be a positive factor, since in their culture it is very natural and common to interfere when somebody speaks. This gave them confidence in her as someone who understood their culture.

We began our analysis by making a list of different tasks we identified on the farm. As shown in table 2, the fieldworker recorded the frequency of incidence and whether the activities were routines or not. After that, in order to systematize the data and analyse it, we created a mind map

Table 2. *Tasks on the farm*

Activity	Person in charge		Frequency of the task		A routine task?	
	Jaume	Elena	Daily	Not daily	Yes	No
Preliminary barn inspection	X		X		X	
Feeding young calves with powder milk	X	X	X			X
Preparation of lamb feed	X	X	X			X
Distribution of grain and feed for older calves	X			X	X	
Distribution of feed for lambs	X	X	X		X	
Cut the hoofs of lambs	X			X	X	
Cleaning the barns	X			X	X	
Stopping ”breast milk” of lambs	X			X	X	
Giving medication (with a veterinary)	X			X		X
House care (cooking, cleaning, ironing, shopping...)		X	X			X
Arrival and departure of animals	X					X
Vaccination	X	X		X		X

with the different data gathered during the fieldwork period. In this mapping, we located the different identified tasks of the farmers and the factors, which intervened, with the development of the tasks. Photos of the tasks were included to complement the data. We compared the field notes with the interview data and memos about the tasks. In the interpretation phase of the analysis we reflected on and considered all the gathered data. The analysis involved connecting the field notes with the information extracted from the interviews.

Solving problems at the farm

During the interviews, the farmers gave detailed descriptions of their daily physical activities as well as detailed descriptions of the different barns and spaces on the farm. Most of the information concerned activities that had already become routine after repetition and experience. However, there were also descriptions of several problems encountered during the course of the activities.

A problem is defined by its objectives or purposes. Hayes (1980) expresses what a problem is by stating "whenever there is a gap between where you are and where you want to be, and you don't know how to find a way to cross that gap, you have a problem". Furthermore the difficulty appears when considering whether an activity becomes a problem-solving situation or not. Bodner (1987) introduced a rather interesting, but simple, way to differentiate a problem from a routine activity. He argued that if one knows what to do when facing the potential problem, it is not a problem but an activity. Thus, most of the activities established in the farm were routinized and therefore not problem-solving situations. Yet some were and we understood them as those activities where the farmers did not know what to do immediately in order to find a solution.

Cattle and their physical condition – such as illnesses, injuries and specific care details – are examples of problems mentioned above. However, there were other problems regarding difficulties related to the daily routines such as feeding and cleaning the barns and also what we call "primary obstacles", which the farmers had to face when doing the activities for the first time, before they had become routines. These "primary obstacles" were particularly interesting because they were mostly related to optimisation and distribution of spaces and time. We chose to focus on these particular problem-solving situations.

Generally, when a problem is encountered and defined, it is developed in such a way that it posits both a clear question and some criteria for recognizing a successful solution. In addition, a strategy for solving the problem is manifested. The strategies can be either executable or unworkable. The final step becomes making the interpretation for the use of the strategy in future tasks.

However, when solving a problem in a formal education situation (i.e. at school), the students tend to rush uncritically (since frequently the problems are out of their school context) to find answers in formulas and pre-established procedures (Schoenfeld, 1985). Basically, those are the tools that their school context provides them with. In the case of the farm, the problems were contextualised in situ and the farmers did not rush into paper-pencil calculations.

We will present two different problem-solving situations on Jaume and Elena's farm and the solutions they found. Both situations are related to animal feeding and their respective solutions involve the use of mathematics. The first problem concerns how Jaume dealt with the use of a barn as a space for the youngest calves and how during the process of distributing the space different mathematical elements emerged. We chose this situation to analyze in more detail because it had been a "primary obstacle" for Jaume and he recognised that it was a problem-solving situation at the beginning.

The second situation is about the use of different objects as measuring tools. We chose it as an example because it is the type of situation where the context does not provide standard tools for solving the problem. Here the farmers had to use what was available in the context of the farm.

Optimisation and distribution of spaces

The farm had an old barn where the smallest calves were meant to live and be fed. Jaume explained that at the beginning this appeared to be a problematic situation because the barn was already built, and thus it was not possible to reconstruct it for serving the new purposes and needs of the cattle. The problem was encountered and defined: He had to optimize the given space and find the variables for maximum capacity. At school a problem posed like this could possibly lead to creating an equation that includes all the variables needed and taking the first derivative of it. Even if Jaume did not have these tools, he still used mathematics to solve the problem at hand.

The only possibility for Jaume was to rearrange and distribute the inside while maintaining the outside structure of the barn. The question was clear: how to distribute the old barn space. The criteria for recognizing a successful solution were that the use of space had to be optimal and the distribution had to permit feeding and living for fifty calves. Jaume articulated the strategies for solving the problem.

During the interviews, he described in detail the process for solving this problem. He drew a plan (horizontal cut of the building) of the barn on a paper and explained how he had examined different possibilities to solve the problem. He tried to draw different pictures for us to understand better the problem and the explanations. He used his intuition to consider the validity of the different solutions he came up with.

He had the possibility to build fences and use a rail of buckets. Jaume had to consider and deduce the possible alternatives from their final purpose. When considering them, he eliminated the ones that were not suitable such as installing permanent fences (since the space was too small and that could reduce the mobility of the animals even more), lining up the feeding buckets from wall to wall (it would have taken too much space and made it impossible to control which animals were fed). All the same, the possibilities of distribution in a square space seemed to be infinite but Jaume insisted that ”keeping it simple” appeared to provide the optimal use of the space.

He had to create different models of indoor fencing to find the most suitable one and he placed the fences in different positions to test them (trial-error method), instead of working out the possible models abstractly or on paper (as would have been done in a school). He divided the problem into sub-goals (Mayer, 1983) or in other words, in Polya's (1945) heuristics he used auxiliary problems. The first goal was that he had to differentiate the fed calves from the not yet fed ones during all the feeding process; second goal was to create an area where the animals could eat in peace and still be under control; and third goal was to obtain as big a space as possible for the calves to be kept between feedings. Then Jaume eliminated the obstacles one by one: for separating the fed calves from the non-fed ones, he came up with the idea of putting up fences. The way to get an area where the animals could eat in peace was to create a smaller feeding area, with just sucking buckets. This area's width was a bit longer than the length of a calf, with just enough space for Jaume to fit between the fence and the calves. This was a control strategy as well as it implicated geometrical ideas. The calves did not have room enough to run around. The area was set by the length of 12 calves in a row and the length of a bit more than a single calf, creating a rectangle.

Mobile iron fences were the best choice for Jaume and Elena due to the reduced available space (144 m^2 is not much space for 50 animals). Jaume built them by using two poles with two parallel bars attached in perpendicular to each extreme of the poles and creating a rectangular frame. Jaume claimed that this way the fences were strong and easy

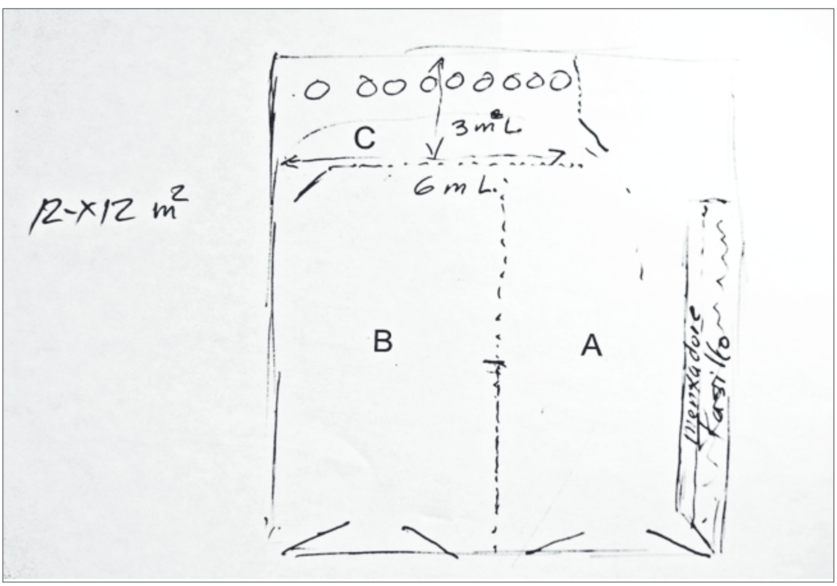

Figure 1. *Jaume's sketch of the barn*

to handle. Once again, he used simple geometrical shapes for obtaining optimal results.

The fences were placed in such a way that the barn was divided in a space for the fed calves (A), another for the calves to be fed (B) and a third one for the calves being fed (C). The spaces were proportional to the amount of calves they were meant to contain. Apart from the sketches that Jaume drew to support his explanation, he also drew alternative possibilities and explained the disadvantages he found regarding the use of space or regarding the control of the animals. Those sketches were very superficial and he did them to clarify his oral explanations. All of them were traced with straight lines and they showed his spatial abstraction capacity. However, when the fieldworker asked Jaume to draft the plan of his own house, he seemed reluctant and argued that that was a more complicated task and he was not able to do it. We see this as a clear example of how much context can modify and provide significance when solving a problem. Jaume used the barn sketch as a tool for his explanations of the problem we were dealing with. All the same, the drawing of a house was not connected in any way to the situation and therefore he claimed that he was not able to do it.

With regard to the space distribution in the barn, the created spaces had different sizes according to the number of calves to be kept. They were proportional. Once more mathematics was used in the solution: proportionality. Space A and B were bigger than C, since C was meant to be for about 10 animals at a time. All three spaces were rectangular (see figure 1).

The transfer of calves from one space to another was done manually by Jaume and in a rotational way.

Jaume: [...] these ones have sucked, they get out from here, and we bring them to this empty space, let's say... well in this place there is nothing. Well we pass 10 more here and we repeat the same thing, the wheel, we make the wheel, all right?

To start the feeding all the animals were gathered in B. From B, groups of 10 calves at the time were transferred into C, fed and then when finished feeding transferred into A. All the fed animals ended up eventually in A. Jaume and Elena explained that they had control over the animals all the time. The animals in A were fed, the ones in B were waiting to be fed, and the ones in C were being fed. After the feeding, the fence between A and B was removed, allowing the animals to have more room to move around. This system was used twice a day, in the morning and in the evening, and it was carried out by Jaume and Elena. Jaume moved the animals and Elena prepared and gave the feed.

As described in the previous fragment, Jaume spoke of the rotational method as ”the wheel”. The analogy of a wheel to the rotational system is a very clear example of how one’s own experience can provide elements for understanding mathematical elements. In particular, Carraher and his colleagues claim that the way humans learn to deal with new specific situations involves remarkable use of previous knowledge such as analogies, categorizations or comparisons (Nunes, Carraher & Schliemann, 1993; Carraher, Carraher & Schliemann, 1988). A wheel represents a round object that serves Jaume as a tool for his reasoning strategy. For him a circle is a never ending object, as the process of feeding is infinitely repeated. He claimed that it was the logical way to proceed as well as the most practical one.

Researcher: [...] but what motives did you have to make this type of rotation of calves (referring to the feeding system)?

Jaume: let’s see ... the practicality of it! The system is like this and it is not in any other way ... not any other way. The distribution that we did has to be like that. As I explained to you. Let’s say. And it cannot go any other way, inside this barn ... it cannot be any other way. OK?

Researcher: OK

Jaume: But I am really sure that it cannot go any other way.

Above all, Jaume’s solution to the problem of distributing the space in the barn and his process for developing the solution indicate Jaume’s ability to reason mathematically (Mason et al., 1982). All the way through the process mathematics were in use since he was able to reformulate questions to examine different possibilities, reject or verify them, give examples, describe and deduce, as well as to find conclusions and review the validity of the arguments. Nevertheless, these processes bring us unequivocally back to Polya’s heuristics (1945). Jaume understood the problem (how to distribute the barn?); he made a plan and carried it out. He had strategies, he evaluated the advantages and disadvantages (for example the use of fixed fences or lineal mangers) and he came up with a plausible and workable solution.

Transforming everyday utensils into measuring tools

The second type of problem-solving situation has many variations in our data. It shows nicely the fluency of farmers to adapt and to solve problems. During one of the interviews, Jaume mentioned the following.

Jaume: I always give them the measure of milk they need. The measure is ... a pot of milk ...

Researcher:	[?]
Jaume:	[...] a pot of litre and a half of milk.

Jaume used the pot of milk as a standard unit of measurement. The pot of milk was, in fact, an old kitchen pot with an approximate capacity for ½ litre of liquid. Every morning and every evening, Jaume and Elena used this pot for calculating the amount of powdered milk solution to be given to the calves. They changed the use of the pot and instead of being a cooking instrument it was a measuring one. More in detail, they took the pot, which more or less seemed to have the capacity for ½ a litre of water. They made it sure by taking a 1 litre empty bottle of water, filling it up and pouring it into the pot. They emptied the pot and filled it again. There was no more water left in the bottle, therefore, 1 litre divided into two pouring times equals two ½ litres, hence the pot's capacity was ½ litre. After that, the pot was no more a pot, but a measuring recipient with a capacity of ½ a litre. This way, they were able to determine the exact amount of solution they needed for each calf by giving 3 times a full pot to each calf. During the interview Jaume said "a pot of litre and a half a litre of milk", but during the feeding, Elena poured three times the ½ litre pot, and therefore the final amount served was 1½ litres. Jaume had confused the total amount to be served with the real capacity of the serving pot. While discussing with Elena, a similar case took place.

Researcher:	What is the quantity of water that you need? [for preparing milk for 49 calves]
Elena:	4 buckets.
Researcher:	[?] Yes ... but how much is that?
Elena:	... mhm ... well ... I don't know now ... 1 and a half litres per calf.
Researcher:	But in a bucket?
Elena:	Count it ... I don't know ... that is what I take ...

Elena indicated the quantity with a different unit: a bucket. She uses what she has available in the context of the farm to reach her purpose. Conventional instruments are not always available and therefore the farmers had to find another solution. Consequently, in lack of conventional measurement tools they use those everyday utensils that are available and transform them into measurement tools and "standardize" them as measurement units. Apparently, very often, formal mathematics gives attention to subject matter, instead of student skills and strategies to solve problems without tools and means. For example, formal mathematics taught at school prepare students to be able to measure volumes, surfaces and lengths in different measurement units, whereas no attention seems to be paid to figuring out how to measure the same things without standard measuring tools or units. Ironically, often, everyday life lacks those tools and people need to create new and different solutions. Jaume and Elena managed to use tools from their close environment and transformed them into unconventional but reliable instruments. Some of these objects had to be transformed or adapted, like the bucket with sucking teats, which were perforated in their bases to attach the rubber teats and as a result, the young calves were able to suck the milk.

In the farm, we found several similar cases of objects that were used for other purposes. Up to a certain extent, this brings us to acknowledge a double identification of the same object: one as an artifact, the technical device constructed according to specific goals (in the case of the pot, for cooking); and another as an instrument, regarding its modalities of use (Vérillon & Rabardel, 1995).

Reflections: the use of mathematics as a constructive process

One of the first questions that the fieldworker asked Jaume and Elena was whether they used any mathematics in their daily activities. Jaume answered affirmatively and showed the fieldworker their office, where they dealt with the administrative papers of the farm, and pointed at the computer. For him, to use mathematics meant to use numbers; in particular, the numbers of the identification of calves, the numbers that showed the amounts of feed and the weight of the calves upon arrival and before they were brought to the slaughterhouse. Metaphorically speaking, numbers kept appearing all over the farm and in the farmers' daily activities. There were numbers when measuring the feed or when counting animals to be transferred to the C space of the barn, as well as for the number of days that the calves were supposed to stay on the farm. Numbers were everywhere.

All the same, the appearance of numbers did not prove that the farmers used mathematics; however, numbers along with the development of solving problems, and putting together rules and using their own experience, made the whole process mathematically constructive. In other words, Jaume and Elena found their solutions, had their routines and learned from their daily activities. They constantly used geometrical shapes and searched for the maximum space to be used, which is another way to solve optimization problems without using derivatives. The ethnomathematical framework helped us acknowledge the value and role of the context in terms of understanding the use of mathematics by Jaume and Elena. However, it was not the mathematics that Jaume claimed to use when he mentioned the numbers in the farm, but the basic mathematics embedded in their activities, such as feeding animals. In addition, the importance of a meaningful context became especially evident when Jaume did not want to draw a map of his house for the researcher since there was no context for doing so.

According to FitzSimons and Wedege (2007), the importance of this type of research lies not only in its explanatory value but also in its potential social use. As Graeber and Campbell (1993) consider, it is evident that mathematics is more stable when it is learned in a significant context through the reasoning of one's own experiences and it is reflected in the ability to reason. In this paper, the ability to reason mathematically has been acknowledged as the capacity to reformulate things in different ways, as Jaume and Elena did. Their mathematical reasoning allowed them to examine the different possibilities, reject or verify them, and give examples of possible solutions or similar situations. Jaume and Elena were as well able to describe the problems and deduce consequences, as well as to draw conclusions (Mason et al., 1982). And above all, even the possibilities to be examined or the tools to be used were determined by the farm as a context. They had access only to what they could find in the farm and therefore, the context becomes a decisive factor for understanding the use of mathematics in their everyday life. Without understanding the context, it is not possible to understand, for example, their choices of tools or solutions. We see this bond between mathematics and context as ethnomathematics. In other words, when we are searching for the practices and uses of mathematics in Jaume's and Elena's farm context, we find examples of ethnomathematics.

On the whole, a workplace environment, such as a farm, has distinct advantages in contrast to other settings for the use and practice of mathematical skills. Our contribution to the ethnomathematical research is an ethnography done in the context of a farm in Europe, unlike many of the previous studies done in other parts of the world (for example Harris, 1991; Gerdes, 1991, 1994; Zaslavsky, 1973; Ascher, 1991; Clareto, 2003). In addition, the few studies carried out in Europe have been focused on specific classes or groups far from the rural context (e.g. Frank, 1999 or Oliveras, 1997), where the farmers, with their daily activities, informally used rules and elements of formal geometry (e.g. squares, rectangles, right angles, parallel lines or optimisation of spaces), estimation and even measuring. For many adults, geometry is a topic that immediately makes sense to them and gives them confidence in their ability to learn. Thus even though the results of this study are not generalizable to all rural situations, they might be transferrable considering the context. This study reaffirms the importance of the inherent spatial sense in adult basic mathematics knowledge (see Massachusetts Dept. of Education, 1992).

In addition to all these reflections and in relation to the knowledge and behaviour focused on quantity, structure, space and transformation along with problem solving used on the farm, all the findings could be compacted into three different mathematical domains hidden in the activities of the farmers: the measuring domain, the numerical and quantitative reasoning domain, and the geometrical-spatial reasoning domain.

In the measuring domain, Jaume and Elena had to calculate the volume of pots and other instruments they used in their daily activities as well as the doses of medication for vaccinations or the amount of feed served to the animals. They used different containers and pots; however, all of them were homemade and self-created, like the pot to measure the milk replacement solution.

The numerical and quantitative reasoning domain was exemplified when understanding and using numbers for different purposes, or when counting fed calves or calculating the amount of feed ingredients.

Finally, the geometrical-spatial domain included the different geometrical approaches when distributing and dealing with the limited space they had in the barns for their different activities, for instance, cleaning the barns, feeding or vaccinating.

The participants of this study, Jaume and Elena are clear examples of adults who reason intuitively (see also Coben, O'Donoghue & FitzSimons, 2000), with common sense. They base their reasoning upon experiences within the specific context of the farm and they use a variety of methods to solve their problems. They benefit from ethnomathematics. The utensils and spaces the farm provides as well as the timing and the circumstances define and shape the responses of the farmers and the farmers' use of mathematics. Although Elena's and Jaume's skills in formal mathematics might be limited, and the level of mathematics they use in their daily life might be somewhat unsophisticated, their basic numeracy allows them to solve real-life, meaningful problems in rather complex context-specified situations. As mathematics educators we could be more sensitive to the fact that human beings make sense of their environments and we could learn more about the ethnomathematical idea of contextualized mathematics.

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