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ABSTRACT

A report on some pilot research which explores ways of investigating the mathematics used in two professional crafts: upholstery and gardening. The paper considers observations and conversations in the light of J. Lave and E. Wenger's theory of situated cognition. It describes a situation in which cognition had to be transferred because of a change in materials. The essay examines the spatial relationships in the structure of the materials and the way that they are used. It demonstrates that the passing on of skills and knowledge displays many similarities with the apprenticeship system described by Lave. Finally, the paper discusses the effectiveness of the research method. (Author/ASK)

An Exploration of Situated Cognition in Two Professional Crafts: Upholstery and Gardening

by

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An exploration of situated cognition in two professional crafts: upholstery and gardening

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Abstract

A report on some pilot research which explores ways of investigating the maths used in two professional crafts: upholstery and gardening. I consider my observations and conversations in the light of Lave and Wenger's theory of situated cognition. I describe a situation in which cognition had to be transferred because of a change in materials. I examine the spatial relationships in the structure of the materials and the way they are used. I demonstrate that the passing on of skills and knowledge displays many similarities with the apprenticeship system described by Lave. I discuss the effectiveness of my research method.

Introduction

This is a report of a pilot study that I am in the process of doing, exploring ways of looking at the maths used in two professional crafts: upholstery and gardening.

My interest in the maths used at work has arisen out of my experience of teaching adults basic maths, where I have found it is very useful to get students to describe their working practices, whether in the public arena or inside the home. Many students arrive at basic maths classes announcing that they cannot do any maths and need to start 'from the beginning'. Coben and Thumpston (1995) found that people tend to describe the maths they can do as 'common sense' and only what they cannot do as 'maths'. Anxiety about maths, as described by Buxton (1981) can also contribute to this situation: many students and others have discussed similar feelings with me.

Discussing students' work and daily activities with them enabled me both to assess their real competence and to plan the curriculum using appropriate contexts. Tout (1995) describes using similar methods in teaching adults. As a result of my conversations with students, I have become very aware of how little I know about the working practices of adults and the maths that might be involved in them. As a maths teacher I do not think I am alone in this lack of knowledge.

Enquiries into the maths required for working in industry often concentrate on filtering the mathematical concepts and procedures out of work practices, with the idea that the maths is best taught in an abstract form, and can then be applied back into the work (Harris, 1997). However, Lave and Wenger argue that learning is essentially a social activity which happens within a particular 'community of practice', whether this is the workplace, school, home, or other places (Lave, 1988; Lave and Wenger, 1991). What has been learnt in one community of practice is not necessarily simply transferable to another, so that abstract learning in an educational institution may not be easily applied in the workplace. Rather people learn at work the skills and knowledge they need at work, not through formal learning, but by participation in the work.

I decided to study upholstery and gardening for two reasons: because they were convenient; I came across the participants in the study by chance through personal contact; and because I thought that they would both be using spatial relationships in their work. This area of maths is ly unexplored: Harris (1997) found that employers tend to ignore it when listing the eir workers require.

The participants in the study

The gardeners

Joe has a small gardening business, called Transformations, which offers restructuring and maintenance of gardens to corporate and private customers. His business card offers any work to do with gardens. He has several people working with him. They put up fences and trellises, construct decks and patios, install automatic watering systems, lay lawns and cultivate and plant flower beds.

The upholsterers

Sean is a professional upholsterer: he has his own small shop-cum-workshop in London, where he undertakes the repair, re-upholstery and re-caning of chairs, settees and stools for customers. He also teaches upholstery one day a week at a local project which organises workshop classes for adults in a variety of crafts. In these classes, students bring a piece of furniture which they strip down, repair, re-finish, and re-upholster or re-cane over a number of weeks, under individual instruction and assistance from Sean. The project provides tools and storage space.

Methods of research

Gardening

I visited the gardeners several times while they worked on three gardens, watching them work, asking them questions about what they were doing, how and why, and listening to their conversations with each other. I drew plans of the gardens. They knew I was interested in the maths they were using but I conversed with them widely about gardening: plants, herbs, types of soil, and fencing.

Upholstery

I visited Sean's workshop class at the local project twice, watched Sean and the students at work, and asked them questions about what they were doing. Sean knew I was primarily interested in the maths they were using, but the students were told that I was studying adult education. We did this because I thought the students might be frightened by the idea of maths, as Buxton describes, and become unable to talk freely to me. I also thought that the students might deny using any maths, as Coben and Thumpston report.

The students explained to me what upholstery processes they were using, what they had previously done, and what they intended to do next. I also visited Sean in his professional workshop, watched him working, and asked him to explain what he was doing. He told me how he had learnt his craft from his father and how his daughters are learning from him. He explained his philosophy of teaching and learning the craft.

Recording the data

I did not take field notes during my visits to the upholsterers and gardeners, because I thought they might find this off-putting and it might discourage them from talking to me freely. I did draw some diagrams because I thought I would find it more difficult to remember spatial configurations than conversations. I think this was probably less threatening to the people I was observing than taking notes, since they could easily see what I was drawing.

After each visit I wrote down everything I could remember about what I had seen and heard, and drew diagrams and plans. At this stage I did not attempt to distinguish between mathematical and non-mathematical data.

shall describe a few examples of what I saw and heard during these visits, and I shall onsider them in the light of Lave and Wenger's theory of situated cognition. Three main

themes have emerged from the data I have collected so far. The first is that where materials change, cognition can be transferred from the old to the new material, within the working situation. The second theme explores the spatial relationships of the structure of the materials and the way they are used. The third theme examines the ways in which skills and knowledge of the crafts are passed on from people with mastery to those learning from them.

Transfer of cognition within the community of practice

Measuring for a lawn

When Joe was measuring up for a new lawn, he said that he prefers to use the traditional (Imperial) system of measurement, because it is based on the human body. He said his feet are about 1ft long and his pace is about a yard; it's a yard from his fingers to his nose, and he knows where a yard comes up to on his body from the ground; his half-thumb is an inch. When he is estimating the cost of a job he measures with his body.

But the firm where he buys his turf has started cutting it in square metres. They told him that the European Community has enforced a change in the size of turfs from a square yard to a square metre.

Joe measured the space for the lawn in metres with a tape-measure. The lawn was to be quadrilateral in shape (Fig 1) and he worked out the area as the sum of the areas of a rectangle and a right-angled triangle. He used a calculator for multiplying, dividing and adding, then he rounded up the answer mentally to the nearest whole number, to give him the number of square metres of turf required.

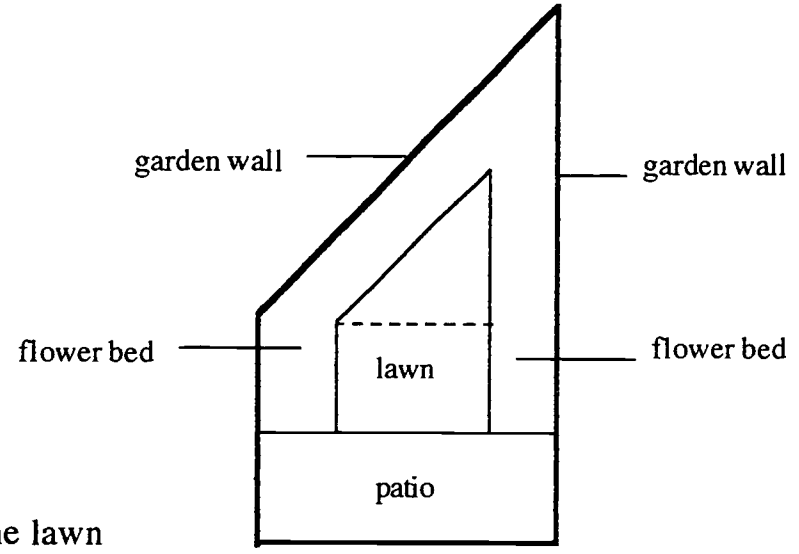

Fig. 1 Shape of the lawn in the first garden

Mathematically, it is easier to calculate in metric units, especially with a calculator, but Joe found it annoying, even though he had no difficulty in doing the calculation. He had had to change his familiar working methods. His concepts of the Imperial units of measurement are related to his use of his body in his work. In measuring and calculating in metric units, he had to think about what he was doing and how to do it. He was able to transfer his cognition of measurement from using his body to using a metric tape. The method he was using for calculating the area does not depend on the units of measurement, so it required no transfer of 'tion.

The spatial relationships inherent in the work

In most of what the upholsterers and gardeners were doing, the maths that they were using was an integral part of their work. It was not 'applied' in the sense that faced with a problem they sought a mathematical process to solve it. In their work they were practising customary procedures to fit materials onto objects or into specified spaces. Measuring lengths or angles or calculating was not always necessary. I shall describe four examples of working practices I observed where this was happening.

Laying a lawn

Lee, one of Joe's workers, started to lay the lawn at the top of the garden (Fig 2), furthest from the house, working from side to side. When I asked him he said it did not matter which way you laid the turfs: the important thing about laying a lawn is that it is not allowed to dry out in the first few weeks when the roots are developing. The gardeners always lay the lawn as the last task in a garden, so that it is walked on as little as possible. But this means that they leave the customer to keep the lawn watered if the weather is dry. Customers do not always do this adequately. If the lawn dries out, the turfs shrink and holes are liable to appear where they join.

Therefore it is very important to lay the lawn in such a way that there are as few joins as possible, especially round the edges, and that no small pieces of turf are used. Small pieces have to be discarded: they can be used as compost.

The space was not marked out: Lee unrolled the first turf from left to right, and settled it in place by eye. (Fig 2.3) He partly unrolled the second turf in the same direction and cut it off at right angles at the required length, which he judged by eye. He then turned the remaining part of the rolled turf through 180 degrees, and unrolled it from the right-hand side of the garden towards the left. He continued this process down the garden, laying each row of turf alternately from right to left and from left to right. This sequence of laying the turfs resulted in the joins between the turfs being staggered across the lawn, rather than clustered round any one point. Where two turfs joined, Lee lifted the edges together then eased them down, to ensure a snug fit. Turf tends to stretch, but this is undesirable, as it will shrink if it dries out. So it needs to be slightly compressed as it is laid.

At the top of the garden where the side edges of the lawn were not going to be parallel to the side fences, Lee cut off the turfs parallel to the fence in a stepped pattern (Fig 2.4). He finished the lawn by laying a strip of turfs down each side. Where the turfs had been cut in a stepped pattern, strips were laid under the edges, and cut along the 'steps', using the edges of the 'steps' as the guide for cutting (Fig 2.5). Then the spare pieces were pulled out from under the strip and discarded. This edging strip of turf ensured that there were the minimum number of joins at or near the edges.

After doing the angled edge on the right-hand side, Lee placed a guide-line for the angled edge of the lawn on the left-hand side, to check that the angles would be equal on both sides. He judged this by eye.

The fact that turfs are cut commercially as rectangles, and to a standard size, with an area of one square metre, meant that Joe could easily calculate the number of turfs required from the dimensions of the required lawn, and Lee could tessellate the turfs very simply: he did not have to think about how they would fit together. Presumably, turfs are the shape and size they are because these make laying them convenient: they are cut to a size that can be lifted, and to a shape which tessellates easily. Lee worked out as he went along, how to avoid using small pieces of turf, and putting joins next to each other. Where the turf was cut in a stepped pattern, one set of edges as a cutting guide for the others. The angles of the edges of the lawns timated visually.

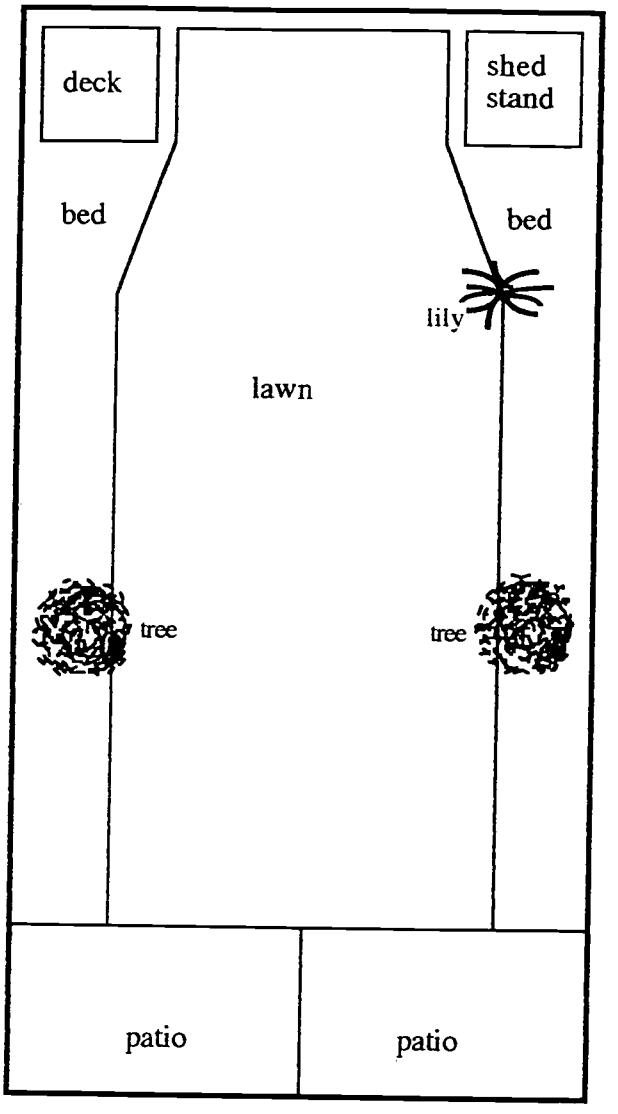

Fig. 2.1 Plan of the second garden

Fig. 2.2 Turf: 1 sq m.

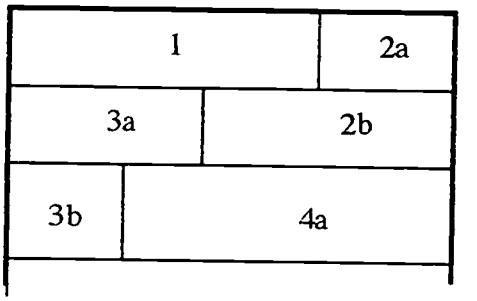

Fig. 2.3 Order of laying the turfs

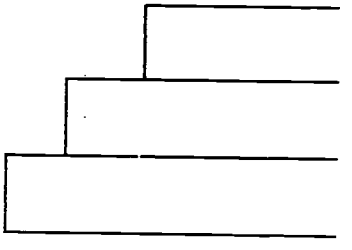

Fig. 2.4 Stepped edges of the turfs

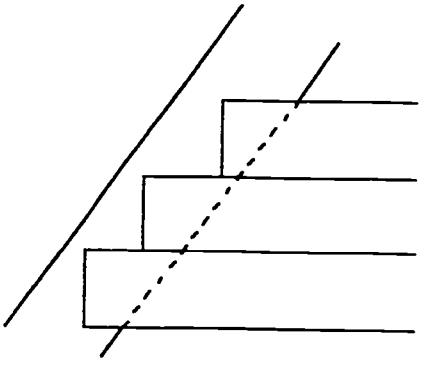

Fig. 2.5 Laying the edge of the lawn

ig. 2 Laying a lawn

So after the lawn area had been measured and calculated and the turfs ordered, no further measurement or calculation was done. Lee followed a set of procedures for laying lawns, adapting them to fit the shape and size of the particular lawn.

Orientating fabric to a chair

When I visited Sean in his professional workshop he was putting the top fabric onto the last of a set of six dining chairs. He explained that the most visible part of a dining chair is the back, so the fabric was tacked to the back first, then stretched towards the front. The fabric was striped, and it was important to finish with the stripe straight across the chair. He showed me how the fabric had to be stretched evenly by tacking it and retacking it several times, stretching it each time. He was both constrained and helped by the stripe in the fabric. He used the stripe to orientate the fabric straight on the chair at the back. At the front, he had to keep stretching the fabric until the stripe was straight. He did not measure or calculate to get the fabric positioned correctly, although he may have done to cut out the fabric and ensure that the stripes ran straight across the piece of fabric.

Measuring a piece of fabric

Sean said the last thing he had to do to the chair was tack a piece of calico underneath the chair seat. I asked him to show me how he cut the piece of calico to size. He picked up a piece which was lying on the workbench and held the length against the side of the chair seat, and the width against the back of the chair. The calico was approximately square, and a few inches bigger each way than the seat of the chair: it was already a suitable size. Sean folded each side under and tacked it to the bottom of the seat.

He didn't need to use a standard measure: he could directly compare the size of the calico to the size of the chair. What he used was his knowledge of the spatial relationship between the size and shape of the calico and the seat of the chair: he knew he had to compare the sizes in two directions to ensure that he had a large enough piece of cloth.

Caning a chair seat

Alice had nearly completed the re-caning of an upright chair when I visited the upholstery class, but she explained to me how she had done it (Fig 3). She had wetted the cane to make it flexible. She had laid single canes from the front to the back of the chair, and pushed the ends through holes in the chair frame, using plastic pegs to anchor the cane (Fig 3.1). Then she had laid single canes parallel to the back of the chair (Fig 3.2). She had then woven in single canes from the front to the back of the chair, the ends being pushed through the same holes as the first canes (Fig 3.3). She had woven in single canes, parallel to the back of the chair.

She had then woven in single canes diagonally, passing over and under two strands each time. Then she had woven in single canes diagonally at right angles to the first diagonal, passing over and under three strands each time (Fig 3.4). As many as four canes ended up in each hole.

While I watched, Alice was placing a single cane round the frame of the chair on top of the holes, anchoring it by 'stitches' of cane, up and down through each hole (Fig 3.5). The ends of the other canes were being used, always worked through adjacent holes. When a new cane was used, first it was put in water for a few seconds, then both ends were pushed through the same hole on either side of the cane running round the frame.

The pattern Alice had made with the canes resulted in a series of octagonal holes between the canes in the seat of the chair (Fig. 3.6). The canes had to be parallel to, at right angles to, and at 45 degrees to the back of the chair (Fig 3). Alice did not have to check that the canes were parallel, this would be obvious by looking at the pattern they made. And she did not have to measure the 90 and 45 degree angles, or think about the angles as numbers: the structure of the materials, the way the holes in the chair frame are placed, and the procedure she followed, meant that the canes would be at the correct angle.

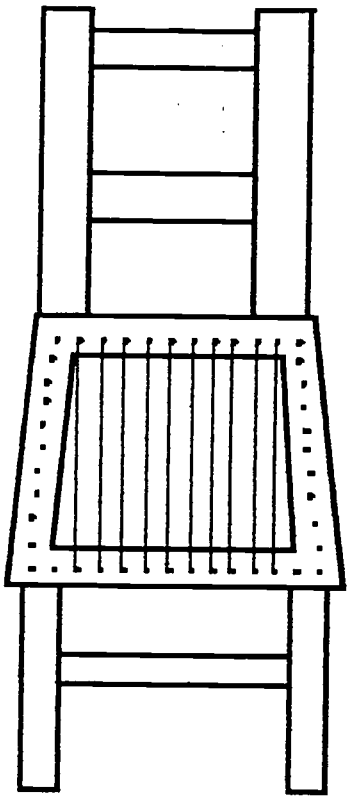

Fig. 3.1

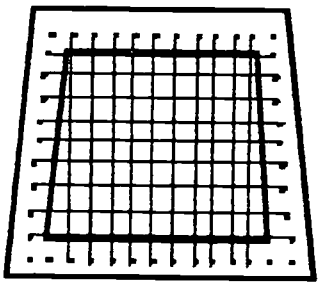

Fig. 3.2

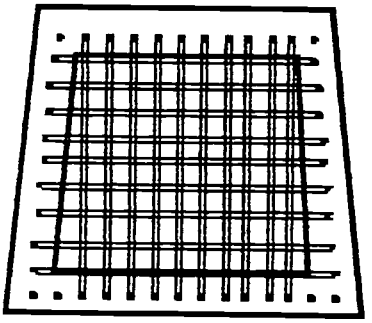

Fig. 3.3

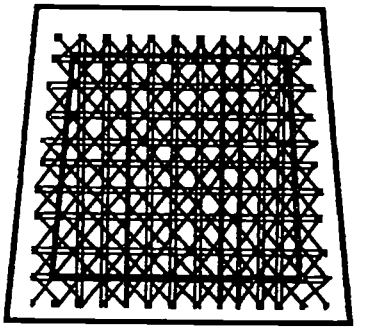

Fig. 3.4

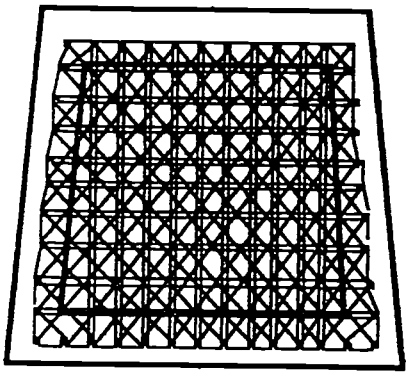

Fig. 3.5

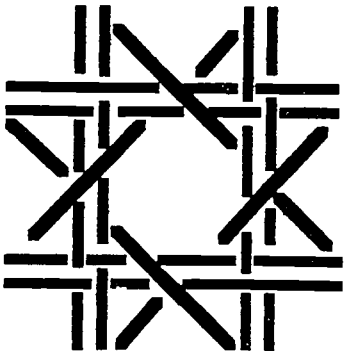

Fig. 3.6

Fig. 3 Caning the seat of a chair

Alice was not applying previously learnt mathematics to work out how to produce her caning pattern: what she explained to me was a set of procedures that she had followed. All spatial patterns depend on parallel lines, symmetry, and equal angles, but they can be produced without using these terms. I don't know whether Alice was aware of the maths involved, but she was using these underlying concepts, to check that the procedure she was following was producing the correct pattern. The spatial relationships in the caning pattern are not learnt separately from the physical materials: they are an intrinsic part of the caning process.

In these four examples, the workers started with something that needed working on, a chair frame or a piece of ground, which has spatial properties: size, shape, a configuration of holes. They used materials, canes, cloth, turf, with size and shape and other physical properties, like flexibility, strength, stretchability or compressibility. The workers followed sets of procedures which are customary in the crafts they are practising. These are flexible and are adapted to fit the particular garden or piece of furniture.

In the examples I have described, the workers estimated angles and sizes, by matching, measuring or cutting one material against another, without using standard measures or calculation. These processes enabled them to fit one shape or series of shapes onto or into another by cutting, stretching and compressing, taking into account the physical properties of the materials, so the chairs could be sat on without sagging or wrinkling and the turfs would grow into a smooth lawn. Underlying what they were doing is an understanding of the concepts of relative size and shape, not in the abstract but inherent in the gardening and upholstery materials and processes. In Lave and Wenger's terms, the maths is an inseparable part of the cognition in these communities of practice.

Passing on skills and knowledge

I was interested in how the skills and knowledge of the crafts of gardening and upholstery are passed on from experts to less experienced practitioners and how the processes compared with Lave's description of the apprenticeship of tailors in Liberia (1988). I describe the relationship between Joe and his workers; how Sean learnt his craft, how he is passing it on to his children, and how he teaches his students.

The gardeners

I did not hear Joe give any instructions to his workers. Ben and Gerry, the other two gardeners, and Lee seemed to know what they had to do. For example, when the turf was delivered, they all went out to unload the lorry, stack the turf, then wheelbarrow it through the house, without being asked. Joe worked alongside his men, but also spent time organising the materials. He conversed continually about all kinds of subjects, including what still had to be done in the garden, and the best way of doing it.

He discussed with Lee whether to round off the corners of the lawn and how to deal with the problem that two trees and a large lily were encroaching on the area for the lawn. This was more in the nature of Joe asking Lee how he was going to do it, raising the problem, than giving instructions. Lee said that he was going to leave the angles and cut a circle round the trees and the lily and this is what he did.

Joe's method of managing his workers, working alongside them and discussing the work with them without giving overt instructions, is very similar to Lave's description of the Liberian tailors' method of passing on skills and knowledge to their apprentices. The apprentices are not given overt instruction in the tailoring process, but learn by watching the master and doing the work.

The upholsterers

Sean told me that his father is a cabinet-maker in Dublin, who practises upholstery as part of his trade. His workshop is in the house where he lived with his five children. When they were young the children were told, 'Watch but don't touch.' As they got older, at about 8 years of age, they were allowed to have pieces of wood and use tools on them. By the time he was 14, Sean was making chairs, and he was expected to work during the school holidays. Out of five brothers and sisters, four now work in designing, making or upholstering furniture.

Sean has two daughters of about 8 and 10. They work on their own projects in his workshop. The younger one had upholstered a small flat piece of wood. The older one makes dolls' house chairs and likes designing furniture. If they say they want to make something he just gives them a couple of pieces of wood.

In the upholstery class, the students were all working on their own pieces of furniture, and Sean was walking round showing them techniques, helping them, and sometimes doing things for them. Sean does not believe in using worksheets or books with his students. He says learning only happens by doing. He tells the students to take note of how chairs are put together as they are stripping them down. He often takes slides of students' work in progress and shows them to the class at the end of term party. It enables the students to review what they have done and see the overall process. The students often ask him what they will be doing next, and he says, 'Wait and see.' He likened the process to doing a jigsaw puzzle: you see the picture after you have finished. He doesn't believe that they will understand what they have to do until they are doing it, or have done it.

Once a term he gets the students to organise a trip to a historic house, where they can see examples of antique upholstered furniture.

The students commented to me, without being asked, on Sean's method of organising and teaching the class, comparing it very favourably with other educational provision. All the students I asked said they were learning upholstery as a leisure activity and didn't intend to use it professionally. Although one of them said she had a chair she was working on at home, all the others said they would not be able to do upholstery outside the class: that every chair is different and they need Sean to help them.

They were learning the techniques by being shown them, trying them out, being corrected and trying again. They were also probably learning from seeing what all the other students were doing: they all had pieces of furniture at different stages of the upholstery process and there was a lot of interaction between students. Sometimes this was purely social, but sometimes students helped each other or watched each other. This is a good example of situated cognition: the students were learning how to upholster chairs by upholstering chairs. They were also learning the vocabulary of the tools, the furniture and the upholstery process and they were ending up with upholstered chairs. One of the students told me spontaneously that they were learning like apprentices.

But this is not quite the same as the apprenticeship method of the Liberian tailors described by Lave (1988). In the tailors' workshops the apprentices were not just learning the manual skills and language of tailoring, they were learning how to be a tailor, which includes organising the work and dealing with the customers. The masters were not giving any overt instruction, they were doing their own work. The apprentices learnt by watching the masters working and by helping with tasks, starting from the periphery and working towards the central tasks. During this process they would produce smaller and simpler garments, at first very imperfectly. But the work of the apprentices was not to produce finished products: it was to become tailors.

Sean was not doing his own work in the class: all his time was taken up helping and instructing the students. He had eight students in his class, more than the Liberian tailors had apprentices

The students were not intending to become upholsterers, only to do some upholstery. The result is that they remain as peripheral participators in the professional craft of upholstery. This is legitimate, because that is their intention. Within the workshop, they become central players.

On the other hand, the way Sean learnt his craft from his father, and the way he is encouraging his own children to learn, is very similar to the tailors' apprenticeship system: he learnt, and the children are learning, by watching a 'master' at work, and by trying out techniques, small parts of the overall upholstery process, without overt instruction. This is legitimate peripheral participation, but leading in Sean's case, and possibly his daughters', to mastery of the craft.

Joe's way of managing his workers and the way Sean learnt upholstery and his children are learning have many similarities with the tailors' apprenticeship system in Liberia. In the upholstery class the students are learning by doing the craft, but Sean uses more overt instruction than the master tailors.

Conclusions

My observations and conversations do confirm Lave and Wenger's theory of situated cognition: the gardeners and upholsterers had learnt or were learning their crafts by practising them. Most of the mathematics used was not the formal maths taught in schools, or even an application of it, but an inseparable part of the practice of the crafts. On the occasion where the customary practice had to be changed, the mathematical cognition was transferred from one set of procedures to another. As this happened within a community of practice, it does not contradict Lave and Wenger's theory.

Effectiveness of the research method

During my visits, sometimes there appeared to be no maths happening at all, for example when Joe was describing the herbal properties of plants. At other times the maths was obvious, like when Joe calculated the number of turfs needed for a lawn. Sometimes the maths only became apparent when I reflected afterwards on what I had seen. For example, when Alice was explaining to me how she had caned her chair, I heard a set of procedures. It was only when I was drawing the pattern that the canes made, that I started thinking in terms of angles. I was able to see this because the community of practice of my work is maths education.

I found I kept missing those activities in which I conjectured there would be mathematical activities. In upholstery, these might include: measuring the furniture, transposing the measurements of the three-dimensional object onto the two-dimensional plane of the fabric, then constructing the fabric into the three dimensional shape; calculating the number and strength of the springs required for the seat and back of a chair; arranging the springs in a regular symmetrical pattern. In gardening, it might include: measuring the sides of the garden for fencing, spaces for patios, and other things, cutting the materials to fit the spaces, calculating the cost of materials and labour. One possible way of getting this information is to interview some of the workers after I have seen them practising their crafts, about specific activities I have seen them doing or that have been done in my absence.

Sean, Joe and Lee were aware that I was investigating the maths they use, but I did not specifically discuss with them what was and was not mathematical about their work. This might be another useful direction in which to extend this research: their concepts of what maths they use.

The procedures people were using were probably learnt by doing the work, although I cannot be sure of this. All the participants in this study had had ten or more years of formal education, which would have included a substantial proportion of maths. How much of this school maths is used at work is a difficult question to answer: calculations are not always done overtly.

Interviewing the people I have been observing about how they learnt the skills and procedures they use, might reveal some information about this, but people may not be very aware of how they learnt what they do.

Observing people at work is extremely useful to gain an overview of the working situation and an insight into the activities people are involved in. It is probably useful to combine this with interviewing workers about their perceptions and to find out about activities which have not been available for observation, to obtain a more comprehensive picture.

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I would welcome any comments on this work or suggestions of ways of extending it.

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