The situatedness of adults' numerical understandings

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This presentation discusses the construction and implementation of a research project concerned with adult learners' formal and social ways of knowing and applying mathematics. It details findings from the literature as well as the researcher's own attempts to begin to investigate individuals' tendencies to disassociate formal and social mathematics.

Mathematical literacy

> To be numerate is to function effectively in one's daily life, at home and at work. And being numerate is one of the major intended outcomes of schooling in Australia, now as it has been in the past and will be for the foreseeable future
>
> (Willlis, 1990: vii).

Mathematics is a way of thinking that is highly prized in nearly all sectors of society, (if you can do mathematics well, you must be fairly clever.). Howsoever acquired or applied, mathematical knowing has been socially sanctioned, (entrance to many professions is reliant on better than average mathematics grades). Mathematics offers elegant ways of understanding, proficient ways of acting and pragmatic ways of making sense of life's experiences. It is a contemporary language that is integral to holistic literacy.

Mathematics can enhance our actions in both social and academic worlds. It confers an effective mode of reasoning that is suited to the resolution of a multitude of problems. The National Council of Teachers of Mathematics [1989] has claimed that mathematical literacy is a vital means of accessing our increasingly complex society. The newly proposed Queensland Curriculum Review (1994) maintains that students should study mathematics from years 1 through 12. Certainly, most educators would agree that mathematics is an increasingly important prerequisite to effective thinking and reasoned action, not only in society today, but for society tomorrow.

All of these claims have marked implications for the teaching and learning of mathematics; students should certainly have the opportunity to become *aufait* with mathematics. However, it should be noted that all of these assertions, taken from their original contexts, seem to imply that there is one and only one mathematics. In accordance with this implication, folk belief seems to hold that mathematics is an empirical body of esoteric knowledge. And that the people who *know it* are logical, able, and somehow especially gifted. For those people that don't know mathematics it can seem like

a mystical domain - a source of incontrovertible wisdom that is accessible only to a few geniuses - mathematics can be a battering ram that knocks them senseless
(Schoenfeld, 1991: 311).

Mathematics is not an abstract aggregation of facts and procedures that a few clever people have managed to access; mathematics is something that people do; mathematics is a verb (Schminke and Arnold, 1971). One need only look at a very small sample of our own culture to realise that mathematics appears in a number of guises. Infants have mathematical experiences, mathematics is learned and practiced in schools, applied to dilemmas in social worlds and put to use in workplaces. There are 'many mathematics'. Several examples come to mind...students, carpenters, engineers, nurses, vendors and consumers all practice forms of mathematics.

Everyday mathematics

Numerous studies have looked at how learners construct and apply mathematical ways of knowing in social and/or work contexts. For example, Walkerdine (1990) observed a child and her mother cooking to try to determine what informal mathematics is used in this social activity. She first observed their cooking behaviours and then interrupted to ask them what mathematics they thought they were using. At that point in time, the participants altered their behaviour to fully illustrate that mathematics *could* be used during cooking. Walkerdine has suggested that the mother and the child may not have thought that cooking was a mathematical activity. The participants may have simply altered their actions to accommodate a researcher's beliefs. This led Walkerdine to suggest that there may not have been any informal mathematics in the cooking activity at all (from the participants' perspectives). The mathematics may have been imposed on the activity by the researcher and her concerns. However, it may also have been that the participants simply did not recognise their own informal mathematical reasoning?

Carraher, Carraher and Schliemann (1985) conducted a study to observe and assess adolescent street vendors' informal and formal mathematics. A team of researchers and research assistants assumed the role of customers to investigate the vendors' informal mathematical abilities. They asked the young street sellers about the cost of a number of their wares. For instance, members of the research team bought a number of coconuts and asked the vendors how much they owed them. These sort of questions formed the informal part of the testing. "92% of the 63 problems presented in the informal test were correctly solved" (1985: 24). One week later the street vendors were retested. This time they were given a formal test and were instructed to use pen and paper to solve a number of mathematical problems. All of these problems were drawn from the previous social interactions and restructured to represent more formal tasks. In contrast to the vendors' successful, everyday mathematical problem solving, 63.2% of formal questions were answered incorrectly. It appeared that the majority of the street vendors were unable to transfer or restructure their social ways of knowing to solve the formal tasks. Perhaps they didn't know they should? It may even have been that the street vendors were not consciously aware that their daily modes of reasoning could assist them in the formal assessment.

In yet another investigation of informal mathematical action, Lave and Wenger (1991) concluded that people generate "reusable solutions to recurring math problems" and "determine ways to enact solutions as part of ongoing activity" (1991 : 313). Their conclusions were based on analysis of de la Rocha's (1986) investigation of people attending Weight Watchers. Initially, systematic dieters used mathematical ways to work out quantities of food. After they had worked out and prepared a required quantity of food or drink they began to generate less formal ways of measuring that same quantity. For example, Lave and Wenger (1991) report that, at first, a dieter would use the Weight Watcher's guide and measuring instruments to precisely work out how much milk he or she could have with a meal.

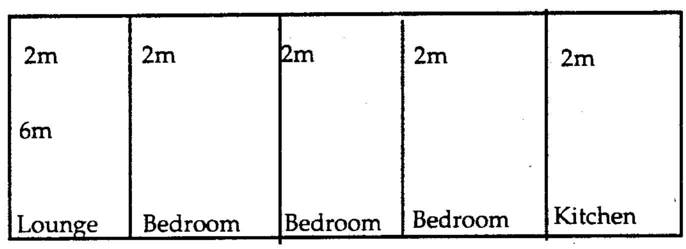
> This procedure was shortly transformed into get out glass and milk and pour milk into the glass up to just below the circle of blue flowers
>
> (Lave & Wenger, 1991: 317).

In an earlier investigation, Lave, Murtaugh and de la Rocha compared a sample's everyday mathematics to their formal mathematics. "The 'Adult Math Skills Project' was designed to investigate arithmetic decision-making processes during grocery shopping" (in Rogoff & Lave, 1984: 69). The twenty five participants in this study were predominantly female and older than 21. Researchers accompanied participants as they shopped for groceries. Each participant had a recording device attached to them. Participants were instructed to think out loud as they decided what products to purchase. This allowed the researchers to collect and analyse instances of social arithmetic. Lave, Murtaugh and de la Rocha (1984) decided to test the shoppers' formal mathematical abilities and compare those results with findings gathered during shopping expeditions. Participants were subjected to "an extensive paper and pencil arithmetic test, covering integer, decimal and fraction arithmetic, and using addition, subtraction, multiplications and division operations" (Lave et al. 1984: 82). The shoppers' arithmetic in the grocery store proved to be far superior to their arithmetic in the formal test. "Their scores averaged 59% on the arithmetic test, compared with a startling 98%-virtually error free- arithmetic in the supermarket" (Lave et al, 1984: 82).

Lave and contemporaries found a number of differences between their participants' informal and formal problem solving. For example, when acting in informal situations people can choose whether they want or need to complete mathematical calculations. For instance, one woman involved in the adult math skill project had a coupon to exchange for a specific bottle of sauce. The sauce could not be located in the store. However, there were a number of other sauces that the woman could purchase. She began to compare the prices of two sauces to see which was the better buy. This proved to be tedious; the woman decided to wait and get her sauce elsewhere.

In formal settings students are shown universal ways of solving problems. They are taught strategies to enable them to organise their thinking. In comparison, shoppers developed their own strategies to solve problems. For instance, one man buying cheese had to delve through a large container of cheeses to find the one he wanted. Once he had found it he looked to see how much it would cost him to buy it. The marked price seemed extraordinarily high. The man was puzzled. In order to solve this dilemma he began looking through the container to find another package of cheese of a similar weight. "His comparison to other packages established which was the errant package" (Lave et al, 1984:77).

Formal mathematics and everyday mathematics appear to be quite different modes of thinking. Although they may have features or ideas in common, both conceptual systems seem somehow context bound. Clarke and Helme (1993) asked a colleague to draw a floor plan of a flat. The man was given certain information about the flat. The flat's area was sixty square metres. It had to have five rooms. This is his completed work.



(Clarke, Helme, 1993: 5).

The researchers asked their colleague how he would get from room to room in the flat, where would he shower? He replied that he didn't know that they wanted a real floor plan

> I was just thinking of the maths involved. I guess that probably comes from the way you learn maths, just doing calculations and learning calculations. But if I was planning an extension for the house...I wouldn't think in that way
>
> (cited in Clarke & Helme, 1993: 5).

A problem

Many people tend to use their formal ways of knowing in educational institutions and their everyday ways of knowing in social circles. "The degree of discontinuity of performance in a subject which many regard as immutable and objective is interesting and still to a large extent unexplained" (Boaler, 1993: 341). It is also problematic. Formal mathematical knowing could assist problem solving in social worlds and conversely, social ways of knowing mathematics could provide foundations for and support in institutionalised learning. The separation of social and formal knowing must be regarded very seriously. Amongst other objectives, educational institutions profess to prepare students for effective social functioning. "One of the most important outcomes of mathematics education is the capacity to deal with commonly occurring (familiar) situations readily and almost automatically" (Willis, 1990: 9).

The study

This investigation is concerned with the disassociation between adult learners' informal and formal numerical ways of knowing and acting. In order to look at the extent that adult learners' disassociate formal and informal numeracy I have to access a number of contexts where they display and build up their sense of number. For instance, I'm going to be gathering data in the educational institution that they attend and in each individual's work place, social and home settings. To inform the concerns that I am investigating, I've chosen to adopt Carraher, Nunes and Schleimann's (1993) working definition that mathematics built up outside of educational institutions is informal or every day mathematics and mathematics used and learned in educational institutions is formal mathematics.

The participants in my investigation attend numeracy classes at a "Language and Literacy" annexe attached to a metropolitan TAFE Institution. The sample is comprised of three male and three female participants. Participants are aged between eighteen and sixty. Each of them has voluntarily returned to upgrade and/or relearn formal mathematics.

Why would this particular sample of adult TAFE students who have led relatively successful, useful lives return to an educational institution to learn formal mathematics? After all, when many adults return to formal education they undergo particular, often severe stresses due to time constraints, family responsibilities and anxieties about their abilities to make sense of a way of knowing that hadn't previously been able to construct (FitzSimons, 1993, 1992; Rogers, 1989). Why do adult students wish to acquire ways of knowing formal mathematics? What do they think formal mathematics can do for them? Why would they voluntarily position themselves in a context much like school where they had previously failed to learn or missed out on formal mathematics? The adult learners that I'm working with obviously want to learn formal ways of dealing mathematically. Are they devaluing their own informal mathematical knowing? Do they feel they need to construct something separate to their social numeracy? A series of semi structured individual interviews have begun to draw out the reasons why these adults believed they should return to TAFE to learn formal mathematics. One such interview proceeded as follows:

Interviewer	Why on earth did you decide to come here to do maths at TAFE?
Jeanette	Well, I'm thirty four years old. And I felt that coming from um, living in two cultures I feel that the change to education from one school to another, I went from one system to another system. It was a big change in my life. Like that happened to me when I was very young, so I jumped straight away to a school and I was supposed to perform like everyone else with maths. I'm talking about fifteen years ago or more, if you didn't understand then you missed out, where if you are still in the same level as everyone else you just missed out. and at my level I missed out. So I grew up with that and I accepted that but I wouldn't accept that I couldn't do it. You know I felt that there must be another way to go about it. I would say **[I got to]** Year Two level, right because I missed out on a few years of school because we travelled and things like that. So I missed out on third grade, fourth grade, fifth grade, so I got up to Year Two level and jumped into school here in sixth grade. For me it was two and two is four and he **[the teacher]** was talking about sixteen plus thirty five plus forty five.
Interviewer:	So you thought it would be useful to learn the mathematics that you missed out on here at TAFE?
Jeanette:	I went, um well because I went to university and they were dealing with statistics and analysis, statistics and that. I mean I'm not saying that other people with higher skills and education, people with higher levels...even they were confused but not the same as me. But in my case, it was more difficult than everyone else because I didn't have the basics. It was then that I thought no, this can't go on any more. I just want it to stop here.

As the interview progressed Jeanette offered a number of other reasons for attending mathematics classes at TAFE. The following responses have been extracted from the original transcript:

- Because I have children, they would come to me with problems and I would have to say I don't know. Multiply one number by four numbers and I would say don't know. If the system fails them and I fail them, they will be like me again.
- The other reason is that I got fed up. I felt completely illiterate with maths, felt like I was disabled. I just got sick and tired of finding my own skills, finding my own way around, finding different ways to survive.
- To survive, you know so you don't get ripped off.....well yeah, in quick decision processes. I was caught in a quick decision and I would think, I would quickly try to work it out in my head, and I just couldn't. They were too big. The numbers were too big. I would give her **[the shop keeper]** fifty dollars and should have got thirty dollars back and I would have to go away somewhere and work it out. I would have to get pen and paper.

In addition to conducting interviews, I have decided to collect participants' written accounts of their social and formal mathematical experiences. Journals have been distributed to each participant. In these journals participants will be given the opportunity to note down their weekly mathematical experiences. Questions have been constructed to guide the sample's responses. However, participants will be advised of their right to disregard any given questions and to pursue their own recollections. It is expected that journal entries will generate information about the kinds of settings where these adults build up and apply mathematics. Entries may also indicate the mathematical reasoning and action that people require to effectuate activities in specific settings.

I also intend to find out what drives these adult learners to value the formal mathematical procedures they do not have over the informal practices they are able to use. Students will be observed working with particular formal ideas and those ideas will be accessed, restructured and represented to students to reflect informal, social experiences. If the student's ensuing engagement with the social tasks prove to be different to in-class methods, he or she will be asked "why do you need to know this other way of doing things (referring to formal methods)? Don't you think your own way of adding is just as good? Do you think this formal way is necessary? Why? Where will you ever use it?" All of these interactions will be audio taped. Each student will then be interviewed. Interview questions will include questions like the following:

- You can budget your money well (all of the students have told me that they can). You can read timetables (I have observed that they can), buy things at the shop and know how much change you should get, why do you value formal mathematics?
- Why is it so important for you to learn formal mathematics? When will you ever use it? These sort of questions taken together with observations, discussions from the first interviews and the participants' journal responses may help to reveal why this sample of adult learners value formal mathematics over the informal practices they have already come to know.

The next phase of the investigation will involve accessing those contexts where participants' apply forms of mathematical knowing. The sample's informal mathematical actions will be audio taped to produce records of their social and work place mathematics for analysis. A third round of interviews will be scheduled to promote discussion about observed social ways of knowing and applying mathematics. Each participant will be asked to explain their social tasks, why the tasks arose and methods of dealing with them. In order to promote further discussions, each participant will be invited to listen to the audio record of his or her experiences. Participants will then be guided to compare their social experiences to their formal activities. All responses and discussion will be video taped.

These are but few of various means that I have constructed to address the disassociation between individuals' formal and everyday mathematics. This investigation into different ways of knowing and applying mathematics should reveal some of the 'many mathematics' and perhaps more importantly, move to generate means to interweave learners' social and formal ways of knowing, acting and learning. This is essential; coming to know, knowing, and applying knowing are "not like [adding] brick[s] to a building - where [each] brick remains as distinct and self contained as it was in the builder's hand" (Seely Brown, Duguid 1993:10).

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