Numeracy Practices in Contemporary Work: Changing Approaches

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Many older people bemoan the numeracy skills of a nation's youth and cast youth in deficit models. This public display has created new forms of training and policy that seek to redress perceived innumeracy. This paper reports on a small component of a larger project investigating the numeracy practices of contemporary work. Using a case study approach with a tool known as stimulated recall, young people across 19 sites were each workshadowed over a period of at least 3 days. The outcomes of these cases show that young people approach tasks very differently from older people and that technology has shifted the emphasis on what and how numeracy activities are undertaken.

Intergenerational differences have been noted by many social researchers. For example, Mackay (1997) compares baby boomers, their parents and their children, noting the differences in attitudes, consumption patterns, work ethic, and so on. In part, Mackay argues that the intergenerational changes are offsprings' reactions to their parents' values but also the changing social conditions. In other literatures, it has been similarly noted that the changes within the wider society and work brought about largely by the emergence of technology, have created changed work patterns and opportunities (Rinehart, 2001; Rothman, 1998). There has been significant research and theorising about the changing face of literacy in New Times and the impact this has on reading and readers both in and out of school (Hagood, 2000; Luke, 2000; Unsworth, 2002). These authors have recognised that new literacies place new demands on workers and workplaces. They have shown that the literacy demands in New Times are substantially different from Industrial Times.

Similarly, in the area of numeracy, it has been shown that there are different demands of workers and workplaces in New Times (Zevenbergen, in press). Lowrie (2003) has shown the impact of technology on how young students read and interpret multiple layers and unseen maps through digital games. However, little is known about the numeracy demands of contemporary workplaces and the ways in which young people are working in these environments. If, as Mackay (1997) suggests, there are intergenerational differences in attitudes to working, and that the literacy demands are very different from Industrial Times, it may be that the numeracy demands and/or the dispositions of young people to working mathematically may be different from their predecessors. In this paper, we draw on case studies from a number of workplaces in order to answer a key question underpinning our research: What numeracies are needed for working in contemporary times? Are these different or similar to the knowledges and skills developed through schooling? By answering these questions, a better understanding of how young people are best prepared for lives beyond schools can be developed.

Numeracy, Work and New Times

Two opposing discourses permeate theorising and researching numeracy practices. On one hand, common sense understandings and conservative politics suggest that young people are deficient in their numeracy skills and that schools need to support numeracy learning. In many cases, numeracy within this discourse is imbued with basics skills and knowledge, most predominantly that of arithmetic and mental calculations. The implementation of the National Numeracy Strategy (Department of Education Training and Youth Affairs, 2000) has seen schools adopt programs geared for the upskilling of basic skills. In contrast, the Australian Association of Mathematics Teachers (Australian Association of Mathematics Teachers, 1997) proposed a much broader definition of numeracy to encompass the application of mathematics to realistic situations in and beyond schools and a disposition towards using mathematics. In contrast to numeracy education, literacy educators have been proactive in advocating changing times brought about by the digital revolution has resulted in very different literacy demands. Arguing that there are multiple literacies for New Times created through the use of multimedia, literacy eductors have challenged many of the old orthodoxies of literacy, instead advocating a repositioning of literacy for and in New Times. This debate has not been as actively engaged by numeracy educators and hence, questions need to be asked about the impact of technology and New Times on numeracy and numeracy education.

Many of the studies conducted in workplaces have sought to identify or unmask the numeracy practices of workplaces (Kanes, 1996; Millroy, 1992; Zevenbergen, 1995). In veins similar to those of Gerdes (1988) seminal work in unfreezing the mathematics in indigenous activities, ethnographic and anthropological studies of workplaces have sought to identify numeracy practices that align with the dominant traditions of mathematics. These situated studies have sought to identify the mathematics embedded within particular practices but have not called into question the existing orthodoxies. The view that all cultures undertake mathematics (e.g., Bishop, 1988) remained unchallenged and the hegemony of western mathematics remained preserved. In more teacher-directed approaches, teachers have shadowed workers in order to identify numeracy practices within the workplace so that links between what is taught in school and the practices of the workplaces can be made (Hogan & Morony, 2000). In so doing, these approaches legitimate particular epistemologies. Much like the ethnographic traditions, the seeking of embedded school mathematics in workplace practices, legitimated the existing knowledge structures of school curriculum. These epistemologies reinforce the existing status quo by identifying particular ways of seeing practice. Skovsmose (1994) has theorised this way of interpreting the world as being a formatting power. From his perspective, mathematics provides a lens for seeing and interpreting particular activities so that, in these cases, the observer interprets activity through a mathematical lens. Such approaches fail to recognise that numeracy practices as undertaken by the participants have been interpreted by the observers within a particular format – that is, mathematical. Dowling (1998) has argued that such interpretation subjugate the activity in favour of a particular view while denying the activity as undertaken by the participant.

The limitations of this approach have been acknowledged as privileging a particular interpretation over others. When studying contemporary numeracy practices in workplace settings, the view of the participants needs to gain a stronger voice in research. To this end, stimulated recall was used to identify the numeracy practices as undertaken by young employees.

Stimulated Recall

Stimulated recall is a tool for collecting data. It is often used with video data, but in this study we used still photographs with the intention that the photographs provided a stimulus for the participants to talk about their ways of working and thinking as they undertook chores. The method involves taking photographs or video of people as they go about their tasks (Lyle, 2003). Often this can be teachers or preservice teachers where they are asked to talk about their thoughts at particular moments in the teaching process (McBride & Bonnettee, 1995; Prawat & Anderson, 1994). The images serve as a catalyst for discussion and reflection on action. Similarly, stimulated recall has been used with students to talk about their thinking as they were working on mathematical tasks (Artzt & Armour-Thomas, 1997; Prawat & Anderson, 1994). Depending on the method used by the researchers, the tool can be used for discussion particular episodes selected by the researcher or for free conversation as the video or photographs are shown. In this study, we opted to use the second method as we did not want to pre-empt any practice or event. We were particularly cognisant that we did not want to 'format' any event with a mathematical lens. We saw it as essential that participants were able to talk about the events within their own frames of reference, recognising that there were aware of the focus of the study. As we will demonstrate in subsequent sections of the paper, this proved to be a useful strategy since there were photographs where it was thought that they were undertaking mathematical thinking but did not and the converse also being true. Suspending our judgement on their actions and thinking proved to be challenging since the formatting power of mathematics is very strong (Skovsmose, 1994).

Method

This study is the second phase of a larger study1. In the first phase a survey was implemented (n = 1000 approx) and results showed significant differences between senior and younger participants in the study (Author, 2004 in press). The second phase involves workshadowing 19 young people in their work. These have included a bricklayer, boat builders, hairdresser, motor mechanic, retial assistant, baker, builder, signwriter, painter, printer, room service, laundry attendant, laboratory technician (concrete testing), receptionist, short order cook, and a chef. In each case, the young person was shadowed for a minimum of three days. Depending on the work, this may have been consecutive days or spread out over a period of time. This was to ensure that a variety of work was included in the study. For example, in bricklaying the employee would work on a particular site for a few weeks doing the same type of work so it was seen as important to capture as much variety in their work. In this case, the observer went to different sites to observe different types of bricklaying. In all cases, the young employee was interviewed prior to shadowing to gain a sense of their schooling, the work they undertake and their confidence in their work. The shadowing was undertaken in a non-intrusive manner so that the employee could undertake their usual work. In some sites, the observations were undertaken in a very naturalistic manner. In the case of builders, they insisted that the researcher climb scaffolding and house frames to ensure that she gained an accurate sense of the work. In other cases, the researcher had to remain in a safe position external to the work due to workplace health and safety regulations. In all cases, accurate representations of the variety

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of tasks undertaken were paramount. Photographs were taken of the employees working across the different tasks. Following the shadowing, a longer interview was undertaken where the participants looked at all the photographs and asked to talk about what they were doing and/or thinking in the particular representations. To further the articulation of their work, employees were also asked about the preparation of school for their work, the support they had in the workplace for learning, advice they would have for mathematics teachers in particular and schools in general; and concluded with asking if there were any aspects of their work that had not been captured in the photographs. The interviews were audio taped and transcribed.

Findings

In the confined spaces of a conference paper it is not possible to provide the richness of 19 case studies so we have elected to present the outcomes of the key numeracy practices observed. From the series of case studies, repeated themes emerged across a range of occupations. These themes included estimation, problem solving, technology, intuition, situated methods, holistic thinking, and measurement (length). Presenting them as a list denies the integration of the themes so we would alert readers that the list is not comprised of discrete entities but often linked with other categories. In each case, we provide an example of the observations. In all sites estimation and problem solving were an integral part of the activities of the young employees. Technology in various forms featured in most sites. Such technology included the modern cash register where items are entered (e.g., bread types) and a space for the number of items; computers with specialised programs (e.g., for laboratory technician) through to more generic programs such as spreadsheets (e.g., for receptionist); and calculators were used in most sites. Within the building industries (marine and housing), measurement of length featured strongly although the methods included both formal and informal. In many sites ranging from those of chefs through to boat builders, informal methods were used and aesthetics featured as a measure of quality control - the food is tasted to check that the ingredients are OK or a horn or door is positioned so that it looks good.

Estimation and Problem Solving

In the marine industry the employees had to mix a two-part bog where one additive was a hardener (much like the commercial produce ‘Araldite’). In theory the quantities are supposed to be mixed in nominated proportions so that the chemicals can react appropriately. The boat builders had to estimate the original quantity to be made and then estimate the amount of hardener to be added. Unlike the accurate calculation to be undertaken, the apprentices used estimation for the quantity to be added but also considered other variables – how big the mixture was so that it would not go off before the complete task had been completed or the temperature of the day as hot days would make the bog set quicker than on cold days. In using the stimulated recall method, the following interview data was collected in relation to Figure 1.

Figure 1. Boat builder estimating

Boatbuilder: That was bog for the dash.
Researcher: How do you determine what the mixture is, how much you would put in?
Boatbuilder: Depends on the time really, like if you want a hot brew, the darker the better. But if you got to work with it, if you need time , you just put a little bit in. You're supposed to measure up with scales and all that, but we don't have any scales.
Researcher: So you just guess?
Boatbuilder: Well, yeah, say we've got a pile like that [gestures large pile], put a little line about that much [gestures a small line] hardener in it.

As such, the view of the mixture was a holistic task as opposed to a quantification task. Similarly, elements of problem solving where various elements or variables impact on decision making are used in making the mixtures.

Technology

In many of the worksites, technology was used to undertake calculations. In the case of the shop assistant, the cash registers are programmed so that the assistant enters the quantity of the product sold, the type of product where all products are listed on the register, and the amount of money tendered. These registers reduce the demands on young employees since all calculations are removed from the task but provide the manager with an accurate count of products sold over a day and the amount of money taken. These are accurate figures for planning for the stocking of the shop as well as for financial management of the business. This is not to say that the employee does not undertake any calculations. For example, in this study, the retail assistant explained her thinking as:

Retail Assistant:

> [In this job it is] just adding, just totalling up things, when they've got vouchers, we have to take off the $2.60, and what you're left with, and stuff like that, probably adding and subtracting. Everything's done through that register, but if you know someone's going to muck around, and you already know how much something's going to be, then you tell them without putting it in. That way before I even put it in the register, I can take their money, and go thanks very much, and when they walk away, that's when I'll put it in.

Within this comment the assistant notes that 'everything is done through the till" but when it is peak time, she would do the task mentally to expedite the process and then enter the amounts later. In this sense, she saw the task as customer service and was able to work flexibly within the constraints imposed. There is also evidence of problem solving and seeing the task of sales as a holistic enterprise. However, in other instances, there was a much stronger deferral to technology. Sales assistants (drawn from Phase One where more sales assistants were included in the survey) offered different accounts of their work practices. In this instance, the shop assistant worked in a large retail store where she would scan numerous items:

Shop Assistant:

> When it is peak time, you get people through all the time and some of them are really nasty. You have to be nice to everyone. One day I had this grumpy old man come through and I rang up his stuff wrong. Well he ripped right into me. Told me I was dumb and I needed to go back to school and that the company should give my job to an intelligent person. I got upset, but when I looked at his docket, I could see that I rang up one item twice and that's where the mistake was. I called my supervisor over to alter the till and he was going mad. I started to cry and my supervisor asked him to come over to the inquiry desk to fix it up. It is so hard when it is busy and it is easy to make a mistake but I could see what I did wrong, he just wouldn't listen.

In this case, the assistant described her task holistically - she did not do the calculation of the account but was able to recognise an error (entered an article twice). In this case, the young person's orientation to the task was to problem solve rather than calculate. The deferral of the calculations to the register is evident.

In the cases of the receptionist and the laboratory technician specialised computer programs had been set up for them so that they could simply enter the data and results were produced. In the case of the receptionist, this was a simple spreadsheet which allowed her to enter the amounts of petty cash spent to create a balance sheet. In the case of the laboratory technician, the programs were more complex and orientated towards different aspects of the quality control process. In the following extract, the impact of technology on the ways of working and thinking become part of how the young person undertakes his work. In this case, the young man had been working out a particular aspect of the quality control process (Figure 2).

Figure 2. Laboratory technician entering data.

Lab Tech: That looks like doing the moisture, working out the moisture. What is it, minus the wet weight by the dry weight to get the moisture content, then divide that by moisture weight to get the percentage.

Researcher: All these formulas are written on the report?

Lab Tech: Yeah, yeah they are, wow. I didn't know that!

As the last comment suggests, the technician knew the process to be undertaken but this was done by technology rather than himself. In this case, the process of technologising the calculation had been internalised to the point where he had no longer recognised the impact of the technology on his work.

Intuition

Across all sites to a greater or lesser degree depending on the workplace, employees would comment that they had a sense of something "being right" or not, or the need for something to "look right". Arguably good estimation skills - whether overtly or covertly operationalised - may help in young employees intuiting situations. Being able to see the placement of a horn on a boat as being midway and hence 'looking right" required the employee to be able to estimate the midpoint.

Situated Methods

The methods for calculating in various fields was often different from that of school methods. For example, in the case of the baker, the day's list of goods to be baked are left for the team to commence in the early hours of the morning. In order to bake the nominated quantity of a particular bread type, the baker basis the mixture on the amount of flour to be used. This will vary from day-to-day depending on the quantity required. To work out how much flour is needed, the baker uses a "yield factor" from a chart that indicates a factor by which the flour is multiplied in order to establish a particular quantity of a given bread type. For example, the yield factor for white bread in comparison to a fruit loaf would

Fruit Loaf

– 100% flour
– 2% salt
– 10% gluten
– 5% yeast
78% water
– 50% apricots
– 40% sultanas
– 30% currants

Figure 3. Bread Recipe.

be different so that if x number of loaves of white bread were needed, the baker could multiply the quantity by the yield factor to find out how much flour is needed for that bake. The recipe for that bread is then stated in percentages so that the recipe is very flexible in order to cater for the different quantities of flour on any given day (see Figure 3). This recipe is very different in form from that of schools where percentages are usually expressed at parts of one hundred so that the total amount would add up to 100%. In this case, the recipe is expressed as a relationship with the original starting quantity of flour. In order to work through this method, the young baker used a calculator to work out the quantities needed for a day's bake. The observations, interviews and photographs showed the baker undertaking the calculations of quantities with a calculator. In the case of the more readily recognise percentages, such as 10% and 50%, he did this without the use of the calculator, but other percentages were undertaken with the calculator.

Conclusion

The results of this study suggest that younger people often approach their work in unique ways that are often different from those taught and learned in school mathematics. They are more likely to approach tasks holistically, to use estimation, to problem solve, to use technological tools to support their work and thinking, to use intuitive methods, and to see tasks aesthetically. The field work raises issues about the dispositions that young employees have towards their work and how they undertake tasks in the field.

For many educators and employers, these dispositions to workplace numeracy may be seen as the antithesis of "good mathematics" since many of the values that are foundational to perceiving and structuring mathematics are challenged. In order to make sense of these findings, we would propose a metaphor which has helped out thinking. Consider the process of building a fence. For parents of the baby boomers, this task was undertaken through manual labour – spaces for post holes were carefully measured and positioned, holes were dug with spades, spacers for railings were hewn with chisels, railings were fixed with nails and hammers, and palings were similarly affixed with manual processes. The baby boomers were born into a time when machines took over a considerable amount of the manual labour – post hole diggers dug holes so the need for accuracy was not so critical since if a hole were incorrectly placed it was easy enough to dig another one; posts were placed with a crude mix of cement and water, railings and palings were fixed with nailing guns. The process represented a significant shift in manual labour. Parents of baby boomers saw their offspring as lazy since they would hire equipment to do their manual tasks. A question now needs to be posed as to how young people today see their work. We would contend that the same shift in manual labour to machines may be the equivalent shift seen in this project. Children of the baby boomers (and younger) defer the cognitive labour of calculations and other mathematical thinking to technology. The need to accurately calculate seems to be deferred to technological tools – computers, calculators, and other industry specific equipment. The skills of estimation are central to their work as is having an intuitive feel for a situation. Old skills of accuracy, meticulous mental calculations and measurement have been displaced by skills of estimation, problem solving, and use of technology.

These results have implications for how young people are prepared for workplaces in New Times. The practices of school mathematics may need to shift to new numeracies – where holistic thinking, problem solving, estimation, technology, and intuitive thinking need to take a higher profile in curriculum. The outcomes of this study suggest that technology has impacted on how young people undertake their work. This is not to say that basic number sense is no longer required since the data suggest that number sense is central to good decision making. Thus, students need to have a greater awareness of how numbers work in the world of work in order to be successful participants in the workplace but whereas past practices valued mental calculation, the practices observed in this study suggest that estimation and number sense help inform participants of a reasonableness of answer but that other tools were able to undertake the mental labour associated with tedious calculations (such as those in supermarkets) where many items are added.

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