A methodology for using classroom teachers to gather information about using mathematics from the work place.

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This paper describes an AAMT project which is endeavouring to develop better understandings of what it means for a person to use mathematical ideas and techniques when completing practical tasks. To help us we have collected some snapshots of young people at work. This was done by using teachers, from around Australia, to go into the work place, shadow a worker for up to a day, followed by an interview and then to write up their findings. This paper looks at the processes used, the issues that have arisen as a consequence of doing it, and at the usefulness of the experience.

Overview of the project

The Commonwealth Department of Employment, Education and Training (DEET) have provided a grant, to the Australian Association of Mathematics Teachers (AAMT), to support a project which aims to promote an informed view of the competency *Using Mathematical Ideas and Techniques* (UMIT) to educators in all relevant areas and provide strategies for the effective development of this competency in young people.

UMIT is one of a set of Key Competencies (KCs) developed by a national committee, chaired by Eric Mayer, in 1992 *(Mayer, 1992, p,5)*. The key competencies were seen as "essential for effective participation in the emerging patterns of work and work organisation...also...for effective participation in further education and in adult life more generally"*(Ibid, p, ix)*. A detailed description of the UMIT competency can be found on pages 33-35 of that report.

The AAMT project entitled Rich Interpretation of Using Mathematical Ideas and Techniques (RIUMIT), commenced in October, 1995 and is due to finish at the end of October, 1996. It is one of a number of projects, funded by DEET, with the purpose of exploring the Key Competencies.

RIUMIT has a wide range of broad outcomes which include -

- a description of the competency which is clear and defensible and where its links to other key competencies, school and training mathematics, and numeracy have been made;
- a clear understanding of the relevance of the competency in educational, training and vocational settings and the applicability of the competency to work and life generally;
- documentation of exciting and innovative examples of how the competency is (and could be) articulated in school, TAFE and training curriculums, and of how, in these same settings, the competency is (and could be) learned, assessed and reported;
- a good understanding of the issues surrounding the learning (and teaching), assessing and reporting of this competency making particular reference to the implications for social justice;
- guidelines for the future development of curriculum support materials, school and Vocational Education and Training (VET) learning environments, and for professional development programs;
- shared understandings and a supportive environment for further development work in this area, and a wider group of interested and involved people around Australia.

As an AAMT project the intention is that, wherever possible, the state and territory affiliated mathematics teachers associations will get involved in the project. Hence each affiliated association has a contact person to assist in keeping the local association membership informed and to help with getting the work done in that location.

RIUMIT is endeavouring to ensure that its research is well grounded in the action of the work place and of education and training situations. This paper focuses on the methodology of the work place research, the initial findings from the trial and outlines some of the possibilities that could be achieved from the research data.

The work place research

The main purposes for the work place research are -

- to develop a set of rich descriptions of a range of people operating in the work place in order to increase our understanding of how mathematical ideas and techniques are used in practical situations and support our pursuit of the project outcomes.
- to develop a methodology that would involve as many people from affiliated associations as possible. It was hoped that the methodology itself could be used by other associations when faced with doing research.

The intention was to -

- develop a description of what was happening in work places without imposing a preset view of what mathematics is and hence corrupting the analysis of what mathematics was being used and how it was being used;
- minimise peoples 'fears' of mathematics to reduce the interference with the process;
- be open to new ideas and themes which may arise when viewing the data; and
- establish a research process which could be a learning experience for all involved.

The scope of the work and size of the sample needed to take account of the cost, and broad geographic coverage required. It was recognised that this would also impact on the training of the researchers and, hence, the quality of the descriptions.

The UMIT competency attempts to describe what a person does when using mathematics to assist in doing a practical task. A premise of the RIUMIT project is that if descriptions of the UMIT competency could be developed which exemplify how it manifests itself in practice, then educators, employers and workers will be better able to identify and develop it. Thus one focus of the research needed to be the work place, where the intent is to describe the actual work as it is being undertaken, and then conduct an analysis from the perspective of how mathematics is used. A similar methodology was used by Baturo et al (1990) who investigated the mathematical demands of a number of unskilled occupations undertaken by people with intellectual disabilities. The research team developed rich descriptions of each worker's job by interview and observation within the work place. These descriptions were then analysed for evidence of the mathematics associated with the work place, the informal and formal mathematics identified in the work place and the metacognition associated with the mathematics. Their descriptions and ensuing analysis supported the power of such a methodology.

In our research workers, from a sample of work places around the country, are being shadowed for a half day by a researcher who is looking to describe the work situation. This information will be analysed by a range of people - the worker, the researcher and others associated with the project. The worker will be interviewed to explore issues that had arisen during the observation and to get a more detailed description of the work. The aim of the interview is to clarify what were routine problems, where new and unfamiliar situations had occurred. Where necessary the worker will talk through the processes they use to make decisions about what to do in the routine and non-routine situations identified. The researcher can negotiate with the worker and employer to return for clarification purposes.

Following the visit the researcher will prepare a descriptive story with vignettes of how the worker dealt with one or two 'interesting' situations. The description and vignettes will be accompanied by an initial analysis by the researcher and, where possible, the worker. The meaning of a set of events are subject to interpretation in a variety of ways so multiple perspective's will be portrayed. The worker will be able to read and comment on what was written by the researcher. They will be encouraged to write an analysis themselves. This will be used to develop a deeper understanding of the work. Other people involved in the analysis will be asked to write their perspective of each story.

The information gathered in each case will be analysed to identify the mathematical ideas and techniques that people used, what is involved in using these mathematical ideas and techniques, what meta-cognitive aspects are evident and what attitudinal aspects were important to the story.

The next phase will involve applying the following questions to all of the descriptions. What generalisations can be made about these stories? What are the commonalities? The differences? How are the mathematical ideas and techniques, using them and the other meta skills related? Can they be separated? What education and training will foster this capacity? In what ways might these stories be used for professional development activities? How might these stories impact on our thinking about curriculum, teaching and learning, assessing and reporting?

The researcher is also being asked to reflect and write on the experience of doing the research. This should provide some insights into the extent to which the methodology provided opportunities for learning for the researcher.

At the time of writing it is imagined that there could be four types of product- the stories themselves, a description of how the UMIT competency seems to manifest itself in the contexts described, a report which addresses the key questions described above and the final project report which will bring together this part of the research with data collected from other sources.

A research methodology was trialed and refined in WA in December of 1995 and January, 1996. Affiliated association contact officers were then invited to find five members who were willing to participate as work place researchers. The aim was to generate about 40 stories covering examples from small business, large business, industry, home, community, self employed, volunteers and the like and including types of work such as hospitality, engineering, retail, agriculture, office and clerical, tourism, building and construction and so on. Workers should come from a range of backgrounds. The term 'work' is being used in its broadest sense. It includes both paid and unpaid work in, amongst other contexts, both domestic and community settings. Researcher received a detailed information package detailing the procedures and examples of stories written in the trial.

The process, permission for the public use of the example in project writings and work shops, and for the description to be used in future publications are all negotiated with the workers and employers prior to their agreement to participate. The workers have the opportunity to critique the descriptions produced and their responses will be noted and described. It is anticipated that any differing interpretations by the workers and researchers will be an important additional information for the analysis. In some settings access to what people are doing will limited by safety constraints. This raises the issue of insurance for the researcher while in the workplace. Teaching staff will be covered by insurance provided the work is seen to be part of discharging their duties on behalf of the school. Each of the contracts, if being completed by a teacher, then need to be endorsed by the School Principal.

Issues from the trial

Four secondary mathematics teachers, from an outer metropolitan senior high school in Western Australia, were involved in a trial of the process late last year. After a short briefing they each spent a day in the work place, wrote up their findings and then spent a half day debriefing the experience. Two of these teachers, along with two new to the experience, trialed the process again in February of this year. As well as helping to refine and improve the research methodology the trial also ensured that we take seriously the following interrelated issues.

1. The placement of researchers : In the first stage of the trial it became apparent that locating the researchers and workers needed to be handled carefully. In this stage there were no restrictions as to where the researchers were situated and it was decided that the easiest way to set the exercise up would be for the school industry link teacher to find each of them placements in local industry. Despite the fact that it had been stated that the workers could be doing any sort of work this exercise reinforced how much people's understanding and feelings regarding mathematics intruded on the type of job to be shadowed. All placements were in large industries and all the jobs were middle management professional positions. One personnel officer, from a large mining and processing company, commented that she had looked all over the site and found that the

accountant was the only person, who she could think of, who did mathematics in his job. In the second stage of the trial the researchers were asked to locate their own worker to shadow using their own network of relationships. This enabled a much easier entree into the work place. It removed the need for 'middle persons', such as school industry link teachers and personnel officers to be involved in negotiating the placement. It also assisted with the relationship between the worker and the researcher (see below). It was decided to use this method for the work across the country. The researchers found their own placements which were checked, in consultation with the project director, to ensure that a range of types of work and areas of work were achieved.

2. The relationship between the researcher and the worker : Not surprisingly some workers were nervous about being watched and often devalued their own work. One worker said "I'll just be doing the same thing over and over so you might as well go home now". Some seemed to be somewhat intimidated by the presence of a mathematics teacher. One researcher, in the first stage of the trial, said "People seemed frightened of having someone look over the shoulder. They seemed intimidated". Clearly the process needed to ensure that the researchers take the time to build the relationship and that they needed to value the work being done by the worker.

Having the researcher find their own work site, through someone they knew (see above), was the first step in helping the relationship become 'easier'. In order to get some balance in the relationships the researchers were asked to be up front and say that they (the researcher) were there to learn from them (the worker). Both of these aspects were included and emphasised in the second stage of the trial with, it seemed, good effect. One of the researchers involved in both trials wrote "This time around was more relaxed, and more enjoyable".

It was also felt that there may be opportunities for the researcher to help with some of the work and get the worker to teach them about what they do and that this reversal of roles would assist develop equality in the relationships, as well as improve the quality of the description of the work (see below). To this point opportunities for this have not occurred.

The information package given to all the researchers included detailed notes on these issues.

3. Selecting the researchers : It was important to get a range of teachers from different contexts involved. It seemed quite easy to get teachers to volunteer for the trial. There was a danger that they could all end up as male secondary mathematics teachers. Contact officers, of the affiliated associations, were instructed to ensure that - there was a balance between male and female researchers, the researchers came from a range of locations and to get some who were not secondary mathematics teachers. In fact the recruitment of volunteers took somewhat longer than anticipated due mainly to the considerable industrial turmoil in many states and territories.

4. The focus of the shadowing : In the trial one work place set up a 'visit' and invited the researcher to talk to a variety of people throughout the day. Given the project's focus on detailed descriptions of people's work it was decided that the researchers needed to stay focussed on the one person.

5. Collecting the data : It was hard for the researcher to "get inside people's heads". One suggestion was to, if possible, become a participant observer. That is, to assist the worker do the work and to ask them to explain to the researcher how they do particular tasks. This had also been identified as a good idea in helping with the relationship between the researcher and worker. It was reaffirmed that it was more important to document some things in depth than get a sketchy overview of everything. Another suggestion was that the researcher should, at the completion of the observation session, take some time to clarify those elements about which more information was needed from the interview. These suggestions were included in the information package.

6. Training the researchers : It was clear from the trial that ideally all researchers should have a briefing and a debriefing however due to the considerable constraints of time, money, and geography this was not possible. In the place of a training program an

information package was supplied to all researchers which included a description of the task, notes on collecting the information, two written examples from the trial, and the contracts that they would be required to have completed. The researcher contract includes a clause which requires them to debrief with a project officer and allows for the possibility of returning to the workplace to gather more information.

Beginning the analysis

At the time of writing detailed analysis of the work place stories was not possible. A snippet from one of the stories collected so far is included here to demonstrate the scope and potential of this work. The full description which includes background information, a summary of observation notes, some vignettes, and the researcher analysis runs to some 10 pages. This story was written by Lisa Thomson and describes the work being done by two women in a health food store.

The Health Food Shop Workers by Lisa Thomson

Vignette

Weighing the dry goods - the weighing scales (which are electronic ones, calculating the cost of the items after a code is keyed in) are situated on the other side of the shop to the bulk goods, so 'D' partially filled a bag with nuts and brought it over to be weighed. Her guess was accurate to within 50 grams. She was consistently close to the required amount with each different item, which indicates that she has become very familiar with the weights of these goods. When asked whether some items were more difficult to estimate than others (for example, was the weight of small grains harder to estimate than that of large nuts?), she said that it wasn't how full the bag was that mattered, but how **heavy** it felt. She added that she had gotten to know that, for example, one scoop of sunflower seeds weighed about 150g, whilst one scoop of bran flakes was only about 50g, and that it was easy to calculate larger amount knowing these basic measurements.

Researcher analysis

Another impressive display of these estimation skills was seen in the weighing of bulk nuts/cereals/grains. To be able to select enough to be within 50g of the required amount, and to be able to do this consistently, regardless of the size or weight of the product, is surely a valuable tool in this industry. 'D' brushed this comment aside, saying that over time, she had just gotten to know how much one scoop of most things weighed, and that she just multiplied accordingly for larger amounts - but what is a **full** scoop? what is a **half** scoop? The scoops were the common, sloped, round edged ones used by most bulk goods outlets, and I found myself wondering about all the different combinations of 'fullness' that could be found amongst the workers just in this one store. When watching each of them, it became obvious that each had a different idea of 'full'. Repetition must play a large part in learning the weights etc of products, but each person had developed her own standard against which to judge and compare all others.

Figure 1

Even in this small slice of work in a health food shop we begin to get some insight into how this person uses mathematical ideas and techniques to assist in the completion of practical tasks. The final KC description of UMIT (Mayer, 1992a, p, 35) summarised the competency as involving the

"• clarification of the purposes and objectives of the activity;
- selection of mathematical ideas and techniques;
- application of mathematical procedures and techniques;
- judgment of level of precision and accuracy needed; and
- interpretation and evaluation of solutions." (Mayer, 1992a, p,34)

Elements of these criteria exist in the story described in figure 1. The worker is clearly competent, in this context, in using particular mathematical ideas and techniques successfully to complete the task of giving the customer the required amount of goods. She knew what was required of her to complete the task. She had to call on her

understandings of number and weight, the idea of comparison, and the technique of using a standard measure to calculate larger quantities. She then applied the ideas and techniques reliably and efficiently to a required level of precision and accuracy. She was able to check that the answer made sense in this context.

However these criteria do not seem to capture the full richness of the performance of the worker. In particular the way that the worker had developed her own idea of a standard measure. This is an essential skill - whether or not the worker actually used 'heaviness' of a scoop as the standard measure (as she claims) or whether she had just learnt how much a full scoop of each type of food contained and remembered it. Other Key Competencies (eg working with others), and attitudinal aspects (eg the motivation to get it right for the customer) are also evident in this example.

The story also hints at the differences between experiences of learning in the work place and in educational settings. Resnick (1987) refers to these differences as working with others when you need to rather than on your own, doing rather than just thinking, contextualised reasoning rather than symbol manipulation and situation-specific learning rather than generalised learning. How did the worker in this story learn to be competent? Did she learn, in the first place, from a colleague? What role did 'doing' play?

It is hoped that the full range of workplace examples will enable us to explore

- the meaning of the UMIT competency,
- the relationships between the UMIT competency and other elements such as the other KCs, metacognitive and generic skills, and attitudinal aspects which could be involved in being competent, and
- how learning in the workplace occurs.

Some reflections of the teachers involved : Given that it was an intention that this work would involve teachers and that the experience be something of value to them the researchers have been asked to write on how doing the research impacted on them. Some of the comments made by the teachers involved in the trial have been included here. There is no sense in which these particular reflections are being supported or endorsed by the writer.

The teachers involved have talked of the improved understandings they had of the work place. They were interested in the way problems were tackled and solved. The larger industries, it seemed, were putting a real emphasis on teams to make suggestions about what needed doing and that the team had to discuss problems and make decisions together.

Some of the researchers were struck by the peculiarities of some work places where workers used their own way of doing things 'because they work'. It seemed that these workers don't really understand why their methods work (nor care). They observed that some workers had built up their own systems for doing things over a long time by trial and error.

The researchers were all confirmed by the amount of mathematical ideas and techniques that were being used in the work place (being a mathematics teacher might be important after all!). There was considerable discussion, at the trial debrief, about their observations of the level of accuracy in calculations (or not!) which occurred in the different contexts. With one work place having very liberal tolerances in their calculations and truncated everything while another put cost efficiencies as vital and calculated everything to the nth decimal point. One researcher talked of the "insight gained to technology in the work place, and the use people made of this technology".

Some have written of the misconception they had of what they expected in the work place. "My preconceived idea was that you would have to know a lot about money to work in Real Estate but Jenny said you could refer to tables and charts and then refer people with more expertise in these fields when conveyancing was necessary".

Some have begun to ponder how their observations in a work place might impact on their own classroom practice and the experiences that they provide for their students. "It seemed to me that the workers were engaged for about one third of their time in getting on with others, one third of their time in solving new problems and one third on

interpreting information. It seemed to me that I should break up my lessons in class in the same way." Another researcher noticed the importance of "the ability to follow a set, standard procedure" but also that "the ability to modify the procedure to suit individual preferences, while ensuring that the job is done properly, is also important." He went on to say "This job would be pretty boring to me but didn't seem to be for S and the others that worked there....Teaching should perhaps be a blend of 'boring' and 'challenging/thinking' work. Maybe I should do less challenging and more steady, routine type stuff. A bit of hard thinking followed by practise." A third researcher went on to talk of the need for workers to learn how to manage change and, hence, that learning should focus on the process of learning.

Clearly such comment depends on the workplace visited by the researcher as it does on the world view of the researcher. The comments of the researchers in their writing up of the story could also be open to analysis and conjecture. The researcher's observation of the work, self reflections about the tasks being observed, and comments made in their analysis could prove illuminating about their relationships with the curriculum, their students and the workers.

Conclusions

The majority of stories will be completed by the end of June, this year. As the stories are collected they will be distributed to the project steering committee for review and comment. They will then be analysed based on the key questions set out in this paper. This data will be put together with the information collected from school and VET settings in order to attend to our project outcomes.

It is expected that the research will be able to provide insights into how people use mathematical ideas and techniques to do practical tasks. This information should be of great interest to those who are currently looking into the numeracy requirements of school and training systems and to people involved in research into situated cognition and mathematics education.

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