Griffith UNIVERSITY

Intergenerational Differences in Mathematics

Final Report

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Executive Summary

This project arose from the outcomes of an earlier ARC-funded project which identified that young people approach their numeracy in ways that are often different from the expectations of teachers, employers and job placement officers. While they may approach their numeracy work in ways that differ from their older colleagues which is often as negative, they bring many strengths to the workplace. Most of these strengths and dispositions have been shaped by digital practices. (Appendix One provides the executive summary from the formative study.)

Aims

The aims of this project were to:

- identify the strengths and weaknesses in numeracy programs with the explicit intention of developing recommendations for more effective curricula in schools, training and workplaces;
- identify issues confronted by key stakeholders (non-Millennials) when working with young Australians (Millennials) in order to develop guidelines to support and address intergenerational differences;
- enhance the numeracy learning of both Millennials and non-Millennials in and for post-modern work environments
- strengthen regional partnerships through the use of forums to disseminate research outcomes.

To achieve these aims, the project sought to

1) identify current practices within selected sites, within each site, identify the affordances and constraints of those sites
2) identify areas of potential change within sites so as to cater for the Millennial;
3) evaluate the impact of reformed practices on key participants;
3) identify those aspects of practice that support/hinder the change process; and
4) articulate the benefits (and areas of problems) offered by changed practices for all stakeholders.

This project spanned a number of different mini projects, in part, due to the inability to attract a diverse range of secondary schools to participate in the study. The original emphasis on changing practice across schools became secondary to the work that could be undertaken.

1) a case study of an innovative site that had the potential to tap into young people's dispositions to new forms of numeracy;
2) extending the study of workplace numeracy into fields where high levels of mathematics were integral (engineering, stock markets, computer design and statistical advisor); and
3) Working with two schools on reforming numeracy teaching and learning in the senior years of schooling.

Young People and New Numeracies

This project arose from an earlier study where the focus had been to identify the numeracies of contemporary workplaces. Founded on the concern that approximately 50% of young people who commence an apprenticeship fail to complete such apprenticeships, the project was primarily concerned with identifying the numeracy demands across a range of industries so as to inform practice and policy. The earlier project sought to indentify the numeracies that were embedded in contemporary work places with the intention of building this information into training packages and selection processes as well as informing teaching of mathematic in formal contexts. To this end, a four-part method was adopted. First a large survey was conducted across nearly 1000 respondents. Second, a series of 19 case studies were undertaken across a wide range of trades and occupations in which the ways young people undertook their workplace numeracy were observed and documented. Third, community consultation was undertaken with key stakeholders to confirm the outcomes of the study. In summary, what this first project showed were:

1) There were very different expectations held by younger and older workers as to the numeracy demands and expectations of the generations and the workplace;
2) Young people had adopted very different approaches to undertaking aspects of their work, including numeracy, than other generations;
3) Young people's numeracy practices and work places where heavily influenced and shaped by digital technologies;
4) Industry was more amenable to changing perceptions of, and practices associated with, young people than were schools;
5) Young people were happy to defer cognitive labour to technology, recognising that the technology would be more accurate and quicker than using mental or pencil-and-paper methods. This enabled them to 'get on with the job at hand' as many of the tasks in contemporary work are far greater in demand than just the mathematics/arithmetic of the task;
6) Young people were good at applied areas of mathematics; preferred to use technology to enable them to complete tasks; undertook holistic thinking and problem solving as they multitasked in their work situations; and
7) Older people valued basic skills over those skills and dispositions brought to the workplace by young workers. This creates a dissonance between the expectations and skill expectations of the generations.

Upon completion of this first study, further funding was sought from the Australian Research Council to enable the embedding of these findings into practice. This report is this final study.

Intergenerational Differences: Theoretical Framing

Within the current conservative climate, governments are being lobbied by a wide range of interest groups on the education of young people. In most cases, there is a general bemoaning of the decreasing skills in literacy and numeracy to which governments have responded in most Western countries by implementing some form/s of testing that seek to measure the literacy and numeracy skills of students in school. Similarly, policies have been developed that explicitly seek to increase or enhance the numeracy and literacy skills of the youth of the nations. However, within this climate, there needs to be some problematising of what are seen as valued forms of literacy and numeracy. Indeed, questions need to be posed that problematise what comes to constitute literacy and numeracy within contemporary times. The current conservative agendas focus on what can be best described as old, basic skills, that is, reading, writing and arithmetic. Spelling, grammar and mental computation (involving basic operations) are seen to the core of these skills. But are they? What are the skills needed for contemporary work? How relevant are basic skills in the new world?

Within this climate, however, there is a growing acceptance of the impact of technology on the ways of life in most Western countries. Terms such a postmodern, global village, New Times, Millennials have been adopted into the academic and populist discourses to signify the changing world where modes of communication, power and work are substantially different from any other period in time. Indeed, in some cases, the radical changes brought about through technology have been likened to the societal and workplace reforms of the Industrial Revolution where societies changed from Agrarian to Industrial, where families changed from extended to nuclear, and where work changed from village to industrial. It is proposed the changes in the late 20th Century are the emergence of new times where the worlds of family, society and work are undergoing radical change. The impact of this on work, education and generations is less well understood. Even less well understood is the potential impact and reconceptualisation of mathematics in these radically different worlds.

Within such a changing environment, the worlds to which young children are exposed are likely to be substantially different and thus create very different dispositions by those living within particular social conditions. Today's youth are the first generation to have grown up totally immersed in a technological age unlike that of any other generation. For them, the internet, digital technology and computers are a way of life. The world of work has been technologised and changed radically so that workplaces of the future (and those who have adopted technology today) offer very different opportunities and demand very different skills and dispositions for those entering the workplace and the wider social and economic spheres of life.

Two things are very different in these new times. First is that the workplace, and society in general, have undergone radical change. The impact of technology has been profound and has brought about new ways of working and communicating. Second is that young people have grown up in a world immersed in digital technologies so their dispositions have been shaped by these artefacts. While many of these changes are being recognised by some sectors of society, the relationship with mathematics is not well understood.

Mapping Intergenerational Differences

There has been considerable media coverage of different generations and how the worlds in which they grow up shapes how they see the world. Mackay (1997) has been an Australian leader in discussing how generations react to their predecessors to shape the ways they act and view their worlds. While focusing on the Traditionalists (those born in the Depression years); Baby Boomers and Generation X, Mackay demonstrates with reasonably robust data, the differences in these 3 generations. This work is in contrast to some of the literatures coming from other sources where the premises have been based on market research which is somewhat less robust.

While the generational literature focuses on years where particular trends were evident in population changes, these changes are not so obvious within the Australian context. As such, it may be more pertinent to see generational changes being more closely related to defining events. These events can be seen to shape the experiences, and hence perceptions and actions, of those who were most shaped by such events. In mapping these events for the Australian context Kelly Zevenbergen and Ruth Delaforce, who were research assistants on this project, were able to devise Table 1 which follows. This table illustrates the defining events that shape generations.

Most of the literature on Intergenerational differences is drawn from the US so events are relevant to that context, some are of international importance – such as the Vietnam War. However, in this research we were concerned with Australian society so have mapped the events within this nation so as to illustrate the defining events that help to shape the habitus of Australian generations. Of course, other factors impact on these habitus – such as family, personal events, social cultural and linguistic groupings, as well as access to wealth, health and education. However, we would contend that even with these differences, there remain generational differences within these groupings as well so that such groupings can be seen to transcend other factors. That is to say, for example, that working-class families may be different from middle-class families, but the children of these two groups will be different from their parents because they have experienced different social/temporal conditions. In some ways, these differences help to unite temporal groupings from their predecessors due to the conditions that they have experienced.

Digital Generation

While the literature around generational differences tends to have periods such as those indicated in Table 1, there is a growing recognition that the latest generation – Millennials, Gen Y, Nexters, or whatever name is assigned to them is significantly different from other generations. This is the generation that has grown up immersed in digital technologies. They know no other world. These digital technologies represent a significant shift from other technologies in terms of speed, connectivity, access and so on. Prensky (2001) has adopted the term 'digital natives' to refer to this generation, and the term 'digital immigrants' for those generations that preceded them. He does not make a difference between the previous generations, preferring to highlight the differences between these two significant groups.

Prensky (2005) contends that this generation thinks differently and learns differently because they have been shaped by digital media so that they have learned to learn in very different ways from previous generations. In particular, their interactions with computers and their engagement with digital games has shaped particular characteristics for this generation. He contends that they work at 'twitch speed" (rather than conventional speed), see technology as a friend (rather than a foe); prefer being connected to others (rather than working alone); expect instant feedback (rather than delayed); process information in a random (rather than linear) mode; tend to access graphics (rather than text) when first encountering information; tend to be active in their learning (rather than passive); expect payoffs for their engagement (rather than being patient); and tend to be contended with fantasy worlds (rather than being embedded in reality).

	Traditionalists (1900-45)	Baby Boomers (1946-64)	Generation X (1965-80)	Generation Y (1981-2000)
Events	World War I and II Gallipoli Great Depression Sydney Harbour Bridge erected	Vietnam War Beaumont children missing Harold Holt disappearance Currency change Man on the moon Gough Whitlam sacking	Gulf War Ash Wednesday fires HIV/AIDS epidemic Bicentenary celebrations Cyclone Tracey French nuclear testing in Pacific Economic Recession	Iraq War SE Asian Tsunami September 11 – World Trade Centre Bali Bombings Southern Ocean Whale Sanctuary
People	Weary Dunlop Nancy Wake Charles Kingsford Smith Simpson and his Donkey Joan Sutherland	Gough Whitlam Robert Menzies Graham Kennedy Dick Smith Kerry Packer	Kylie Minogue Bob Hawke/Paul Keating Eddie Mabo Michael Hutchence	John Howard Pauline Hanson Steve Irwin Heath Ledger
Entertainment	75 records Radio Silent films ‘Talking’ films	Television LP records Drive in cinemas	Cassette tapes/CDs INXS Countdown Comedy Company Neighbours Hey Hey! It’s Saturday Walkman	Pay TV introduced Reality TV Silverchair Big Brother Australian Idol High definition TV
Sport	Don Bradman Pharlap	Melbourne Olympics Roller skates	Australia won America’s Cup Chappell Brothers First one-day cricket match Kieran Perkins First State of Origin Match	Shane Warne 20-20 cricket Steven Bradbury Indian Premier League cricket Sydney Olympics
Social Conditions	White Australia Policy Pensions introduced Outdoor Toilets Trams Workers Unions 6 o’clock swill	Aborigines given rights to vote End of White Australia policy Last death penalty carried out Voting age dropped from 21 to 18	Recycling First IVF baby Equal pay for women Maternity leave introduced Gay rights	Drought GST introduced Workplace Agreements Children Overboard Scandal
Technology	Victa Lawnmower (1952) Hills Hoist (1946) Washing machines	Calculators Typewriters	Home computers Nintendo and Sega Mobile phones Disposable cameras	I-pods & Laptops Internet Nintendo Wii, Xbox, PSP GPS Facebook & MySpace

Table 1: Intergenerational differences

These literatures suggest that young people entering schools and the worlds of work are potentially very different from previous generations. The difficulty is to identify appropriate teaching, training and selection processes that will enable young people to make successful transitions into contemporary workplaces. Simultaneously, industry and schools need to recognise that young people bring to these contexts a range of strengths and dispositions that may not be recognised by those currently in positions of power (such as teachers, employers, trainers, selection/recruitment personnel). As such, it becomes critical that education, training and industry identify:

1) core knowledges and skills needed for the contemporary workplace;
2) the potential of young people to bring new skills and dispositions to school and work that have not been acknowledged
3) new approaches to selection, training and education that unites the dualism between what are legitimate demands of school and work in conjunction with the strengths that young people bring to contemporary worlds.

Young People/Older People: How they see Digital Natives

Given that most of the research conducted with generational differences has been with market surveys, we sought empirical data that might highlight areas of concordance and disagreement with the perceptions of young people held by the different generations. In order to gain a sense of how young people and older people see Digital Natives, a survey was undertaken with representatives from each group of people scoring on a strongly disagree/strong agree likert scale. The scale was a 7point one in which 1 was disagree and 7 at the agree ends of the continuum.

The survey was administered to over 300 people – young people (in schools or work) and older people who were involved in education, training or working with young people. Young people were defined as being 24 and under for this survey so that the age group aligned with the Digital Native/Gen Y trends in age distribution.

The data are presented in Table 2 where the mean scores for the two cohorts can be seen. These data show areas of difference using shading where the difference in scores is greater than one; where the scores are different by 0.8 to 1.0 and where there are similarities (where the difference is less than 0.2).

The questions that were used as the basis of the survey were drawn from a range of sources that document the differences between generations (Charp, 2003; Zabel, 1999; Zemke, 2001). These literatures have argued that there are marked differences between generations. These differences were used to frame the survey so it would be possible to assess whether or not there were similar differences (or not) among the young people who were the focus of this study.

Similarities between the generations

Areas where there appears to be agreement between young people and older people is that they see young people as;

- Being very good at computing (5.13/4.97)
- Behaving ethically (4.38/4.45)
- Having high aspirations (4.88/5.00)
- Being prepared to work outside school hours (3.56/3.78)
- Working collaboratively (4.83/5.00)
- Enjoy working with others (5.17/5.29)
- Prepared to take short cuts (5.08/5.28)
- Spend too much time on computers (4.42/4.42)

In considering themselves in relation to young people, both parties saw

- Young people are industrious
- Young people are well prepared for work or school
- That they were aware of the numeracy demands of the workplace
- Aware of the skills need in the workplace

Differences between the generations

In contrast, there were differences between the two cohorts when considering the following dimensions. In considering these, the group that ranked the item higher is listed, along with the higher score: Scores in italics are those where the difference is between 0.8 and 1. Scores in normal font are those where the difference in greater or equal to 1.

- Young people have good work ethic (*young people 4.37*)
- Young people are reliable (*young people 4.52*)
- Young people are prepared to undertake challenges (young 5.18)
- Young people are focused on their career (young 4.95)
- Have high levels of literacy *(young 4.20)*
- Have high levels of numeracy *(young 4.26*)
- Have high levels of general knowledge (young 4.61)
- Show initiative (*young 4.78*)
- Relate well to young people/peers (young 5.26)
- See the potential in young people/peers (*young 5.12*)
- See computers and technology shaping new ways of working (young 5.59)
- See technologies as the way of the future (young 5.68)

What is interesting from these data is that young people consistently scored themselves higher than older people on all dimensions where there were differences between the generations.

When considering all questions, there were only two scores where there was a difference where the score was higher by older generations. The first was in relation to computers where older people indicated that "young people were good at computers". The other was when the question was framed in the negative – " I worry about the lack of skills of young people."

These quantitative data suggest there are some areas of difference between how young people differ in their perceptions of self from older generations. There is some agreement, however, as to the impact of digital technologies as shaping dispositions of young people towards their ways of working.

Survey

(dark shading)	Data where there is a difference >1
(light yellow shading)	Data where there is a difference 0.8>x>1
(beige shading)	Data where there is a difference <0.2

Question	**Mean**	
Young people….	Older people	Young people
1. Are well prepared for work and school	3.88	4.27
2. Are willing to work hard in school/work	3.71	4.30
3. Have a good work ethic	3.58	4.37
4. Are prepared to undertake challenges	4.13	5.18
5. Are willing to learn	4.25	4.89
6. Are very good at computing	5.13	4.97
7. Are reliable	3.79	4.52
8. Behave ethically	4.38	4.45
9. Respect their superiors	4	4.55
10. Willing to undertake menial tasks	3.79	4.30
11. have high aspirations	4.88	5
12. are focussed on their careers/goals	3.88	4.95
13. Have high levels of literacy	3.30	4.20
14. Have high levels of numeracy	3.48	4.26
15a. Are prepared to do work outside of school hours	3.56	3.78
15b. Are prepared to work beyond normal work hours	3.88	4.46
16. work collaboratively with others	4.83	5.0
17. seem to prefer to work with other young people	4.96	5.35
18. spend a lot of time on mobile phones	5.71	5.28
19. have high levels of general knowledge	3.38	4.61
20. enjoy working with others	5.17	5.29
21. show initiative	3.96	4.78
22. are prepared to take short cuts	5.08	5.28
23. are punctual	3.78	4.28
24. enjoy spending time on computers	5.46	4.95
24. spend a lot of time playing on computers		4.82
25. prefer to let technology to their thinking	5.75	5.37
26. spend too much time on computers	4.42	4.42

I think...		
27. I relate well with young people/peers	4.30	5.26
28. I see the potential in young people/peers	4.32	5.12
29. I worry about the lack of skills of young people	4.34	3.99
30. I value good reading and writing	4.37	4.77
31. I value strong numeracy skills	4.37	4.70
32. I see that accuracy in numeracy is important	4.38	5.07
33. I have problems relating to young people	4.35	5.33
34. I see young people as industrious	4.37	4.5
35.I See young people as well prepared for school or work	4.37	4.13
36. I am aware of the numeracy demands of the workplace	4.39	4.17
37. I am aware of the skills needed in the workplace	4.41	4.53
38. I am well prepared to support my students/staff in their preparation for work	4.39	
39. I am computer literate	4.41	4.97
40. I recognise the important roles computers play in work and school	4.45	5.0
41. I value the computing and technology skills that most young people have	4.49	4.96
42. I see computers and technology are shaping new ways of working	4.52	5.59
43. I see that technologies are the way of the future	4.55	5.68
44. I am flexible/willing to allow different ways of working as long as the job gets done	4.53	
45. I learn new ways of working from young people	4.52	

Table 2: Survey responses

Summary

The data presented here confirm much of the market research where there is a marked difference between younger and older generations.

What is very clear from these data is that young people consistently see themselves more positively than their supervisors, employers and teachers.

New Numeracies of Contemporary Work: Stock Broker, Statistician, Computer Designer

In the earlier project, the young people who were involved in the case studies were drawn from apprenticeship and traineeship areas. A total of 19 case studies were undertaken and included:

Baker	Receptionist	Printer
Retail assistant	Boatbuilder (3)	Painter
Chef	Bricklayer	Room attendant
Hairdresser	Motor mechanic	Laundry attendant
Builder	Short order cook	Sign writer
Laboratory technician (Concrete testing)	Shop fitter and cabinet maker	

One of the criticisms of this earlier study was that the sample was of low level users of mathematics and that the outcomes may have been influenced by the occupation types. Despite producing similar outcomes as those identified by Noss, Hoyles and colleagues where they studied nurses (Noss, Pozzi, & Hoyles, 1999), bankers and other occupations, there was still some hesitancy in the acceptance of the results of the study, particularly among educators. To this end, a further dimension was included in this study where a number of high-level mathematics occupations were included. These included:

- Stock brokers (3);
- Engineer (civil);
- Computer designer; and
- Statistician.

Data Collection: Stimulated Recall

A novel approach was used within the workshadowing, partly out of necessity to ensure minimal disruption to employees. However the method that was adopted has been well documented in the methodology literature. Stimulated recall has been used in recent history with the use of video data and where participants are asked to reflect on their actions as they view excerpts from the video (Artzt & Armour-Thomas, 1997). In some cases, all of the video is shown whereas in other cases selected sections are used. These may be temporally selected or purposively selected. However, in this study, still photographs were used as the purpose of the workshadowing was to capture the variety of tasks undertaken by the employee.

The workshadowing involved a preliminary interview regarding the participant's background and perceptions of their work; photographs that were taken of each activity that the participant undertook; and an interview after the workshadowing at which participants discussed the photographs to outline what they were doing in the task and what they were thinking. The amount of photographs taken within any one occupation varied considerably depending on the nature of the work. For example, in the original study, in boatbuilding and shop fitting there was considerable variety in the work undertaken, whereas the chef and retail assistant there was a high degree of repetition in their work. At the completion of the workshadowing, each participant was shown all photographs (in chronological order) and asked to comment on the work they were doing and what they were thinking as they undertook that work. In particular, they were asked to talk about the mathematics, if any, they used as they worked. This method has been found to elicit insights into the metacognitive processes of participants. As such, the method was particularly useful in this study in order to access young people's thinking about their work. It was shown to be highly effective in most cases.

Work-Shadowing in High End Occupations

The first phase of the Intergenerational Differences Project was focused upon numeracy skills of young people engaged in retail and trade-related employment. The research findings indicated that young people (under 25 years of age) applied numeracy skills in different ways to that of older generations. It was proposed that these different skills were attributable to the impact of digital technology as a medium with which younger people had considerable experience and which had permeated most aspects of contemporary work. It was proposed that the impact of digital technologies shaped new/different approaches to numeracy as a practice. However, the mathematical demands of these workplaces were often perceived to be a lower level than those occupations where employees needed to undertake tertiary studies and where in that course of study some mathematics was seen as core. In order to test the conjecture that these digital media were reshaping the ways in which mathematics was undertaken in the workplace, the initial study was extended here to incorporate occupations that were seen to demand higher levels of mathematics.

Much like the original study, gaining access to employees proved to be difficult. To this end, four occupations were shadowed – stock brokers, civil engineer, statistician, and computer designer. All employees except the statistician were young people.

Participants

In total, seven participants were recruited for this phase of the project. As with the original study, recruiting participants for this study was very difficult. Gaining access to sites is particularly difficult with current workplace safety requirements. The requirements that surround this legislation significantly constrain the access that can be gained to sites. Similarly, many sites have concerns about the data collection methods and the preservation of commercial and personal information. While an engineer had been included in this study, the recording equipment failed in the data collection so that no transcripts of data could be provided.

Digital Technologies Shaping Mathematics

The data that were collected in this part of the study confirmed the outcomes of the original study. This outcome, albeit with a limited sample, indicated that the original study was consistent for young people regardless of the fields of work or the level of mathematics that was integral to the work being undertaken. The findings indicated a significant reliance upon technology by all professional participants, not only in undertaking their tasks, but the analysis of results also.

Case Studies

In the following sections we discuss the four different worksites that were studied in this project. They were undertaken with professions where a higher level of mathematics was seen to be an integral part of their work. While there is other data that can be reported that enhances the case, what is presented here are the data that highlight the ways in which digital media shape the work that is being undertaken by the employees. In each case, the employees demonstrated how their patterns of work were considerably shaped by the digital media.

Stockbrokers

Three stock brokers were followed. In their preliminary interviews, it was found that they had strong backgrounds in mathematics, having taken a higher level of mathematics in their senior years of schooling and then undertaken further studies in mathematics of some sort or another:

> **Charlese:** *In high school I did Maths B, and then, at university, I did Commerce and Economics, so, yes, I did statistics and econometrics, and stuff like that. I didn't do any majors in mathematics, though*.
>
> **Mike***:* *I did Maths B at school, all the way through. And at university, I studied commerce, economics - and that was – I majored in accounting and finance, so there was quite a bit of maths all the way through, in accounting and, also, in economics. And I did a little bit of stats as well, so there was a bit of maths in there.*

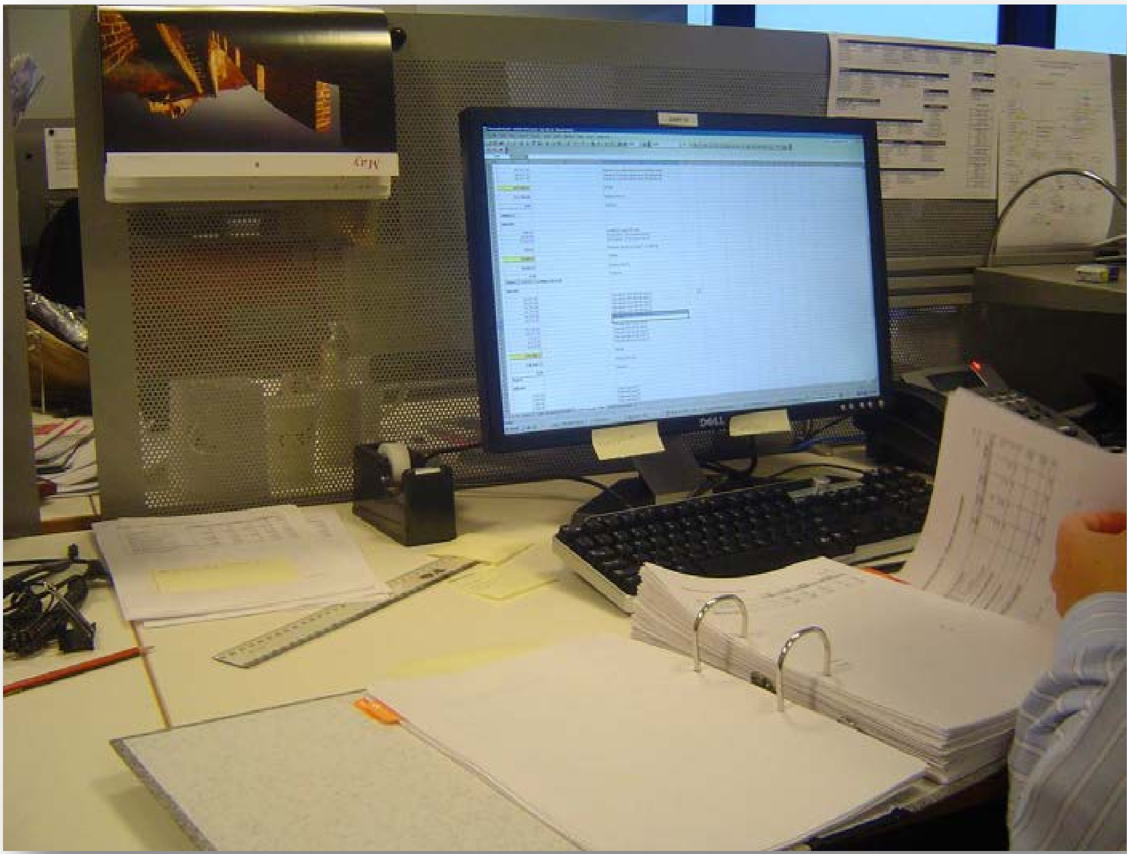
The demands of the industry were shaped by the actual roles they played. In the case of stockbrokers, there was considerable synergy across all three responses and the nature of the mathematics can be best captured in the following comment where the participant illustrates that most of their work is built around modelling.

> **Researcher:** *And how would you describe the maths in your job?*
>
> **Charlese:** *I guess, what we research – like, the mathematics in the job is, like, based on financial modelling. So I guess it's a combination of doing the round figures, and then forecasting into the future, and then calculating the present value, and things like that, but it's using all the numbers out of the annual reports to help us come to our conclusions, or use them to calculate ratios and things, to give another insight into business, or so that we can compare it with other companies, and things like that. So, yes, those sorts of things.*

This position was similarly articulated by another one of the stock brokers, thus suggesting that the role was based considerably on the development of some model.

> **Mike:** *Well, basically, I am meant to - as a research analyst, I am supposed to analyse data, both quantitative and qualitative, and look at a company, look up its balance sheets, its financial reports; everything in terms of that. Look at the industry, look at that, and then take all that information and come up with a model – using the numbers, come up with a valuation. So you have to come up with a forecast, the numbers.*

Within this process, however, the level of mathematics that was used was seen to be minimal. The mathematics that was used was largely calculations (basic operations) and the use of percentages.



Researcher: How much maths would you use, to do that?

Charlese: *Definitely not as much as an actual analyst; they would use it quite a lot, I'd say. It's all – basically, it's all about mathematically coming – like, working a result out of – from the finished maths, it's come out of the markets. So they would have to model everything mathematically, so they would use maths all the time. And there's probably – there's nothing required, it's about really – it's just about your basic understanding about it.*

Query: *So what type of maths would you use?*

Stockbroker: *Mostly just division, multiplication, a few powers, averages, percentages; that type of thing.*

However, there was a strong recognition of the ways in which software was an integral part of the work that was undertaken. All participants commented on this. Further, as Charlese indicates below, the functions that have been set up in the spreadsheet may not be familiar to the stockbroker:

Charlese: *I have learned skills in Excel, definitely. I don't know if it's skills or just a lot of understanding. I mean, there are some formulas in Excel that I don't understand how they use that, and I don't know if that's their function. I don't really know Excel as well as other people, which is what I think it probably is. And also, I am sure, there's a lot of maths in it, but I guess the problem is that Excel sort of takes out the maths, because they have a function that you just add in your inputs, sort of thing, so it's---*

There was a general sense that technology was an integral part of the workplace,and indeed, it would not be able to function without technology:

> **Charlese:** *Technology is just a massive part of it. I mean, even just seeing how everyone else operates in the business, too. Like, I haven't really been here that long, but they're constantly putting together spreadsheets, and then being on the computer all day, keeping up to date with the markets. So, yes, if they didn't have that, it would be a severe blow for the company, if the technology wasn't there. So, I mean, it's all about keeping up with the rest of the industry; so, yes, a massive, massive part, I think, of the position, really.*

They were highly dependent upon technology. Their duties included the use of a variety of software programs - for data-mining and manipulation, maintaining contemporaneous knowledge, communication, and in the analysis and reporting of their work.

> **Stockbroker:** *Technology is just a massive part of it. I mean, even just seeing how everyone else operates in the business, too. Like, I haven't really been here that long, but they're constantly putting together spreadsheets, and then being on the computer all day, keeping up to date with the markets. So, yes, if they didn't have that, it would be a severe blow for the company, if the technology wasn't there. So, I mean, it's all about keeping up with the rest of the industry; so, yes, a massive, massive part, I think, of the position, really.*

In particular, all participants referred to the need for advanced skills in Excel software as this was how most of the modelling was undertaken.

> **Stockbroker:** *I guess it's all about learning how to best use the computer. Like, I know I need some skills there. With my uni background, it is probably a big gap between knowing how to do things on the computer and the theoretical knowledge. But I know what I need to know, but learning how to do it on the computer – I think that I lack that.*

All the stockbrokers referred to the mathematical skills required to undertake their duties as comprising basic mathematical understandings:

Hiding Mathematics

The participants also referred to the 'hidden maths' that was incorporated into software programs such as Excel. This is similar to the findings of Noss and Hoyles where they argued that with contemporary technology, the mathematics that is embedded in the work practices often becomes invisible. Thus, the complex mathematical thinking is undertaken by the technology and the worker needs to develop a different skill set, such as estimation, to evaluate the reasonableness of a response.

> **Stockbroker:** *Like, all the maths is calculated in them, so it's a matter of putting in the figures and you don't actually have to put in formulas, and things like that…And also, I am sure, there's a lot of maths in it, but I guess the problem is that Excel sort of takes out the maths, because they have a function that you just add in your inputs.*

Web Designer

The web designer's duties are wholly focused upon technology. His duties included the production of 'interactive objects' for a tertiary institution, described as follows:

> **Web Designer:** *An academic finds a gap in their learning, or something the students are having trouble getting a grasp on, so they then contact our unit, who then goes through, has a look at it, breaks it down to an educational stance, sees if technology is the best answer for that and then if the answer is yes, then we design and create interactives etc.*

The mathematical skills and requirements of the role were described by the web designer as 'Cartesian planes stuff,' noting that:

> **Web Designer:** *Everything you do on computers is ones and zeros, but we just don't get exposed to those layers anymore, everything is sort of hidden away from you… In the past, where you would have to calculate trajectories of things, and if things hit each other, how they bounce off and work with each other - well now, the system takes care of that. You still have to have a bit of an idea, but you don't have to know, "Okay, cosine, what is this actually calculating?"… It's becoming more like when calculators came in, you didn't have to do so much of your division, subtraction, multiplication and stuff by hand. It's gotten a lot easier.*

Statistician

The statistician was from an older cohort to those of the other participants; that is, he was over 25 years of age. In describing the nature of his work and the links with mathematics, the statistician commented:

> **Sam:** *Well, it's quantitative methods as a research technique so basically I'm involved with a research study, it's not always quantitative but certainly over the last couple of years it's been quantitative so knowing how to operate the major statistics packages. The maths I'm using is not high powered maths it's just knowing where to look on the output for the relevant numbers that you need to put into a table or into your report what the numbers mean. There's no high powered maths involve din the work that we do. Underlying the work that the stats package does is high powered maths there but I don't pretend to understand that.*

Like the stockbrokers in the early section, the final comment in the above quotation again suggests that the mathematics is hidden in the technology so that the participant is able to get on to the task at hand. With the case of statistics, the technology has enabled a much more complex analysis to be undertaken due to the computer's capacity to consider more variables than would have been possible without this technology.

Sam: *Over the last 10-15 maybe 20 years, one of the analytic techniques that has become available simply because computing power has become available and the software that make it easy for people like myself to be able to run it in, so you don't need to be going back to software that requires to be setting up your models in terms of matrix commands, so to be able to work that software you need to know your matrix algebra, which I don't. So over the last 10-15 years this modelling technique has become available to run of the mill quantitative researchers. And all it does is simply take account of the clustering of, say, students within classrooms, which has opened up a whole raft of techniques available to quantitative researchers. In that sense there has been a fundamental change to the way in which I've applied numbers to my work. Previously we would have ignored that clustering of students within the classrooms, now we can take these clusters or whatever. One of the studies I am working with is looking at the clustering of mums and dads within families. We can take the family into account, take the classroom into account, take the school into account.*

However, similarly, the statistician referred to the reliance upon technology in performing his tasks:

Researcher: What role does technology play in your workplace?

Sam: *Well, a lot. People can't do these sorts of sums by hand any more, they have to depend on the computer to do them. So I could spend a few hours at a computer running the analyses and then printing the analyses or taking the outputs off the screen and enter them into whatever is needed, a table in a report or the text. But yes, without the software I'd be doing something very different.*

The statistician referred to the mathematical skills required for fulfilment of his role as noted in the first comment in this section. As with the earlier study, there is a strong need for intuition - knowing where to look; knowing what an output may mean and its validity or value – are key roles when using the statistical packages. These roles subsume the need, as the statistician acknowledges explicitly to understand the high powered mathematics that is in the statistical package:

Sam: *The maths I'm using is not high powered maths; it's just knowing where to look on the output for the relevant numbers that you need to put into a table or into your report; what the numbers mean. There's no high powered maths involved in the work that we do. Underlying the work that the stats package does, it's high powered maths there, but I don't pretend to understand it.*

Finally, as noted earlier, the role of technology has dramatically reshaped the work of statistics. Rather than undertake tedious calculations, the statistician's calculations are undertaken by the technology so that his role is more about the successful reporting of analysis.

High End Users Case Study: Conclusions

The data in this part of the study confirmed the findings from the original study – that technology was creating new and different ways of working mathematically. As with the original study, digital media were used to perform mathematical calculations. What was more important in these new workplaces was the skill to estimate so as to enable participants to intuit that an outcome or observation 'looked right' or "felt wrong" and that there would then be a need to recheck the calculations with the use of technological devices. As the statistician indicated, there is a much richer world made possible now through the technologies available in this high end user category.

The data from these case studies highlighted that higher levels of mathematics are needed in these occupations but they are not undertaken by the workers. The technology enabled the processes to be undertaken while the worker got on with the task at hand. This was evident in each case.

Summary

Although there were limited participants in this phase of the project, there were a number of recurrent key issues that were raised. These issues are summarised as follows:

- The participants indicated a range of self-identified mathematical competency, from very confident in their understandings to a 'lack of interest.' School level maths courses undertaken by these professionals included Maths in Society, Maths A and Maths B;
- The participants appeared to vary in their assessment of the application of mathematical skills learned in school and university to professional duties, although at least one participant referred to the importance of 'understanding the basics;'
- Although initial perceptions of particular professions are that high levels of mathematical skills are required, for the participants, their mathematical skill-sets were correlated to a proficiency with the technology and software programs being used;
- For all the professionals that participated, technology and communications were an integral feature of their workplace. As one participant noted, 'Without the software, I'd be doing something very different;' and
- There were references to the need for continuous updating of software programs by technical specialists, and incorporating particular formulas into the programs as required, to facilitate the professional user's ability to quickly and efficiently extract, manipulate and analyse data. In correlation with the continuous upgrading and capacity of software programs to undertake these functions, is the premise that the mathematical skills of the user will become increasingly more dependent upon their proficiency with technology.

Authentic Learning: Building Industry Case Study

There is increasing recognition that contemporary school may not be meeting the needs of young people and industry. To this end, a pilot 'college' was put into operation in 2004 where two schools became feeder schools and the boys were able to undertake their senior years of study at this site. The site was orientated towards the building industry and was developed around the philosophy of adults learners. While still needing to meet the requirements of the senior years, the college was able to be much more flexible in their curriculum and pedagogy.

The work program was built on a cyclic approach where teams of young men worked on rotations so that they would either be engaged in formal school work, construction training or on building sites. They worked in small teams of approximately 6. They would undertake their work within these groups.

The content of the courses still needed to cover essential curriculum such as mathematics, English, science and so on. Some degrees of freedom had been sanctioned by the Department of Education. However, the curriculum had to ensure that the graduates would still meeting basic requirements of a senior graduation. This included the graduates being literate and numerate and needing to pass the national reporting standards at level 4. On top of this, the curriculum also included many of the requirements of the building industry so that it was likely that the participants would be involved in obtaining particular certifications necessary for the workplace, such as blue cards (safety requirements), and other certificates that were relevant to the industry in which the participants were seeking work.

The head of the college had built the school on a model where industry could display their products to the public (for access to new products for home construction or renovation) but where the manufacturer would then be required to train the students in the application or construction using that product. This approach was seen to provide the students with access to latest building techniques so that they would graduate with a working knowledge of the most up-to-date building materials and application techniques.

What was observed at this site was that:

a) there was considerable potential to explore rich mathematics in situ – that is, within the building trade there are many examples in which the mathematics is embedded in the work being undertaken by builders;

b) teachers tended to teach building skills in the context of building, and mathematics in the context of the classroom – there was little to no teaching of mathematics as it related to the building trade;

c) the courses that the students needed to undertake as part of their qualification process were rich in mathematics but this was not articulated;

d) teachers were not familiar with creating curricula that reflected and embedded mathematical demands of the building trades in a curriculum context.

To this end a number of tasks were undertaken. These included an audit of the units of work that were essential for the building certification. These documents were audited and aligned with the key documents of the National Reporting Standards NRS) Level 3 Framework which is considered the core level for a Queensland; the Queensland Studies Authority Curriculum for Pre-vocational Mathematics (a non-Board subject) and Mathematics A (a board subject). The audit revealed that the Building Units that the students were required to undertake met most of the standards for the NRS Level 3 and the Prevocational Mathematics. The main area that lacked in the Building Course was that of data representation and analysis. If this aspect of mathematics were not included in the syllabus documents, then all other areas were more than adequately covered. In terms of Mathematics A, a considerable breadth of the curriculum was covered with the data component of the curriculum.

School Mathematics Learning Environments

There has been a substantial literature that has been critical of contemporary practices in the teaching of school mathematics. The Queensland School Longitudinal Reform Study (QSLRS) (Education Queensland, 2001) studied quality teaching in Queensland schools. As a study of considerable merit, it reported that of all the curriculum areas, mathematics was the most poorly taught. It scored lowest on all dimensions of learning. While scoring indicated that teachers offered supportive learning environments, they quality of teaching was very low. Using what is now commonly known as the Productive Pedagogies Framework, the QSLRS showed how dimensions of quality were more or less evident in classrooms. It has been a tool to enable the analysis of classrooms for quality teaching. More recently, Gee (2003) has been arguing that the games environment provides a strong model of learning that is relevant to the digital generation. He argues that the principles that underpin games environments should be embraced by educators as these environments successful engage young people. When these literatures are considered in concert with contemporary practices in school mathematics, they beg askance of how school mathematics is meeting the needs of young adults (or learners across the lifespan).

What literature exists on contemporary classrooms suggests that there is a recognition that a change is necessary to cater for learners in ways that are more engaging than the practices of the past. There are numerous case studies of exemplary practice but the reality is is that most mathematics classrooms are dominated by pedagogies of the past. These usually involve teacher directed lessons with the teacher being on control of knowledge transfer; where students work individually, quietly, and often competitively; there is often little group work or collaboration among peers; the work is often based on a commercial scheme with accompanying teacher and student resource books; assessment is often pencil-and-paper testing and undertaken in test situations. Grouping students by perceived ability is very common in mathematics. These practices generally become more honed the higher students progress in schools. In her study of reforming pedagogy in mathematics Gutierrez (1998) has shown how resistant secondary teachers were to implementing reform in their classrooms.

Despite the widely recognised problems students have with engagement, participation, selection and so on of school mathematics, there has been little systemic change in the teaching of school mathematics. Of particular importance to this project, a number of key principles seem to be needed to underpin reform in school mathematics if there is to be a greater synergy between the learners and the discipline:

1) learning needs to authentic – mathematics is often taught as an abstract discipline where particular principles are seen to underpin significant concepts. There is often little in the way of connecting mathematics to applications to authentic contexts;
2) digital tools should be integrated into learning so as to enable rich mathematical problem solving to be undertaken. This will enable rich ideas to be developed.
3) Rich mathematical thinking should be embedded in tasks where students need to collaborate in their resolution.

Productive Pedagogies Framework

The productive pedagogies framework is one which has been taken up by schools nationally, albeit with some variations across the states, to provide a framework for analysing and improving pedagogy. It provides a rich description of various aspects of pedagogy that are seen to contribute to quality learning outcomes. The descriptions for each of the dimensions and pedagogies can be found in. For the purposes of discussion in this paper, we do not intend to elaborate on these pedagogies.

Intellectual quality	Connectedness
Higher order thinking Deep knowledge Deep understanding Substantive conversation Knowledge as problematic Metalanguage	Knowledge integration Background knowledge Deep understanding Connectedness to the world Problem based curriculum
Recognition of difference	**Supportive School Environment**
Cultural knowledge Inclusivity Narrative Group Identity Active citizenship	Student direction Social Support Academic engagement Explicit performance criteria Self regulation

Digital Learning Environments

Gee (2003) has shown how the games that engage the digital native learner have been carefully crafted to adopt learning principles that are in stark contrast to that of their parents. He contends that games have been structured so that the learner passes through increasingly complex worlds but each stage develops the skills and knowledge needed for later levels. The scaffolding through the games enables the immediate gratification for the gamer but where there are errors in the playing, the gamer learns from these so as to build the core skills and knowledge needed for subsequent levels. Gee's analysis of the games environment shows how the designers craft learning so as to engage the digital learner.

By understanding the learning principles that games designers adopt in when planning and designing games, Gee has identified a number of key principles. These principles show how the learning environment is one that engages the digital native.

These principles include:

Low cost failure: The costs are low so the gamers are prepared to take risks. For example, in the games design, if the gamer cannot master a particular manoeuvre, he/she does not return to the start of the game but rather to the start of a particular level or scene. IN this way, the cost for failing is not significant. This is contrast to school or work where failure is often significant and public.

Competition and Collaboration: In the games environment, there is health competition with others and self. Often the games environment involves collaboration with others – this might be in the games environment but may also exist outside it where gamers will share cheats and other information that enables them to progress through the games. When a gamer fails to meet a challenge, they do not lose status and are able to maintain status or face within their group.

High interactivity: The games environment allows gamers to interact with others, particularly in on-line games or games with multiple consoles. The interactions can be social as well as cognitive so that gamers can act, think, speak and seek advice. This can be in the immediate context of the game or beyond the game context. A support industry has been developed to support interaction among gamers. These can be on-line or through magazines and blogs.

Customisation and Production: The games environment often allows the gamer to modify the game to suit their needs or interests. In this way they can play the game or shape the game.

Strong Identities: IN the games environment, gamers can take on identities of their characters. These can be shaped by the person so that they are able to assume particular characteristics that will be used in the games. The gamer takes on attributes that he/she sees as important in that game. Similarly, they can take on physical characteristics. Collectively these help to shape a strong identity with the game.

Problems are well ordered: The games designer carefully plans problems so that earlier ones build the skills that are needed for subsequent levels or situations that the gamer will need in order to succeed. For example, in a low level, the gamer learns to tumble but this tumble is needed in the next level but where it is modified so that the gamer will incorporate the tumble with another action to enable a particular challenge to be met. The earlier level is simple and is mastered within that level so as to be extended in the next level.

Pleasantly frustrating: The games environment pusher the player to his/her outer level of confidence but is kept within a level of competence. This challenge is critical to keep the gamer engaged so that while learning new skills, the gamer is pushed but without feeling threatened or inadequate.

Grade of Expertise: The gamer keeps in a level where he/she is able to practice a new skill to a level of competence so that the skill becomes routinised. A new problem is then introduced where the learned skill no longer works so that the gamer is forced to modify and enhance what he/she has learned if he/she is to progress in the game.

Deep and Fair: Games are not set up so as to fail gamers. The game is seen to be fair when a gamer is unable to undertake a particular level. It is the not the game that is seen to be the problem but that the learner needs to develop higher levels of skills to be able to move through the challenges. The game is deep when it looks simple at the start and relative easy to move through but as the gamer progresses through the levels it becomes more difficult and hence more powerful the further the gamer moves into the game. These twin characteristics enable the gamer to see the game as a challenge – too easy and there is no challenge, too difficult and there is no motivation.

Gee's work has profound implications for uniting the habitus that the digital natives bring to a learning environment – whether in pre-school settings, school setting or workplace settings. Where the habitus has been shaped by particular digital practices but the learning environment fails to recognise these new potentials, then it is possible that the formal learning environment may be lacking features that engage young learners.

	Numeracy/Pedagogy	Non Maths lessons	Maths Lessons	Authentic Maths Lessons
NRS Level 4	Select appropriate math'l info	1.56	0.00	3.00
	Select and apply maths strategies	1.44	1.00	3.00
	Reflect on & question reasonableness	2.00	0.75	2.75
	Oral and written formal language represent	2.44	2.13	3.00
	Meaning making strategies	2.11	0.75	3.75
	Problem solving strategies	2.44	1.13	4.00
	Mathematical knowledge	2.22	2.38	3.75
	Mathematical representation	2.44	2.38	3.50
New Numeracies	Problem solving	2.44	0.88	4.00
	Estimation	1.67	0.88	4.25
	making sense of models	2.22	1.25	
	Intelligent use of calcs ICTs	1.67	1.75	3.50
	Holistic thinking	3.22	0.50	3.25
	Communication & representation	3.44	1.38	
	Authentic situated tasks	3.33	1.13	3.50
	Adaptability	2.78	1.00	
	Informal measurement	0.89	0.00	
	Aesthetics and functionality	3.67	0.25	
Productive Pedagogies	Higher order thinking	1.78	0.25	3.50
	Deep knowledge	2.22	0.13	3.00
	Deep understanding	2.22	0.25	2.75
	Substantive conversation	2.56	0.50	2.00
	Knowledge as problematic	1.33	0.00	1.50
	Metalanguage	2.89	0.50	1.50
	Knowledge integration	2.56	0.25	2.75
	Background knowledge	2.33	1.13	3.75
	Connectedness to the world	4.22	1.50	4.50
	Problem-based curriculum	2.33	0.38	4.25
	Student direction	2.89	0.13	1.50
	Social support	4.67	2.88	3.25
	Academic engagement	3.11	1.38	3.25
	Explicit performance criteria	4.33	2.25	2.50

	Self regulations	3.67	1.50	2.75
	Cultural knowledge	2.33	0.38	0.00
	Inclusivity	2.33	0.25	0.25
	Narrative	2.67	0.63	0.75
	Group identity	3.78	0.75	0.25
	Active citizenship	1.78	0.25	0.00
Digital Environments (Gee)	Low cost failure	2.67	2.00	2.50
	Competitive collaboration	3.67	1.13	1.75
	High interactivity	3.56	1.00	3.25
	Customisation & production	4.67	0.25	1.00
	Strong identities	3.00	0.38	0.00
	Well ordered problems	3.44	2.13	3.00
	Pleasantly frustrating	3.11	0.88	2.75
	Grade of expertise	4.11	1.75	1.75
	Deep and fair	2.33	0.13	2.25
	Empathy for complex systems	2.00	0.25	1.50
	Simulation of experience	3.56	1.25	3.00
	Artificial intelligence	2.67	0.25	3.25
	Cross functional teams	2.33	0.13	0.75
	Situated meaning	3.00	0.75	3.50
	Open mindedness	1.11	0.50	2.50
	Assessment	4.56	2.38	2.50

Table 3: Summary of Lesson Observations

From Table 3, it can be observed that there is a general trend where the scores in the mathematics lessons were generally lower than in non-mathematics lessons. These results are somewhat troublesome as they suggest that non-mathematics lessons may be able to adopt numeracy-based approaches to teaching mathematics/numeracy more appropriately than in mathematics lessons.

When teachers adopted a more problem-based approach to teaching mathematics, as will be explained in greater detail later in this report, the scores for mathematics lessons increased.

When considering dimensions related to the teaching of NRS Level 4, the data in Figure 1 below, it can be observed that in each dimension, the scores were considerably higher in every dimension than both mathematics and non-mathematics lessons.

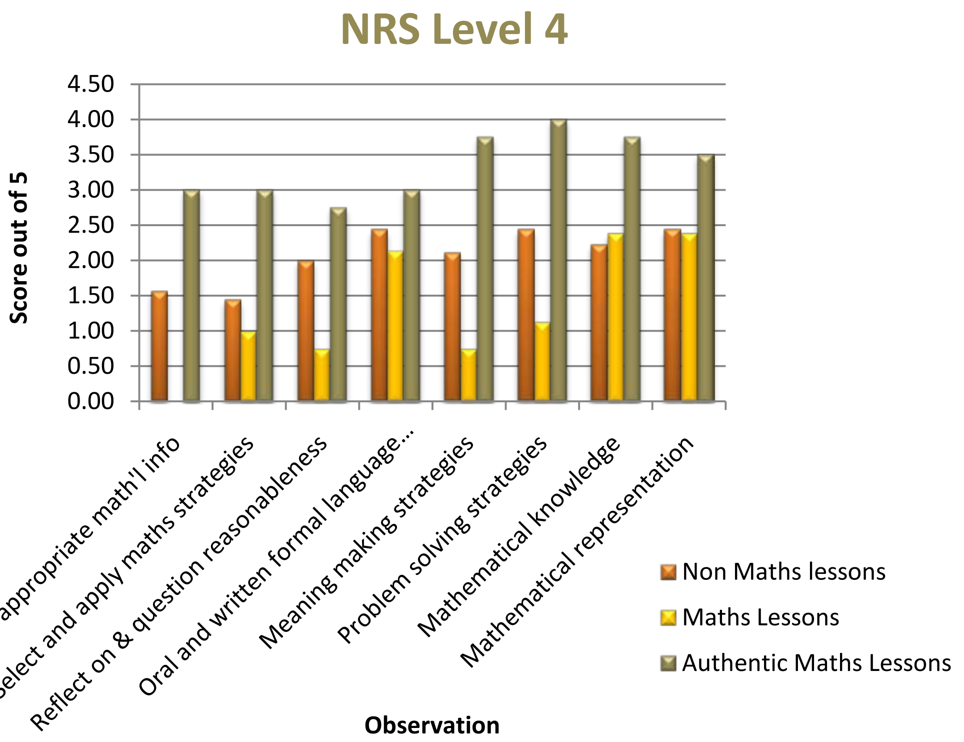


Figure 1: NRS Level 4

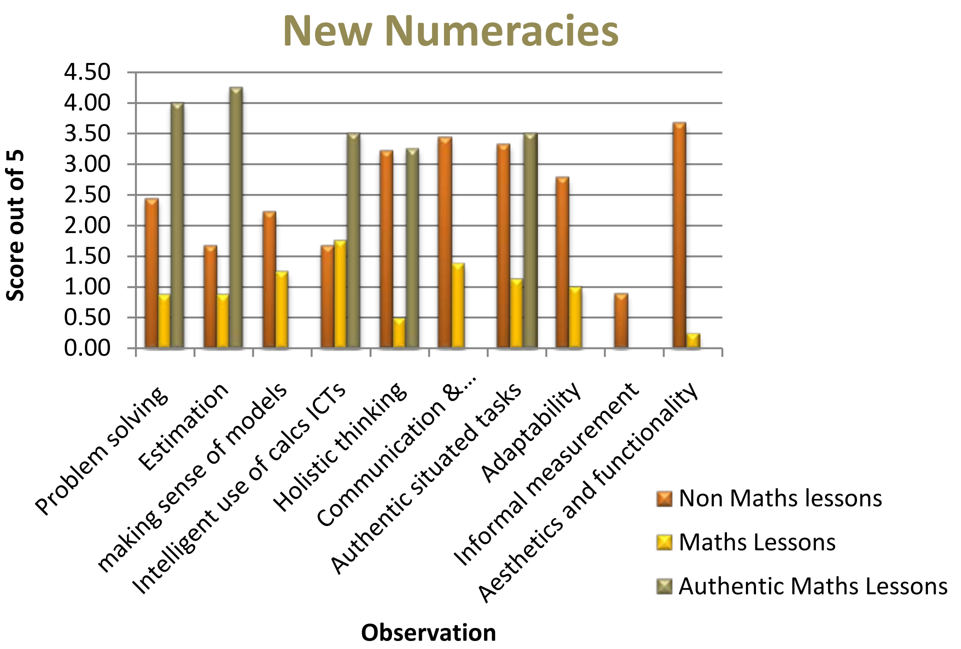


Figure 2: New Numeracies

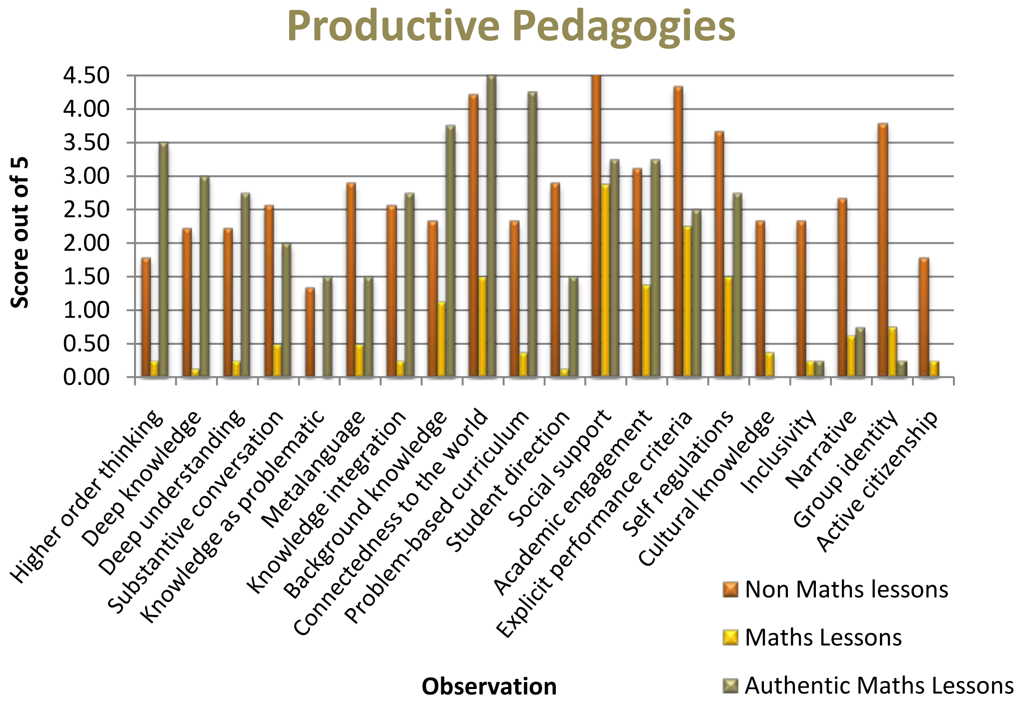


Figure 3: Productive Pedagogies

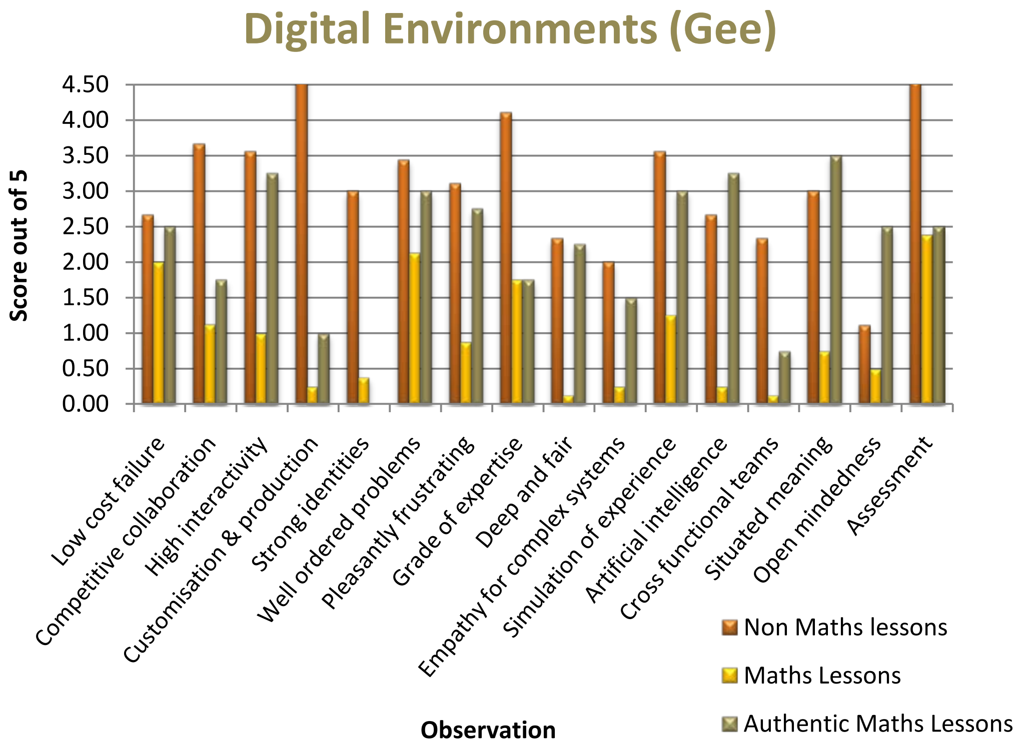
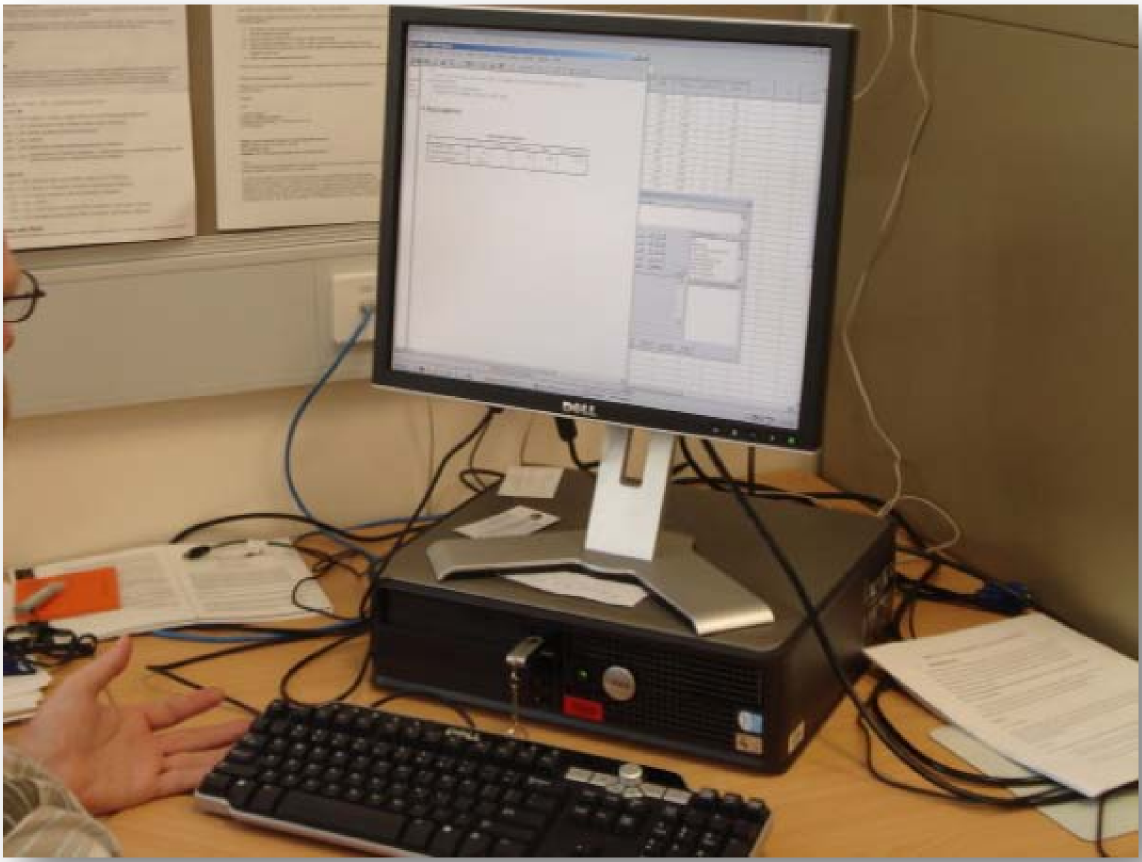


Figure 4: Digital Environments (Gee)

Implementing School-Based Authentic Task: Case Study



Drawing on the ideas from the Building Program designed for the Building College, one of the schools in the study undertook a part of this program. The school modified the selected activity to fit in with the school program. This task involved the students planning, budgeting and building a number of garden beds. The construction unit of work consisted of the following sections:

- Developing a site plan
- Analysing and designing a quote
- Gathering data equipment and labour costs
- Preparing a Gantt Table
- Running the project/Building the garden beds
- Writing a Final Report

Method

Data collection consisted of

- Interviews with the HoD; 3 teachers involved in the teaching of the unit
- Observations of lessons over a period of 2 weeks.
- Observations of the construction of the garden beds
- Follow up interviews with students and teachers
- Survey conducted by HoD with students.

Preparation

The demands for implementing a radically different approach required the school to allow for adequate preparation. In this case, the HoD allowed one teacher a week off class to undertake the necessary preparation

> **HoD:** *I am happy that Steve [teacher] has run with that, and he has been quite enthusiastic about it. I let him have a week off last term to plan, and he took full advantage of that, and I think he has put together a good document which is quite inclusive of marking and planning.*

This planning resulted in a 48 page workbook to be produced that would be distributed to students. There was also some expense to the school to allow for the resources. However, the HoD indicated that these costs were acceptable as there was often little money allocated to the prevocational students.

Benefits of Approach

> **HoD:** *Student engagement. I think that is what it is all about. This has given me a tool, as the head of department, to sort of try and push my staff a little bit, because prevoc quite often gets to be the one that gets left behind, and I realise that, and I am trying to make it more of a priority with my staff, and try and spend a bit of money on it… I am trying to put a little more money and resources to the subject, and push my staff to think a little bit outside the box and not just take that easy option of, 'Oh, I've got another prevoc class,' and that perception of, 'I'm just going to sit down for an hour and just make them do some worksheets.'*
>
> *...And so the student engagement side of things is the biggest thing for me, as head of department.*

The initial comments from the teachers were also positive about the benefits and expectations of the construction unit:

> **Teacher 1:** *Yes. I think it's great. I think it's realistic. I think it's real life for them, and often they will ask questions like, 'Why do we have to do this?' and now they are finding out that this is a real life situation and something that they might do. And I think that they are a bit excited about the fact that they are actually doing something.*
>
> **Teacher 2:** *And I am actually asking them advice, which is a different teaching strategy, because yesterday, we were talking about the lengths of the bolts and nuts for the pine sleepers, and I said, 'Righto, boys, what lengths do they come in?' because I had no idea. So they said, 'Well, it depends on the thickness of the sleepers.' So they are actually giving me – you know, they are teaching me, whereas I don't profess to know everything.*
>
> **Teacher 3:** *The project is giving the kids something tangible, that they can see that they are going to get out of this, rather than just getting another 10 weeks' worth of maths exercises. So the fact there is something visible at the end tends to be something that they haven't really fully believed, because every now and again one of them says, 'We are going to build this, aren't we?'*

From the above quotes it can be seen that the overall feeling is very positive so it will be interesting to see if the teachers hold a similar view when Ruth and Richard go back to Merrimac and conduct follow up interviews with the teachers and students.

Class Observations

In weeks 3 and 4 of Term 3, 6 lessons were observed, of which 4 were analysed using a range of indicators:

- QCE Numeracy
- NRS Numeracy features and performance strategies
- New Numeracies
- Productive Pedagogies
- Gee's learning principles
- Gee's games for learning

These are the same indicators that were used early in the study. Comparing these original data with the data from the authentic task show that there is a significant increase across many of the indicators.

Garden Bed Construction:

On Tuesday 9th September, Robyn and Richard visited Merrimac to capture some footage of the construction of the garden beds. The school had allowed them to allocate the whole day to the construction of the garden beds as it was felt that this would be a more efficient use of time rather than 1 hour blocks over a two week period. The student turnout was very good and while at first many students were hesitant about getting involved, after the morning tea break nearly all students were involved in the project. John, the Head of Manual Arts overlooked the whole project and went through safety issues with the students. The logistics of undertaking such a project were challenging for everyone with delays becoming apparent with the slowness of pouring the cement and working out the most efficient way to construct the wooden frames of the garden bed. I am sure many lessons were learned that day that will prove invaluable next time round.




References

Artzt, A., F., & Armour-Thomas, E. (1997). Mathematical problem solving in small groups: Exploring the interplay of students' metacognitive behaviours, perceptions and ability levels. *Journal of Mathematical Behaviour, 16*(1), 63-74.

Charp, S. (2003). Engaging the tech-savvy generation. *T.H.E. Journal, 30*(7), 8-9.

Education Queensland. (2001). *The Queensland school longitudinal reform study*. Brisbane: GoPrint.

Gee, J. P. (2003). *What video games have to teach us about literacy and learning*. New York: Plagave MacMillan.

Gutierrez, R. (1998). Departments as contexts for understanding and reforming secondary teachers' work. *Journal of Curriculum Studies, 30*(1), 95-101.

Mackay, H. (1997). *Generations: Baby boomers, their parents and their children*. Sydney: Macmillan.

Noss, R., Pozzi, S., & Hoyles, C. (1999). Touching epistemologies: meanings of average and variation in nursing practice. *Educational Studies in Mathematics, 40*(1), 25 - 51.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon, 9*(5), 1-5.

Prensky, M. (2005). Digital Natives: How they think differently. from http://coe.sdsu.edu/eet/articles/digitalnatives//start.htm

Zabel, D. (1999). Selling to Generation Y, virtual workers and baby boomers. *Reference and User Services Quarterly, 39*(1), 1-6.

Zemke, R. (2001). Here come the millennials. *Training, 38*(7), 44-49.

Appendix One

Numeracy, Youth and Employment: A study of contemporary numeracy practices

Executive Summary

This project was a partnership between the Chief Investigator Prof Robyn Jorgensen (Zevenbergen) from Griffith University and The Gold Coast City Council; Centrelink; Gold Coast TAFE; Queensland Studies Authority and SCISCO Career Pathways. The project was initially developed out of a concern of the consortium regarding access to and retention of young people in work within the Gold Coast region. It was recognised that numeracy was an important element of how young people were selected for work as well as their on-going retention in work. Within such a context, it was also recognised that little was known about the contemporary demands of workplace numeracy such that if recommendations were to be developed they needed to be aligned with contemporary practice. As such, the project sought to identify contemporary demands of workplace numeracy through a range of methods.

The study was conducted over a period of three years from 2002-2004 with 2005 being a phase for final analysis of data. An iterative approach was used where the outcomes from one phase were built upon in following phases. The Industry Partners were involved throughout the development of research protocols and on-going analysis, thus providing valuable insights into various aspects of education, training, selection and retention of young people. The approach used a mixed method approach and involved a large scale survey with almost 1000 responses in the first phase. This was followed by 19 case studies of young people in work across a range of industries and skill levels. Arising from the first two phases came a realisation that young people approached numeracy in ways that were quite different from those anticipated at the commencement of the project. The final phase thus involved two distinct processes: first community consultation where focus groups were held to discuss outcomes and reaction from stakeholders; the second was the development of recommendations arising from the outcomes of these three distinct actions.

The outcomes of the project was substantially different from the assumptions that underpinned the initial project. Where it was anticipated that the project would seek to develop strategies to support existing assumptions about workplace numeracy practices, the project highlighted very different expectations and views about numeracy in the workplace between younger and older people. The initial survey showed statistically ($p<0.01$) that there were differences in what the senior respondents (teachers, employers and job placement officers) identified as important aspects of contemporary work when compared with younger participants (students in work; workers and job seekers of 22yrs of age and under). Using a "" analysis it was found that nine variables were identified as being statistically different between the two cohorts – 5 related to aspects numeracy (number – mental calculation; statistics; measurement) 3 related to the use of technology; and 1 to literacy (non-verbal communication). What was interesting in this outcome was that 8 of the discerning variables in the two cohorts could be tied to numeracy and ways of working mathematically in the workplace. It was also noted that senior people saw that mental calculation was a key important numeracy skill whereas younger people were more likely to identify applied areas of numeracy (statistics, measurement etc) as more important in their work. Open-ended responses and interviews further elucidated the ways in which the two cohorts saw these as important.

The second phase of the study involved 19 case studies of young people in work. A preliminary interview was conducted, 3-5days of workshadowing; and a final interview. Interviews with employers were also conducted. It was found that the young people worked very effectively in their workplaces but in terms of their ways of working mathematically, the case studies confirmed the differences found in the survey. It was found that young workers tended to use considerable estimation; informal methods; holistic thinking; and problem solving as they undertook tasks. Furthermore, the impact of technology in the workplace was significant whereby it was found that as an integrated component of the workplace, it had not only changed the ways in which young people undertook their work, but also that they saw technology as a tool to support their work. This also confirmed the survey data in the ways in which the two cohorts viewed technology. Young people were happy to defer cognitive labour to technology whereas senior people were more likely to value mental methods over the use of technology.

From these phases, it was concluded that young people have substantially different ways of working mathematically in contemporary work, often shaped by the use of technology. This technology could be an integral part of the workplace, but equally it is an integral part of their worlds both in and out of work. It has thus shaped how they come to see tasks, particularly mathematics, and how they undertake such tasks. It was found that in many cases, the technological dispositions of young workers meant that they offered new and often more effective ways of working in the workplace but this was not capitalised upon by employers, job placement officers or teachers. Focus groups, public dissemination meetings and other forums have been used to seek reaction from older stakeholders. It has been found that the outcomes confirm the experiences of such stakeholders. However, there is some resistance within some sectors as to retaining old values and methods while dismissing the potential of new ways of working.