Numeracy of First Year Commerce Students: Preliminary Analysis of an Intervention

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Abstract: Literacy and numeracy have become important global educational issues. Numeracy has been shown to impact on the performance of first year tertiary students and evidence suggests that students without recent maths studies are underprepared for programs such as science, IT, economics and accounting (Belward et al., 2007; Alcock et al., 2008). This paper uses a maths aptitude test developed by Ballard and Johnson (2004) to measure commencing commerce student maths abilities. Participating students are then offered a place in a maths workshop to assist with their basic maths skills. We find that the maths skills test is predictive of students' performance in the first year statistics course. Qualitative evidence suggests that students benefited from the workshop in terms of skills development and confidence. We therefore suggest that commencing student attributes will influence graduate attributes and hence demand further attention.

Keywords: Maths Aptitude, First Year Students, Numeracy

Introduction

IN RECENT YEARS the higher education landscape in Australia has changed as the ground swell behind teaching and learning performance has grown. This has come from several quarters. There is increased government interest (and funding) in the quality of learning outcomes, and pressure from professional bodies in terms of graduate attributes and accrediting agencies in terms of accountability for program level goals. The 2008 Bradley Review of Australian Higher Education confirmed the public and private sector focus on teaching and learning activities and reiterated concerns with the work-readiness of graduates, in particular their lack of 'generic' skills (Australian Education Council, 1992; ACCI and BCA, 2002; Bradley et al, 2008). This public and private sector pressure is exacerbated by the changing demographics, attributes and skills of incoming students. For example, there exist concerns about the communication skills of international students, and the literacy and numeracy of domestic students (Parnell, 2009). Underlying this is the increasing diversity of the student mix, and the resourcing and skill required to handle this. This has, in part, led to interest in more comprehensive admission procedures for tertiary programs such as the Federal Government's ongoing pilot of a national Student Aptitude Test for Tertiary Admission (SATTA), and the uniTest assessment developed by the Australian Council for Educational Research (ACER).

The above concerns with and responses to poor numeracy and literacy of commencing students reflects the fact that those skills are predictive of student success, engagement and

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retention in higher education programs. From a tertiary perspective, these matters influence student satisfaction, learning and graduate outcomes and hence the institution's overall teaching and learning performance. The recent AUSSE report highlights this, finding that one in three students seriously consider discontinuing their studies prior to graduation and actual attrition rates range between 22-45% (ACER, 2008). While there are a number of issues that lead to attrition (including personal and financial concerns), it is also known that enhancing student engagement, providing effective support and setting high expectations are effective in combating student retention problems (ACER, 2009). It is on this basis we examine whether an intervention in relation to commencing students' numeracy attributes influences student performance in their first year.

Numeracy has been shown to influence the performance of first year students (Maris and Jacobs, 1995; Alcock et al., 2008) and that students without a maths prerequisite are less prepared for tertiary study (Ballard and Johnson, 2004; Standing, 2006; Belward et al., 2007; Rainsbury and Darroch, 2009). This paper examines whether conducting a mathematical aptitude test ('maths quiz') in orientation week, followed by offering students a workshop program ('maths workshop') to develop (or in some cases refresh) their maths skills influences their performance in a 1st year course.

Based on the performance of the students in their first year and evaluations completed by the students we determine that the maths quiz has predictive power in relation to first year student performance. Furthermore, students report a positive and engaging experience in the workshops, from which they both developed their skills and gained confidence.

The remainder of the paper is structured as follows. The following section provides a brief review of the relevant literature with the research method presented in section three. Section four contains the results with section five discussing both limitations of the research and future directions. Section six contains the concluding comments.

Literature Review

Numeracy (and literacy) has increasingly been under international scrutiny and comparison of primary and high school student competence brings pressure on governments. For example, the Organisation for Economic Co-operation and Development's Program for International Student Assessment (PISA) has gained more attention with each reporting period. While Australia has performed well in these rankings, declines over time have raised concerns. For example in the state of Queensland, which ranked second lowest in Australia in the first National Assessment Program in 2008, the State Government has introduced a range of measures including: compulsory literacy and numeracy tests for new primary school teachers; a new 'Prep year'; reduced class sizes; and an increase to the school starting age. Despite these measures, there remains evidence that class standards are declining (Belward et al., 2007). Given these points, one then must ask whether these lower abilities impact on student learning in a higher education environment, particularly in programs that have quantitative applications in their curriculum.

The existing evidence affirms the importance of studying secondary mathematics vis-à-vis performance in the first year of tertiary study (Maris and Jacobs, 1995; Alcock et al., 2008). Furthermore, a range of studies have found that commencing students' mathematics skills are inadequate for their enrolment in accounting (Rainsbury and Darroch, 2009), business (Standing, 2006), economics (Ballard and Johnson, 2004) and mathematics (Belward

et al., 2007). The Rainsbury and Darrock (2009) study also found that students underestimate their abilities in mathematics, suggesting they may be poorly prepared for first year course work and fail to seek assistance prior to being confronted with the material.

There is a reasonable volume of literature that has assessed the value of students having prior studies in areas such as accounting in terms of then studying accounting at the tertiary level (Baldwin and Howe, 1982; Ramsay and Baines, 1994; and Rohde and Kavanagh, 1996). The same is true of mathematics for tertiary studies in science (Coutis et al., 2002; Barnard, 2003) and information systems (Campbell and McCabe, 1984). In terms of commerce studies, there is little published evidence with the Alcock et al. (2008) study the only published study available at the time of writing.

The lack of research in commerce studies is interesting given the significant number of students in commerce programs, the diversity of students (international students, no clear gender bias as found in some areas such as education, engineering and information technology) and significant numbers of mature age students. Furthermore, the curriculum of a typical commerce program contains significant quantitative content (such as accounting, finance, economics, statistics and financial planning) highlighting the importance of maths aptitude. In addition, the professional bodies in commerce programs (for example CPA Australia, Institute of Chartered Accountants of Australia (ICAA) and the Financial Planning Association) value generic skills that incorporate and assume maths aptitude. In some cases professional bodies have developed accreditation programs that explicitly require universities to include generic skills development in their programs (such as the CPA and ICAA through the work of Birkett (1993)). Evidence to date raises concerns about a gap emerging between graduate attributes developed in university degrees and what industry requires (Albrecht and Sack, 2000; Kavanagh and Drennen, 2008).

Given the concerns over student development, retention and engagement, and the evidence that the mathematical skills of students on entry influence student performance, it is then worth briefly examining the entry requirements that Australian universities currently set for commerce degrees. As Alcock et al. (2008) note, some, but not all institutions have mathematics as an entry requirement and of those that do, most appear to now accept the lower non-calculus maths as meeting the requirement. Others recommend maths, but do not enforce it as a pre-requisite. The outcome of a review of the websites of 39 Australian universities for entry requirements for degrees that incorporate accounting and finance (these disciplines fall under a number of degree names including commerce, business, and business management) are reported in Table 1. This shows that only seven of the 39 universities have an explicit maths entry requirement at some level, 14 recommend prior maths studies or note it as assumed or desirable and one has a maths requirement at one or more campuses, but not at all locations. This leaves 17 (44%) that do not state maths as a requirement for entry to their commerce programs. This outcome is somewhat surprising given the nature of commerce degrees, although in line with the commentary in Alcock et al. (2008). While the reasons for this are unclear, what is certain is that this highlights the need for commerce faculties to understand what maths skills their students bring with them to their first year courses. If the evidence of research noted above holds true (in terms of low and declining maths skills of commencing students), then the teaching and learning response to this may be an important element of student engagement and retention strategies. It is in this respect the maths quiz with revision workshop was developed. The performance of the students who completed the

maths quiz is then tracked to determine the instructive nature of the instrument vis-à-vis their first year performance, and the impact of the maths workshop.

Table 1: Entry Requirements into Australian Undergraduate Commerce Programs

University	**Program**	**Maths Entry Requirement**
Australian Catholic University	BBus	QLD No, NSW and Vic Yes
Australian National University	BCom	Yes
Bond University	BCom	No
Central Queensland University	BAcc/BFp	Recommended
Charles Darwin University	BAcc	No
Charles Sturt University	BBus	No
Curtin University of Technology	BCom	Desirable
Deakin University	BCom	No
Edith Cowan University	BBus	No
Flinders University	BCom	No
Griffith University	BCom	No
James Cook University	BBus	Recommended
La Trobe University	BAcc	Yes
Macquarie University	BCom	Assumed
Monash University	BCom	Yes
Murdoch University	BCom	Recommended
Queensland University of Technology	BBus	Recommended
RMIT University	BCom	No
Southern Cross University	BBus	No
Swinburne University of Technology	BCom	No
University of Adelaide	BCom	No
University of Ballarat	BCom	Yes
University of Canberra	BCom	Recommended
University of Melbourne	BCom	Yes
University of New England	BCom	Recommended
University of New South Wales	BCom	Recommended
University of Newcastle	BCom	Assumed

University of Notre Dame Australia	BCom	Recommended
University of Queensland	BCom	Yes
University of South Australia	BCom	No
University of Southern Queensland	BCom	No
University of Sydney	BCom	Assumed
University of Tasmania	BBus	No
University of Technology Sydney	BAcc	Assumed
University of the Sunshine Coast	BCom	Recommended
University of Western Australia	BCom	Yes
University of Western Sydney	BBus & Com	No
University of Wollongong	BCom	No
Victoria University	BBis	No
This table contains information drawn from the relevant universities websites (retrieved 10 July 2009).		

Research Method

This paper applies a mixed methods research approach. The relevant "mixing" involves a sequential use of qualitative and quantitative research methods. First, a testing instrument is used to determine student maths aptitude (the maths quiz). Second, students subject to the testing instrument voluntarily participate in a workshop series designed to improve student maths aptitude (the maths workshop). Students complete a qualitative evaluation at the conclusion of the maths workshop. The students' qualitative statements serve two main purposes:

- To identify the benefits of the maths workshop in terms of numeracy skills and self-confidence; and
- To support the continued, and potentially compulsory, offering of the maths workshop for poor performing students in the maths quiz.

These purposes are particularly important, if there is a predictive value of the maths quiz on student performance in the first year statistics course. Finally, quantitative methods are employed to examine the resultant data. These instruments and the resulting sample are discussed in turn below.

Maths Quiz

Two commencing student groups are asked to complete a maths quiz in their orientation programs. The test is in the form of a 10 question quiz drawn from Ballard and Johnson (2004) which is designed to provide information on the basic maths skills of students. This is seen as a relatively robust measure as the students were not aware of the impending 'quiz'

and hence could not have prepared for it. Students completed the maths quiz in exam like conditions and the purpose of the test (providing them an indication of their abilities and the subsequent workshop program that was offered to assist them with their first year studies) was provided. The question papers were collected, marked, and the results distributed to students along with details of the workshop program.

The results show that of the 144 students that completed the quiz, slightly more than half (51%) of the students failed to gain more than 6/10 on the quiz, which for the purposes of this experiment was seen as representing weak maths skills: Table 2. The sample had more females than males, however both genders had approximately a 50% failure rate. In terms of age, approximately half of the under 20's passed the maths quiz, while the 20-30's group faired slightly better with 55% passing. The over 30's group performed the worse with 75% failing.

Table 2: Summary Maths Quiz Results

Sample	**N**	**Score**	**%**	**Male**	**Female**	**Age<20**	**Age 20-30**	**Age >30**
All	144	6.45	100%	56	88	73	56	15
Score <=6	73	4.93	51%	27	46	35	26	12
Score >6	71	8.06	49%	29	42	38	30	3
Note: This table contains summary student results from a basic maths quiz completed during orientation.								

Maths Workshop

Of the 144 students that completed the quiz, 37 participated in the maths workshops, 34 of which failed the quiz. This left 39 students who 'failed' the quiz and 68 that 'passed' the quiz that did not attend the workshops. The workshops were conducted over two consecutive days and consisted of six, two hour sessions. Given the time and resources available and the small number of students that attend it is unlikely to result in an immediate, statistically significant, impact on the students' grades. Nevertheless it is hoped that attendance at the workshop will have a cumulative effect over the course of the students' degree program by reducing their maths anxiety and increasing their confidence in their own ability to cope with the mathematical content of their courses.

The curriculum of the workshop is, in the strictest sense, remedial and is motivated by the presumption, which is offered to the students as an explanation of their difficulties, that at sometime in the distant past they have misunderstood some simple mathematical concepts and operations. It is these misunderstandings that may have undermined their confidence and abilities throughout the remainder of their schooling. This presumption can directly contradict students' own perceptions of the source of their difficulties which they generally attribute to being 'just not good at maths'. Consequently the workshop begins by persuading the students that the source of their difficulties are to be found at the most basic level and that the purpose of the workshop is to give them an opportunity to work with the lecturer to find the particular misunderstanding that lies at the heart of their difficulties and through practice, fix it.

The mode of delivery would best be described as a version of 'chalk and talk' which encourages students to participate by continually interacting with each other and the lecturer in an atmosphere informed by the fact that all of the students present have difficulties. It is made clear to the students that everyone will make mistakes, that identifying these mistakes is a necessary prerequisite to improvement and therefore, no one, including the lecturer, need feel embarrassed about making mistakes in front of the other students. The simple message is that we are working together to fix the problem.

The nature of the workshop is such that a strict curriculum designed around an assigned text book would be more of a hindrance than a help and would also discourage attendance by increasing its cost, which is primarily confined to the time needed to attend. Students are asked to bring a simple calculator, rather than a scientific or financial calculator, a note book in which they can do rough working out and an exercise book in which they will in effect create their own text book. It is hoped that through this last element the workshop will have a continuing impact. In the exercise book the students are asked to record the basic rules of algebra as they are revised and their own examples, written in their own hand, of how they work. This book will not only provide the students with a ready reference to basic mathematical operations but provide them with evidence, in the form of their own recorded examples, that they can do maths and they did understand these basic rules. Therefore, it is envisaged that the students will leave the workshop persuaded that any difficulties they may encounter in their courses can be ameliorated through revision, practice and persistence.

The first day of the workshop deals exclusively with the basic rules of algebra beginning with the rules of addition, subtraction, multiplication and division as they apply to positive and negative numbers. It is here that difficulties are usually first encountered in respect to operations involving negative numbers and fractions. Having dealt with these matters the course moves on to dealing again with these basic operations in combinations involving brackets where a negative sign in front of a bracket is a common cause of confusion. From here we go on to cover again these same operations involving indices and finally logarithms. At the end of this first day the students have in effect written themselves a ready reference to all of these simple operations and recorded examples of how they work in their own hand. They have also, with rare exception, discovered that they did not have a firm grasp of these most basic of mathematical operations and that this is in all likelihood the source of the difficulties that have led them to believe that they are 'just not good at maths'.

The second day of the workshop deals with using the basic rules to first solve equations involving one variable. The difficulty here is simply to persuade students by demonstration that the equals sign is an 'equality sign' and that consequently nothing is changed by performing the same operation on both sides of the equation. This part of the workshop is perhaps the most important as it builds confidence in dealing with equations which students often find frightening and mysterious. On occasions this results in the students competing with each other and the lecturer to find the simplest and most elegant solution. Solving the same problem in two or three different ways is a useful exercise, as is asking a student who obtained the correct answer using a different approach to explain to the class exactly what they have done. At some point examples involving two variables are introduced which naturally leads to the student solving simultaneous equations. At this point it is helpful to pause briefly with an example of the solution to just such an equation on the white board to remind the students just how far they have come. That is, in less than two days they have gone from not under-

standing how to divide one fraction by another or to subtract one negative number from another to solving systems of equations: how can they 'just not be good at maths'?

The final session of the workshop reviews examples of the maths that the students will encounter in their actual course work. Examples include the calculation of variance from statistics, calculations involving interest rates from finance and accounting and the graphical representation of equations from economics. The point of these demonstrations is to impress on the students that the equations they have spent the day solving are all more complex than those that they are likely to encounter in the course work and consequently should not cause them any great concern when they are encountered.

Student Performance Descriptives

The resultant data set is divided into four groups: (1) failed the maths quiz and attended the workshop; (2) failed the maths quiz and did not attend the workshop; (3) passed the maths quiz and did not attend the workshop; and (4) passed the maths quiz and attended the workshop. Table 3 shows that Group 4 had only 3 constituents (as expected) and hence is not included in much of the analysis, other than to note that some students thought it worthwhile to refresh their skills. Of the students that failed the maths quiz, less that half undertook the workshop, resulting in 24% of the sample in Group 1 and 27% in Group 2. In addition, more females who failed the maths quiz attended the workshop with 27% (25%) of the female survey respondents in Group 1 (2), while only 18% (30%) of males. Hence, more female students sought assistance with their basic maths abilities in comparison to males. Interestingly the three students in Group 4 are also females.

Table 3: Descriptive Statistics

Group	N	Male	Female	Age<20	Age 20-30	Age >30
1	34	10	24	17	10	7
2	39	17	22	18	16	5
3	68	29	39	37	27	4
4	3	0	3	1	2	0
Pooled	144	56	88	73	55	16

Results and Discussion

The empirical analysis that we have been able to perform has confirmed that performance on the maths quiz is predictive of students' performance in the introductory business statistics course. This however, did not produce any statistically significant evidence of improvement in performance that can be attributed to the maths revision workshop. The analysis involved regressing the students' final mark in the business statistics course on their mark out of ten in the maths quiz, their age, a dummy variable indicative of their gender and another dummy variable indicative of attending the maths workshop.

$$Stats\_Mark_i = \beta_0 + \beta_1 Quiz\_Mark_i + \beta_2 Age_i + \beta_3 Gender_i + \beta_4 Attendence_i + \varepsilon_i \quad (1)$$

The estimated coefficients on age, gender and attendance were found to be statistically insignificant at all traditional levels of significance and were removed from the model which was re-estimated giving the following results:

$$\hat{Stats\_Mark}_i = \underset{[7.8]}{53.66} + \underset{[2.5]}{2.4}\, Quiz\_Mark_i \qquad (2)$$

$$N = 46 \quad s.e. = 13.01 \quad R^2 = 0.13 \quad JB = 2.4 \quad DW = 1.8$$

This regression indicates that the maths quiz mark alone explains 13% of the variation in the student's result in the statistics course and that for each additional mark on that maths quiz, results in an average rise in the students' statistics mark of 2.4. This finding is supported by the literature discussed above in terms of commencing students' maths abilities influencing student performance. The key to understanding why attendance did not demonstrate a measurable increase in marks in the business statistic course lies in the sample which includes only 46 observations. This sample was obtained by collating the relevant information on the students who enrolled in business statistics for whom we had both a maths quiz mark and a statistics mark. The course involved 108 students of whom only 49 took the maths quiz; three of these students with maths quiz marks that our model indicates would have passed the course without difficulty withdrew for reasons unknown. The remaining sample of 46 contains only one student who failed the course and did have a very low score on the maths quiz. The remaining 59 students who did not take the maths quiz present a different picture. Of these eight completed all assessment items and subsequently failed the course, another seven failed the course having not completed all of the assessment items and another eight withdrew from the course for reasons unknown. This indicates that the students motivated and interested enough to take the maths quiz and attend the maths workshop (if necessary) account for only 13% of the total number of students who failed the course.

We contend that the maths quiz and subsequent workshop served as a convenient method of revision for motivated and interested students while it would appear the opportunity it presented was not taken up by those students in most need of assistance. Clearly the voluntary nature of the maths quiz and attendance at the maths workshop will have to be reconsidered. This would introduce difficulties as many of the students at the workshop expressed their appreciation of the fact that those who did not want to be there were absent. It may be worth considering holding two workshops - a brief voluntary workshop for those whose maths quiz mark was five or six (which represent the majority of students in this data set who attended the workshop) and another longer compulsory workshop for those whose maths quiz results are at the lower end of the scale.

Students at the maths workshop were also asked to complete a standard evaluation form. This qualitative data provides additional insight into the relative success of the maths workshop. For many students, the workshop served as a timely 'refresher' and gave them confidence in tackling mathematical tasks in their first year courses:

> It has already helped me understand the formulas and workings in Money, Banking and Finance and Intro to Financial Planning.
> Maths workshop refreshed my basic maths skills.

> It makes equations in the lectures much less daunting, when we have seen and understood them before.

Other students noted that the workshop assisted with their skills development and clarified long held uncertainties in terms of their maths knowledge:

> I think I benefited from attending the maths workshop because it cleared up a few errors that I had and I understand the concept of things better now.
> I think I will benefit from attending the Maths workshop because on day 1, I heard 2 + 2 and now it had equations that I haven't seen and experienced. I enjoyed the maths workshop.

It is also interesting to note that all students believed the maths workshop should be offered in the future and some went so far as to suggest that it should be compulsory for students who 'failed' the maths quiz. Students also felt that their colleagues who did not attend would have benefited from it:

> Yes, definitely, I did benefit a lot from it and I know of lot of other people in our class did too, especially the older students.
> Yes, I believe it could be extremely valuable to students to have, considering that being accepted to Uni doesn't mean that you know year 12 maths or that you are supposed to know (which I didn't) prior to acceptance into Uni.

In summary, the students that participated in the workshop provided very favourable feedback on their experience. It is clear from this that they benefited from the workshop on several levels including confidence, affirmation of abilities, skills development and its relevance to courses in their first year studies. Based on this, together with the evidence of the predictive ability of the maths quiz, we conclude that commencing students in the commerce program benefit from recent studies in maths.

Limitations and Further Research

The research conclusions reported here need to be viewed in light of several limitations including the small sample size and case study nature of the work. Further research will help mitigate these, and further add to our knowledge, by expanding the dataset, using alternate student engagement mechanisms and more rigorous evaluation processes.

It is noted that student non-participation (in both the quiz and the workshops even when performing poorly on the quiz), undermines the process. Consequently, we suggest that further steps are required to further engage students in this process, with one possible solution being a mandatory bridging program for students that either fail an entry maths quiz, or do not have a maths prerequisite.

Conclusion

Concerns about declining numeracy of commencing students, the received evidence of the impact of maths abilities on student performance and the acceptance of the importance of generic skills development, motivated this paper. In addition only a small number of com-

merce programs offered by Australian universities enforce a maths prerequisite. We investigate the maths aptitude of first year commerce students and the impact that this and an associated voluntary maths workshop program has on student performance. We find that the maths quiz has predictive power in terms of student performance in the first year business statistics course. This supports prior literature in regards to the lack of preparedness of first year students for tertiary education. Furthermore, student feedback on a maths workshop offered to all who participated in the maths quiz is positive and provides preliminary evidence of improvement in student confidence and skills. Also, an entry maths quiz is useful as a self assessment tool for students, and when supported with a workshop/seminar series will provide positive benefits for students while generating goodwill towards the institution. Therefore, we conclude that the current focus on graduate attributes should be matched with concern and resources devoted to commencing student attributes. This may offer an alternative approach to engaging students, developing student skills and generally assuring positive student outcomes.

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