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The effect of academic skills support for numeracy on student performance in a first year university health sciences unit

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Abstract. Increasingly in recent times, first year higher education (HE) students are under-prepared for academic study, with many lacking the necessary numeracy skills for success in mathematically based units of study. This study aimed to determine the efficacy of a numeracy skills assistance strategy for students enrolled in a mathematically based first year health sciences unit at university. Students enrolled in an introductory biomechanics unit were invited to participate via a survey. Participants (n=79), who also indicated their level of prior mathematics experience, were tracked to determine whether they attended supplementary numeracy assistance sessions and whether there was an effect of attendance at these sessions on academic performance in the unit. Results demonstrated no significant effect of attendance at these sessions on performance and no interaction effect of attendance and prior levels of learning. There was however, a significant effect of prior mathematics learning levels on academic performance. Despite a lack of effect of the academic skills intervention, these findings demonstrate that the level of numeracy competence that students bring to university is a clear determinant of performance. In reference to clear evidence in the literature, it was also acknowledged that the intervention investigated in this study may not have sufficiently targeted 'at-risk' students and that other factors, such as student beliefs, attitudes and motivations play a substantial role in determining the success of academic skills interventions. Simply advertising the availability of a supplemental assistance programme, whether formally embedded in an academic unit or not, may not be enough to elicit the desired effect of improving performance and retention in new undergraduate HE students who are under-prepared and lack necessary numeracy skills upon enrolment.

Keywords: higher education; numeracy; academic skills; support; remediation.

1. Introduction

One of the biggest barriers to success for first year higher education (HE) students is under-preparedness due to insufficient core academic skills such as numeracy [1]. Unfortunately though, there has been a long-recognised international decline in the numeracy standards of entry level university undergraduates over the last couple of decades [2-6]. In fact, as early as 1995, the Council of the London Mathematical Society commissioned a report to investigate what they termed as 'the mathematics problem' [7]. In this report, they discussed an "unprecedented concern amongst mathematicians, scientists and engineers in higher education about the mathematical preparedness of new undergraduates" [7]. The reasons proposed for the decline in mathematics preparedness (or numeracy competence) were numerous and complex and included changes to secondary school approaches to teaching science, technology, engineering and mathematics (STEM) curricula; perceptions that mathematics was losing relevance in society; together with a decrease in the time spent teaching and learning mathematics in schools [7]. These findings are exemplified globally with the overall decline in the level of numeracy competence in Australia being, in large part, attributed to a decline in engagement in mathematics by senior high school students throughout this period [8, 9]. Therefore, despite a recent shift in student demographics that includes larger numbers of mature age entrants [10], decades of erosion in numeracy competence has augmented the present 'mathematics problem' [11-13].

Modern pedagogy in higher education recognises the importance of better understanding our new students and what they bring, including their levels of academic competence, specifically so that teachers and institutions may make appropriate adaptions aimed at creating positive student outcomes [14]. Again, it must also be acknowledged that there is a shift in the number and demographics of new undergraduates [10] that adds

to the complexity of this issue. Depending on the institution and the course of study, between approximately 25% and 50% of new undergraduates are mature age (>25 years of age) [10] and many more new undergraduates are enrolling as a direct result of government policies aimed at addressing traditional social inequities in HE [15-17]. Couple these factors with, as Gale [16] states, a university sector business model in Australia that is now heavily focused at driving 'bums onto seats', and HE educators are working with students that have less academic skill preparedness than ever before. With all of this in mind, teachers of mathematics in HE have attempted to engage in a number of studies and practices aimed at addressing the so-called 'mathematics problem' in an attempt to improve student engagement, success and retention [2, 11, 13, 18].

Integrated and holistic approaches to mathematics support for new undergraduates have included utilising specialised numeracy skills staff to work with students and liaise with academic staff [2]; identifying and supporting vulnerable or 'at risk' students [2, 13]; providing pre-entry programmes and workshops to support students identified as 'at risk' [11, 13, 18]; providing supplementary programmes, workshops and resources for 'at risk' students during session or as remediation [11, 13, 18]. There have been varying degrees of success with these strategies and it must also be acknowledged that successful outcomes are somewhat moderated by factors other than just age and prior mathematics education, such as student perceptions, beliefs, attitudes and anxieties regarding mathematics [19-23]. Notwithstanding the influence of these other factors however, the evidence suggests that a variety of approaches, such as those outlined above, can lead to improved student outcomes, including engagement, better learning and greater retention [2, 11, 13, 18].

Therefore, the purpose of the present study was to investigate the efficacy of embedding customised numeracy workshops within session, conducted by a specialist

academic skills staff member, on student performance in a first year university health science unit of biomechanics. A secondary aim was to determine whether the effect of these supplementary workshops on performance was moderated by the level of prior learning in mathematics. It was hypothesised that students who engaged in the supplementary mathematics workshops (attendees) would perform better in assessments than those who did not (non-attendees). It was also hypothesised that this effect would be moderated by the level of prior learning in mathematics.

2. Methods

2.1 Research population and sample

This project was approved by the Human Research Ethics Committee of Southern Cross University (Approval #ECN-16-028). Data was sampled from a cohort of 192 students, enrolled in the first year undergraduate university unit of introductory biomechanics (BIO00207 Mechanics for Movement), in session 1, 2016. BIO00207 is a core unit in a range of health and human sciences degrees at Southern Cross University and requires students to understand and use basic mathematical operations. Students were asked to volunteer for the study by completing a brief survey that included questions about their age, gender and their prior learning in mathematics. Seventy nine respondents (average age 26.0 ± 10.3 years; age range 17 to 65 years; 35 male, 47 female) completed the survey and also completed all assessment tasks, thereby providing the sample for further analyses.

2.2 Prior mathematics learning levels

Due to the heterogeneous nature of the cohort sampled, questions regarding the level of previous mathematics levels were phrased generically. Participants were asked to select one of the following statements as representative of their prior experience with mathematics:

1. *I did not study mathematics in senior high school (years 11 or 12)*
2. *I studied a basic level mathematics course in senior high school*
3. *I studied an advanced level mathematics course in senior high school*
4. *I have undertaken a mathematics unit or course at the university level*

For statistical purposes (see *2.4 Statistical approach* below), participants were grouped as having 'basic' mathematics experience (selected either of statements 1 or 2 above) or as having 'advanced' mathematics experience (selected either of statements 3 or 4 above).

2.3 Embedded academic skills (numeracy) support

A numeracy specialist from the institutions Centre for Teaching and Learning was engaged to provide supplementary numeracy workshops and consultations with BIO00207 students. Resources for these supplementary sessions were developed in consultation with academic staff teaching BIO00207 and, as such, were customized to provide the appropriate context for the biomechanics content. Study participants' attendance with this supplementary service was recorded for subsequent analyses. Participants were then grouped as having attended ('attendees') or not attended ('non-attendees').

2.4 Statistical approach

All data were reported as mean ± SD and all statistical analyses were performed using SPSS v22. A 2 x 2 (Attendance × Math Background) factorial ANOVA was performed to determine whether there were: i) any main effects of 'Attendance' with the embedded supplementary numeracy skills assistance (Attendee versus Non-attendee); ii) any main effects of 'Math Background' due to prior level of mathematics experienced (Basic versus Advanced); and iii) any Attendance-Math Background interactions. Statistical

significance was set at $p \leq 0.05$. When a significant F-ratio was identified, a Bonferroni post hoc test was used to locate the pairwise differences between means. Effect sizes were calculated using partial eta squared (η^2_p).

3. Results

The 2 x 2 factorial ANOVA showed that there was no main effect of Attendance, $F(1,75) = 0.042$, $p = 0.839$, $\eta^2_p = 0.001$, indicating that supplementary numeracy skills sessions had no apparent influence on overall scores from assessment in BIO00207. The main effect analysis of Math Background was however significant, $F(1,75) = 7.374$, $p = 0.008$, $\eta^2_p = 0.090$, indicating that those participants that had completed Advanced levels of mathematics experience prior to enrolment in BIO00207, performed significantly better in BIO00207 assessments than those that had had basic levels of mathematics experience prior to enrolment in BIO00207. The Attendance-Math Background interaction effect was found to be non-significant, $F(1,75) = 0.474$, $p = 0.493$, $\eta^2_p = 0.006$, confirming that performance in assessments was only affected by Math Background, irrespective of Attendance. A breakdown of final assessment scores (mean ± SD) for participants grouped according to both Attendance and Math Background is displayed in Table 1.

< Insert table 1 here >

4. Discussion

Our hypothesis that students who engaged in the supplementary mathematics skills sessions (Attendees) would perform better in assessments than those who did not (Non-attendees), was not supported. Therefore, our secondary hypothesis that any such effect would be moderated by the level of prior learning in mathematics was also unsupported, by virtue of the non-significant interaction effect. Interestingly though, an effect of Math

Background was found, suggesting that prior learning in mathematics was a determinant of performance in BIO00207.

Despite evidence that demonstrates that interventions for numeracy skills assistance with new university undergraduates can improve student performances in mathematically based studies [11, 13, 18], the present study was unable to replicate these findings. Interestingly too, the unit investigated in the present study (BIO00207), while requiring students to understand and perform mathematical operations such as basic algebra and trigonometry, also had a substantial theoretical component (>50% of content), where mathematical operations were not required. Nonetheless, students who had previously studied advanced levels of mathematics out-performed their counterparts with basic level mathematics experience only. It is reasonable to postulate therefore, that being proficient at mathematical operations may also enhance understanding in theoretical concepts in fields where similar skills in logic may deepen understanding. Therefore, future investigations of such units may benefit from analysing a breakdown of performances in assessment tasks with mathematical operations versus demonstrations of theoretical understanding.

Regardless of the non-significant effect of 'Attendance' in the present study, based on empirical evidence [11, 13, 18], it is reasonable to postulate that numeracy support programmes may need to be more targeted and/or, that they should be implemented prior to participation in units where numeracy skills are required. For instance, a proactive support programme at the University of Queensland (UQ) for engineering students, first identified 'at-risk' students based on their performances in pre-requisite studies or whether they were repeat students in the unit [11]. These students were then invited to the programme, which among other things, included an additional 1-hour tutorial per week. They reported a pass rate of 79% for at-risk students who engaged

in the program versus <50% for these at-risk students who did not participate in the program [11]. While the present study found no effect of Attendance at supplementary numeracy skills sessions, there was no empirical determination of numeracy standards via an independent assessment of numeracy skills prior to enrolment in BIO00207. The present study merely asked participants to self-report prior experience in mathematics, without determining current competence.

Objective determinants of numeracy competence have been shown as predictors of performance in subsequent mathematically based units of HE study. For instance, Hieb et. al. [18] reported that student scores in a mathematics readiness exam (taken prior to enrolment), significantly predicted performance and retention in a calculus-based engineering analysis unit. At-risk students were identified by these tests and targeted for a pre-entry remedial programme. Interestingly though, while participants in this study improved their performance in the readiness test, performance in the subsequent engineering unit was not affected by participation in the remedial programme [18]. Contrast this finding however, with analysis of data related to successful academic remediation programmes for 28,000 students in the U.S. college system [13] and the findings by Hieb et al. [18] might be considered as an outlier. Furthermore, Hieb et. al. [18] determined in their study that factors such as motivation and learning strategies were also predictors of performance in their sample. Recognising the impact of this aspect of that study, particularly in the context of well-documented findings of the effects of these factors, and more, on student outcomes [19-23], again demonstrates the level of complexity with this issue.

In conclusion, despite the findings of the present study, or perhaps because of them and the apparent inconsistencies in other pertinent literature, there is a clear need to more cleverly construct any numeracy skills assistance programmes and interventions for

new and under-prepared HE students. Future programmes should objectively determine readiness, immediately prior to enrolment and should also aim to better understand perceptions, beliefs and attitudes of students identified as at-risk by these pre-entry assessments. Identifying at-risk students early and then engaging them effectively, albeit easier said than done, seems to be the key to the success of subsequent intervention programmes and ultimately, student success, engagement and retention. Simply advertising the availability of a supplemental assistance programme, whether formally embedded in an academic unit or not, may not be enough to elicit the desired effect of improving performance and retention in new undergraduate HE students who are under-prepared and lack necessary numeracy skills upon enrolment.

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Table 1. Performance, as the mean (± SD) final percentage score for the unit, of students grouped by workshop attendance and prior mathematics level of study.

		Prior mathematics level of study	
		Basic (n=54)	Advanced (n=25)
Supplementary numeracy skills sessions	Attendees (n=40)	67.8 ± 17.38% (n=35)	83.16 ± 13.75% (n=5)
	Non-attendees (n=39)	71.9 ± 15.89% (n=19)	80.98 ± 14.05% (n=20)