Journal of Academic Language & Learning
Vol. 10, No. 1, 2016, A57-A68. ISSN 1835-5196

AALL
Association for Academic Language and Learning

Failing quantitative literacy: But who is failing? Students or universities?

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(Received 14 August, 2015; Published online 30 January, 2016)

There is substantial evidence that first year business students have difficulty with quantitative subjects, and the literature examines some of the underlying causes of poor results in subjects such as accounting, business statistics and economics. Whilst a range of reasons for poor student performance in these subjects generally have been posited, there appears to be little research into the experience of *international students* in these subjects, despite the large number enrolled in business degrees. For example, what impact might English language proficiency (ELP) have on quantitative literacy? Is there an intersection between these two? If they do indeed intersect, as is posited by this author, then it becomes important to determine whether the English entry standards set by Universities for entry to undergraduate business degrees are appropriate or whether they are setting international students up for failure. While there is a plethora of research about how universities are attempting to assure international student preparedness through English language proficiency levels, there is a void of research on how this relates to quantitative subjects in business degrees. This paper argues that there is a need to address this issue through further research into the intersection between ELP and quantitative literacy to ensure Universities make informed decisions about entry standards and thus fulfil their obligations to assure that all students are appropriately equipped to participate successfully in their course. Further, if there is evidence of a correlation between ELP and quantitative literacy, there are implications for curriculum design, teaching and learning and approaches to learning support which will provide equitable opportunities for international students to participate successfully in their studies.

Key Words: quantitative literacy, numeracy, academic literacy, international students, business degrees.

1. Background

The higher education sector in Australia is currently experiencing a great deal of change brought about, in part, by the demands of globalisation. Increasing connectedness between countries and across cultures has created a mobile student body, with the result that there are increasing numbers of international students seeking to enter Australian Universities. This has resulted in stronger competition between institutions to attract these students to quality higher education, but also in more robust regulations relating to standards and quality assurance. Universities are now required to ensure compliance and assure educational quality through the Tertiary Education Quality and Standards Act (2011) and the TEQSA Higher Education Standards Framework Threshold Standards (2011); standards designed to "support and enhance the national and international mobility of graduates and workers through increased recognition of the value and comparability of Australian qualifications" (AQF, 2013, p. 9).

With the evolution of the regulatory bodies, Universities are experiencing greater scrutiny of a range of practices relating to the student experience and learning, and student retention and success. This is particularly true for the experience, retention and success of international students including the role universities play in assuring, through appropriate entry standards, that international students enter university equipped to participate and be successful in their studies (Dawson & Conti-Bekkers, 2002; Dooey & Oliver, 2002; Feast, 2002; DEEWR, 2007; Australian Government, 2010; Victorian Ombudsman, 2011; Murray & Arkoudis, 2013; Briguglio, 2014; Hewison, n.d.).

However the issue of student preparedness to undertake tertiary studies does not solely relate to international students: it is of concern across the higher education sector, particularly in relation to *quantitative subjects* (those which require students to apply numerical skills to real –world contexts such as accounting or finance) in undergraduate *business* degrees (Ballard & Johnson, 2005; Galligan & Taylor (2005) cited in Brady, 2013; Pozo & Stull, 2006; Alcock, Cockcroft, & Finn, 2008; Cybinski & Forster, 2009; Kremmer, Brimble, Feudenberg, & Cameron, 2010; Stenberg, Varua, & Yong, 2010). Large numbers of international students are enrolled in these degrees--in some instances up to 60% of the student body (Barthel, 2013)--yet, with the exception of the recent work of Kremmer et al. (2010) the research into student preparedness to undertake quantitative undergraduate subjects focuses on mathematical skills only and fails to comment on, or explore the impact of, the diversity of the students, particularly the cultural and linguistic diversity of international students.

The literature clearly identifies that there are links between English language proficiency and performance in mathematics subjects in higher education (Galligan, 2001; Barton & Neville-Barton, 2003; Yushau, 2009) but only two studies could be found which identified that there was a similar link between English language proficiency and performance in *quantitative* subjects (Wong & Chia, 1996 and Bretag, 2004). One of the key University entry standards for international students is English language proficiency and yet, while there is a plethora of research around how universities are attempting to assure international student preparedness for higher education generally through English language proficiency levels (ELP), there is a void of research on whether these standards are appropriate for entry into business degrees which include quantitative subjects.

Given this void, there is a critical need to conduct research to determine whether the existing English language entry standards set by universities for students to enter undergraduate business degrees are appropriate to the requirements of the quantitative subjects within those degrees. Whilst universities purport to have appropriate entry standards, there is no evidence to confirm that this is the case: in fact, based on the evidence from mathematics subjects, it is questionable. This then raises the question: are universities failing international students when it comes to determining the students' preparedness to enter undergraduate business degrees which include quantitative subjects. In order to answer this question it is first necessary to position the discussion by identifying the type of subjects referred to as 'quantitative subjects' in a business degree, and what is meant by quantitative literacy in this paper.

Quantitative subjects in business degrees generally refer to subjects which require a level of quantitative literacy such as accounting, finance, economics and business statistics. Other business subjects may also require some quantitative literacy skills (such as understanding the concept of 'price' and how it works in a marketing context). Unlike pure mathematics or applied mathematics disciplines such as physics or engineering, quantitative subjects are those that require the application of numerical skills to a broader context, subjects which "… [require] experience in the use of mathematics beyond the mathematical classroom, and hence [require] an across the curriculum commitment" (Human Capital Working Group, Council of Australian Governments, 2008 in Goos, Geiger, & Dole, 2012, p. 148). Hogan (2000) refers to these subjects as those which use mathematics in 'real' contexts; which require the capacity and skills to use numbers in contexts outside the classroom.

Balatti (2013) gives some insight into the range of terms that are used in the literature to identify this skill including: numeracy; quantitative literacy; quantitative skills; mathematical literacy;

numerical skills; financial literacy; statistical literacy and economic numeracy (see also Morony, Hogan, & Thornton, 2004).

The term 'numeracy' is most commonly used in the literature in Australia and the UK (Goos, Geiger, & Dole, 2012). In the higher education context Brady (2013) uses the term "academic numeracy", defining it as "…the capacity to confidently and competently use mathematics at university level, and to be able to apply, interpret, critique and communicate mathematical concepts in particular disciplinary contexts" (p. 1). This is a helpful definition in that it acknowledges the disciplinary contexts.

'Quantitative literacy' is the term used mostly in the United States (and often interchangeably with 'numeracy' in the literature) and, by definition, identifies the elements of quantitative literacy as:

> confidence and comfort with quantitative methods, appreciation for the role of mathematics in science and culture, ability to understand and interpret data, logical thinking, decision making, ability to apply mathematics appropriately in a given context, ability to estimate numbers accurately, practical skills in solving real-world mathematical problems, the ability to use a wide range of mathematical and statistical tools, and understanding of mathematical symbols. (Steen, 2001, as cited in Linton, 2010, para. 3)

McClure and Sircar, writing about the importance of quantitative literacy for business students in the 21st century, use Dingwall's definition: "An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication, capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work". (Dingwall, 2000, cited in McClure & Sircar, 2008 p. 369). In the context of a higher education business course, it is the author's view that the term 'quantitative literacy' as defined above more accurately encompasses the requisite skills in quantitative subjects; thus the term 'quantitative literacy' is used throughout this paper in preference to 'numeracy'.

2. The Intersection of Quantitative Literacy and Language

2.1. Points of Intersection

There are a number of points of intersection between language and quantitative literacy: where the importance of proficiency in language impacts capacity to successfully engage in quantitative activities.

Firstly there is the use of everyday vocabulary which takes on a unique meaning in a mathematical or quantitative context. Consider the following examples: operation, range, product, table, mean, capital, demand, growth, round, reduce or take away (Barton & Neville-Barton, 2003; B. Vance, personal communication, October 30, 2015). In addition there are a range of homophonic words which vary in meaning between everyday use and quantitative use. For example: sum and some, plane and plain and mode and mowed (Meiers, 2010).

Secondly there is the use of different words to signal the same concept such as add, sum, increase and plus, or off, deduct, take away, subtract and minus.

The use of prepositions is also critical in dealing with quantitative word problems but can be unfamiliar to students from non-English speaking backgrounds. Consider the following three sentences as an example: "The cost was reduced by $10. The cost was reduced to $10. The cost was reduced from $10" (Barton & Neville-Barton, 2003, p. 4).

Syntactical structures can also cause difficulties for international students. Barton and Neville-Barton (2003) identify some of these including "… the use of numbers as nouns; the increased use of logical connectors; and the way in which adjectives carry a higher load of conceptual meaning" (p. 4) as well as the use of multiple clauses, long noun phrases and the lack of clear relationship between syntactic units (Meiers, 2010).

The way language is used in quantitative contexts – where literacy and quantitative literacy intersect – has clear implications for international students studying quantitative subjects. Not on-

ly must they attempt to complete the cognitive tasks using quantitative skills, they must also – and often initially – complete a range of linguistic tasks.

2.2. Why it matters: evidence from existing research.

The research provides some specific evidence about the impact of this intersection on student performance. In the school sector the evidence shows that English proficiency is related to mathematics achievement (Austin & Howson, 1979; Secada, 1992, as cited in MacGregor & Price, 1999) particularly for those studying mathematics in a second language. Jones (1982) provides strong evidence for this, particularly in word problems and specifically in a study of the understanding of the relational words 'more' and less'. Zushi (n.d.) provides similar evidence for the necessity to understand English language in a mathematical context: "For example, learners would benefit from knowing that *half price* and *50% off* mean the same thing; that *off* is another word for *subtract, deduct or take away*; and that the adjective *down* is an alternative way of saying *reduced or lowered.*" (para. 12)

In 2001, Zevenbergen (cited in Meiers, 2010) similarly observed, in relation to school mathematics, that "The justification of applied word problems is to attempt to make greater links to the world beyond school. … *What is central is that this contextualising process increases the literacy demands* in school mathematics" (italics added). Given that quantitative subjects at tertiary level rely on 'contextualising processes', Zevenbergen's assertion in relation to the centrality of literacy becomes an important consideration in terms of the skills required by students, including international students, to negotiate these subjects successfully at University.

When it comes to the higher education sector the literature focuses on the relationship between English language proficiency and student performance in pure mathematics subjects. Galligan (2001) looked at English-Chinese language differences in processing mathematical texts, identifying at the outset that in solving mathematical problems, "In the reading and understanding process, language is pivotal" (p. 112). Barton and Neville-Barton (2003) found that 'other-language' (EAL) students experienced a 10% disadvantage in overall performance in mathematics. Gerber, Engelbrecht, Harding and Rogan (2005) found a significant difference between mathematics achievement of Afrikaans students attending Afrikaans lectures and those attending English lectures (the latter being lower than the former). In 2009, Yushau, in response to the lack of attention to the "…crucial role of language in the teaching and learning of mathematics" (p. 915), conducted studies on bilingual Arab university students learning mathematics in English. Yushau found, for example, that the language used to describe units in Arabic is different from English and this leads to misunderstandings during the reading stage. Yushau concluded that "…English proficiency has consistently appeared to be critical for students' performance in different mathematics courses" (p. 924).

Despite the evidence about the relationship between language and mathematics, the research on the intersecting relationship between language and performance in quantitative subjects – as opposed to mathematical subjects – is surprisingly sparse. A study conducted by Wong and Chia (1996) showed that there was an effect of English language proficiency on the performance of non-native English speakers in a first year financial accounting course when students also had a higher degree of proficiency in mathematics. They concluded that their results provided evidence of the importance of considering this intersection of "numerical and communication skills in the accounting discipline" (p. 188).

A second study was conducted by Bretag between 2001 and 2004 at the University of South Australia. The scope was broad but the first question explored was "What are the learning issues for ESL business students, particularly those studying Information Systems?" (p. 531). The quantitative data Bretag collected showed there were gaps between learning outcomes of international ESL students and native speaking students, but that with learning support, the gap narrowed and international students who availed themselves of support provided by the University out-performed those who did not.

Finally, a study conducted by Barratt, Hanlon, and Rankin in 2011 identified the benefit of context-specific skills support for students from non-English speaking backgrounds in a post-

graduate accounting subject, focussing on the language of the discipline rather than the quantitative skills required.

Since these studies, there appears to be little other published research conducted specifically in the area of English proficiency and international student performance in quantitative business subjects.

An additional aspect of language is the cultural component. Language is a key element of culture. In fact, Kramsch (1998) posits that language is the way of embodying or expressing culture and therefore the two are inseparable. Attitudes, beliefs and values – components of culture – are reflected in the way language is used and in fact *shape* how language is used. The impact of the relationship between language and culture in education is not new: Austin and Howson (1979), in looking at the relationship between language and mathematical education, highlighted the impact of culture on language, and the implications for students in understanding mathematical concepts in a review of research conducted between 1956 and 1973.

Since that time research in this area of language and culture has used the term 'socio-linguistics' as a framework to explain the cultural aspect of language and its application to mathematics education (see Moschkovich, 2007 for a review). "Sociolinguistics stresses the social nature of language, starting from the assumption that language is not only cognitive but also cultural, social and situated" (Moschkovich, 2007, p. 122). An example of this with a word problem in a quantitative subject might be the difficulty a Middle Eastern student would have identifying the financial impact for a business on greeting card sales over the 'festive season' in November/December. International students may be disadvantaged because they are unable to correctly identify what the question is asking because of socio-linguistic factors, rather than being unable to perform the requisite mathematical computations.

In a similar vein is the ethno-mathematical framework which holds that mathematics is culturally and socially constructed. Mathematical knowledge is "…expressed in the language code of a given socio-cultural group… tightly linked to its reality and being expressed by a language… umbilically connected to its culture; its ethnos" (Borba, 1990, p. 40). This variation in the way cultures express numbers or mathematical knowledge can be evidenced in uses of "…jargon, codes, symbols, myths and ways of reasoning and inferring" in numerical contexts (Francois, 2009, p. 1517). Code in Chinese, for example, can be read and written from left to right or from top to bottom; as previously mentioned Arabic it is read and written right to left as opposed to English which is read and written left to right. Arabic also uses . to represent zero and 0 to represent 5 (Yushau, 2009). Furthermore, culture can impact the perception of logical patterns, notions of equality and the use of number systems which may not include ways to represent zero or large numbers, and which may attach to objects rather than being used in an abstract sense (Austin & Howson, 1979). These examples clearly indicate that the culture may have implications for the way an international student would understand mathematical or quantitative concepts in English.

Francois (2009) provides an excellent overview of ethno-mathematics and its changing role in mathematical education. She states very clearly that the concept of ethno-mathematics must translate to "…mathematics education where the teacher is challenged to introduce the cultural diversity of pupil's mathematical practices in the curriculum..." (p. 1518) and cites Prediger's view (1997) that "Starting from pupils' mathematical knowledge and their everyday mathematical practices is a basic principle of the new orientation towards realistic mathematics education and the development of innovative classroom practices" (p. 1519).

Once again, however, the research focuses on ethno-mathematics in a mathematics classroom rather than a quantitative subject, and the mathematical education referred to in all the literature reviewed is that at school level rather than in higher education. What is worthy of consideration is what Prediger's 'principle' might look like in the context of a higher education accounting or economics classroom with a diverse cohort.

3. Setting the standards: Have we got it right?

If it is accepted that language and quantitative literacy do, in fact, intersect, and in light of the evidence in the literature supporting the impact of this intersection on student performance, we return to the question at hand: are universities failing international students in responsibly ensuring that the students are appropriately equipped to participate in their studies.

International students entering Australian universities must meet minimum English language proficiency levels as well as academic standards. The most common measure of English language proficiency for international students in Australia is the Academic IELTS score (International English Language Testing System) (Dooey & Oliver, 2002; Feast, 2002; Victorian Ombudsman, 2011). This is a score based on a student's performance in four modules covering the four language skills – listening, reading, writing and speaking. Where an IELTS score is not provided, students are required to provide satisfactory evidence that they have achieved at a similar level to a required IELTS score.

The minimum IELTS score required to enter any Australian university at undergraduate level is an overall IELTS score of 6.0 with no sub-score (individual module score) less than 5.5. Many Universities require an IELTS of 6.0 with no sub-score below 6.0. Some Universities require higher scores for particular undergraduate courses and/or for post-graduate study. However, "in general, an Overall Band Score between 6.0 and 7.0 in the Academic modules is accepted as evidence of English language proficiency for higher education institutions around the world" (Ciccarelli, 2001, p. 1, as cited in Feast, 2002).

According to the IELTS guide for education institutions (cited in the Australian Government's Review of Education Services for Overseas Students (ESOS) Act 2000, 2010), an IELTS score of 7.5–9.0 would be acceptable for a linguistically demanding academic course (such as medicine or law), an IELTS score of 7.0 would probably be acceptable, and at 6.5, English study is deemed to be needed. For linguistically less demanding academic courses (such as information technology or pure mathematics), an IELTS of 7.0 and above is deemed acceptable, 6.5 is probably acceptable and 6.0 means English study is needed (see IELTS (2013)).

A business degree would arguably fall into the category of a linguistically demanding course which means that with an entry level of 6.0 or even 6.5, by IELTS' own definitions, English study is needed. If one argued that business was not a linguistically demanding course, then an IELTS of 6.5 is only 'probably acceptable' and at 6.0, English study is needed (Australian Government, 2010).

One of the key differences between IELTS 6.0 and 7.0 is that at 7.0 the user "generally handles complex language well and understands detailed reasoning". At 6.0 it appears they cannot be expected to understand detailed reasoning and their ability to handle "fairly complex language" is best in familiar situations (IELTS, 2002 cited by Victorian Ombudsman, 2011, p. 22) (see IELTS (n.d.) for detailed band descriptors).

IELTS scores are not intended as a predictor of future academic success and in fact have been shown to have little or no predictive validity in forecasting academic performance (Cotton & Conrow, 1998; Dooey, 1999 cited in Humphreys, Haugh, Fenton-Smith, Lobo, Michael & Walkinshaw, 2012); their purpose is to "… indicate whether or not students possess a level of proficiency in English sufficient to cope with the linguistic demands of an academic program or to cope academically without English proficiency inhibiting their academic performance" (Ingram & Bayliss, 2004, p. 4).

Whilst IELTS is most commonly used by Universities as a measure of English entry standards, as previously highlighted, it is not the sole measure of proficiency; and, where it is used, should only be used as a guide. IELTS does not purport to test the elements of literacy that intersect with quantitative literacy and therefore is not a reliable indicator of proficiency for quantitative subjects. Nonetheless, the Australian Government Review (2010, p. 22) states that: "Providers should ... take responsibility for entry to their courses so that all students enrolled in that course can fully participate and contribute to it." Individual entry should be determined on the basis of

each course's linguistic demands and with a view to ensuring the student has the correct capability (Ingram & Bayliss, 2004).

The established links between English proficiency and performance in mathematics subjects in higher education and the lack of research in relation to *quantitative* subjects, provide a compelling case for the need to conduct further research into the potential effect of English language proficiency on international students' performance in quantitative subjects in Australian business degrees, and the level of English language proficiency realistically required on entry.

It is the view of this author that this lack of research into the intersection of quantitative literacy and English proficiency, combined with the inadequacy of IELTS as a measure of ELP for QL, means that Universities are basing their English entry standards for business degrees on incomplete information and potentially incorrect assumptions, impacting on student performance and retention. This is not to say the entry standards are wrong: simply that more research needs to be done specifically in this area to provide evidence to assure that they are appropriate. Ingram and Bayliss (2004) state: "While academic success relates to many factors, the ability to meet the language demands of certain tasks is clearly connected to proficiency. A lack of linguistic readiness presents a threat to academic success in that it affects the student's confidence , his/her capacity to become involved and included in the learning context, and it also influences the perceptions of those responsible for grading student performance " (p. 55). Institutions have a duty of care to ensure that the students they enrol, particularly international students, have the requisite English proficiency to engage in their course of study in a positive and effective way. If this cannot be assured through the use of IELTS testing it may be that Universities should consider the development of a pre-enrolment test specifically for courses requiring quantitative literacy or, at the very least, take steps to ensure that students are adequately supported to develop their quantitative literacy post-entry.

4. Working with current standards: what are we doing and is it enough?

Until more research is completed and evidence becomes available it falls to individual institutions to adopt their own approaches to improving student preparedness for, and capacity to successfully participate in, quantitative subjects.

One approach has been to conduct post-entry numeracy assessments (PENA) as a diagnostic tool to identify students who may be underprepared for studies requiring quantitative literacy skills. The implementation of a post-entry language assessment (PELA) in Australian universities is becoming more common yet there is little data available on whether a similar number of post-entry *numeracy* assessments are conducted (Barthel, 2014) despite evidence that, designed appropriately, they are a reliable predictor of student performance and serve a useful diagnostic purpose in earlier identification of at risk students (Kremmer et al., 2010; McNaught & Hoyne, 2013).

Arguably those institutions that do conduct PENAs are at least attempting to identify students who may be under-prepared; but what of those that do not? Are they failing their incoming students – particularly those from non-English speaking backgrounds? And if the testing instrument is not 'fit for purpose' for quantitative literacy, how valid or useful will it be? Johnson and Kaplan (2008) for example, argue that assessment tests for quantitative literacy must be *specifically* designed, and that doing well on a maths test does not guarantee that a student is quantitatively literate. A post-entry assessment instrument designed to test quantitative literacy skills specifically could prove an invaluable tool to assist universities in identifying students who may require additional support to meet the requirements of their business degree. The development and implementation of one such test at Michigan State University was reported by Johnson and Kaplan (2008); other tests have been successfully utilised at Northern Illinois University (Delaney, Keys, Norton, & Simon, 1979) and Miami State University (Ward, Schneider, & Kiper, 2011). Furthermore, the information obtained from such an assessment could be used by institutions to understand and develop broader practices and assist in planning of QL curriculum, improving teaching practices, and strengthening the skills of graduates which is, arguably, critical (Ward, Schneider, & Kiper, 2011).

A second approach is to embed quantitative literacy development in the curriculum throughout the course of study. Galligan (2013) provides a comprehensive strategy for this approach in a nursing degree. But again, she points out that such a strategy requires curriculum designers to "… develop, *firstly*, an understanding of what students know" [italics added]. Applying this to a context for international students, this understanding could be broadened to include what they know *numerically and linguistically*. This approach again supports the benefits of a carefully constructed diagnostic testing instrument and its role in developing institution-wide approaches to the quantitative literacy.

The little available literature in this field shows that a third approach – providing high levels of support to students – has a positive impact on student success in quantitative subjects (Bretag, 2004; Kremmer et al., 2010; Brady, 2013). Kremmer et al (2010) found evidence that when a post-entry maths test was followed by workshops, there was preliminary evidence of improvement in student skills in first year commerce subjects.

Again it is argued that research is required to provide more robust evidence to universities to encourage more innovative, inclusive and appropriately targeted approaches to learning support. An informal audit of the websites of fifteen randomly selected Australian universities showed quite clearly that at the majority (twelve), the number of workshops around academic literacy and language skills far outweighs workshops supporting mathematics specifically or numeracy[1] (see Fig. 1). Of the balance, one university has a dedicated Numeracy Centre; another has specific maths and numeracy learning advisers (interestingly identifying the difference between the two) and the third supports students specifically in addressing the language of mathematics for non-mathematics (quantitative) subjects such as nursing and marketing. None of these institutions specifically listed workshops.

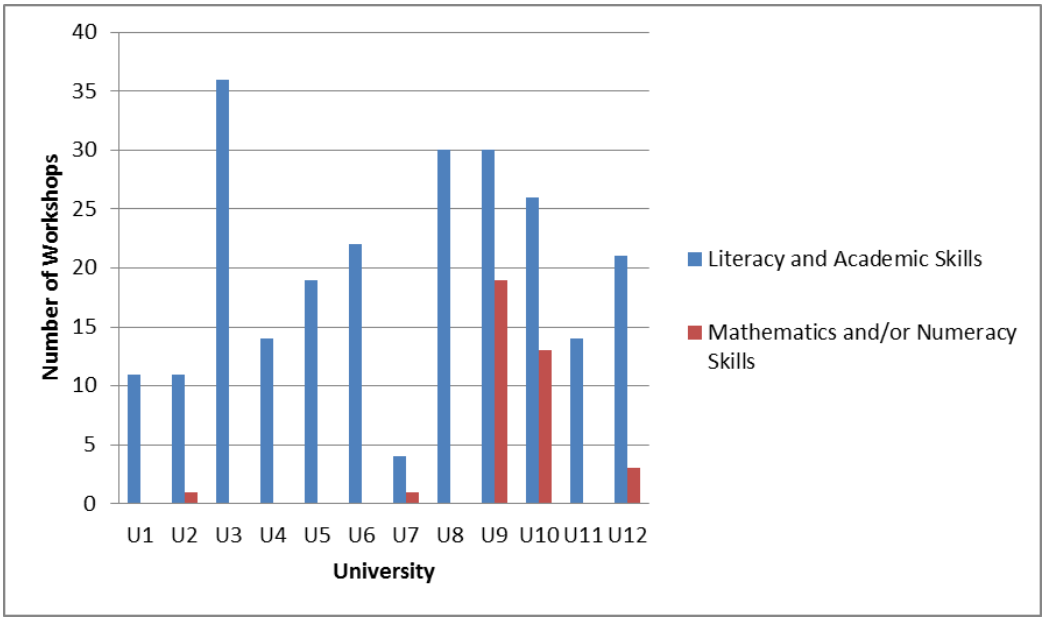

Figure 1. Generic, Literacy and Numeracy workshops: a comparison in July 2015.

This data was obtained from websites because no research has been conducted in this area. Further research is required to substantiate these informal observations. Data on student performance and retention of those students who take up the support that *is* available would also be

[1] It is acknowledged that this data is based on advertised workshops only and that there may be high level support available through drop-in, one-on-one appointments. It also does not include those institutions where support is embedded in the curriculum and thus should not be taken to be a rigorous or robust piece of research. None-the-less, as a comparative exercise, the results show a significant discrepancy.

helpful in building an accurate picture of how Universities can successfully support all students – and particularly international students.

5. Final comments

Who is failing at quantitative literacy? In a results spreadsheet it may appear to be the students but ethically and morally, it may be our institutions. Universities must fulfil their obligations to ensure that the students they enrol are appropriately equipped to participate successfully in their course. In 2013, Galligan argued that academic numeracy was an area "undervalued and under-researched in higher education" (p. 734). In 2015, the same argument holds true. In particular there is a need for research into the intersections between quantitative literacy and English language skills to ensure that international students have equitable opportunity to participate and be successful in their studies. "Where the necessary entry requirements are in place, where inclusive curricula and teaching practice are adopted, and where ongoing support is readily available, the maintenance of standards can be an expectation, shared by all staff and students" (Kuiper & Cameron, 2003, p. 15) including an expectation of academic success. Failure to address the critical need for research into the intersection between quantitative literacy and language will result in continued failure to meet such expectations.

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