[O9] Counting on numbers – squaring the numeracy divide

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ABSTRACT

Key skills are an important element of the United Kingdom Government's educational agenda (Dearing, 1996; NCIHE, 1997). Nationally recognised key skills include application of number (numeracy). Dearing (1997) emphasised the need for HE institutions in the UK to deliver 'numerate graduates'. Subsequently the Department for Education and Skills' Numeracy Task Force proposed a definition framing the skills that are attributed to a numerate individual (DfES, 1998); however across a range of subject disciplines evidence suggests that a significant number of undergraduates do not match this definition (Phoenix, 1999; Engineering Council, 1995; LMS, 1995; Engineering Council, 2000; Tariq, 2002a; Tariq, 2002b).

Decline in the mathematical fluency of students embarking upon HE courses appears to coincide with low confidence and negative attitudes to learning related to the use and application of numbers (Mackenzie, 2002). This project explores self-efficacy of students when applying numeracy skills and whether a dissonance in perception between students and staff exists. During induction students completed a questionnaire that included items on prior learning experience in numeracy, attitude to numeracy, and perceived confidence in applying particular numeracy skills. Staff completed a related questionnaire of their perceptions of students' abilities in applying particular numeracy skills. There is a clear dissonance in staff and student perceptions and an apparent lack of confidence and some negative attitudes and concern towards numeracy. Positive attitudes to prior maths learning are noted; as students recognise the situation of numeracy in academic and work contexts. Staff perceptions appear more consonant with male students. The results of the project will be used to inform provision of appropriate support strategies to enhance numeracy skills and increase confidence and capability in their application.

INTRODUCTION

Concern about levels of basic numeracy has engaged politicians, educators and employers alike. Qualifications for 16-19 Year Olds (Dearing, 1996) and the report of the National Committee of Inquiry into Higher Education (Dearing Report) (NCIHE, 1997), in addition OFSTED (1993) and the Basic Skills Agency (1997) following evidence of poor levels of numeracy in the UK school and adult populations. Low levels of numeracy for students entering higher education (HE), across a range of subject disciplines are well documented in the literature (Phoenix, 1999).

Decline in the mathematical fluency of students embarking upon HE courses appears to coincide with affective issues, a so called

'maths anxiety' (Mackenzie, 2002). Presage (Biggs, 2003; Ramsden, 2003) is a key issue, particularly against the backdrop of the 'massification' of higher education (Barrington, 2004; Coaldrake, 2001) and many HE institutions strong commitment to widening participation and lifelong learning. Students enter university with a range of qualitatively different conceptions of and approaches to learning; this will be no different for numeracy and mathematics (Crawford *et al*., 1998). The aims of this study were to explore the confidence and attitudes to numeracy among level one students studying at the School of Applied Sciences, University of Wolverhampton, and to investigate student and staff perceptions of numeracy and identify any consonance or dissonance that may exist.

METHOD

A questionnaire was prepared, the construction of which was influenced by the ideas of Mackenzie (2002) and Tariq (2004), and issued to year 1 Applied Science students during induction week. Questions related to three themes; prior experience of numeracy, attitude to numeracy and perceived confidence in numeracy application. This third theme was further subdivided into student and staff perceptions. A five-point Likert scale of 'Strongly agree', 'Agree', 'Neither agree nor disagree', 'Disagree' and 'Strongly disagree' was used for assessing prior experience and attitude, and a four-point scale for rating confidence C=0 (not at all confident), C=1, C=2 and C=3 (very confident). Students were asked to rate their personal confidence (self-efficacy) in each of twenty eight numeracy skills (after Tariq, 2004) and staff asked to rate their perceptions of what level of confidence would be expected of a level one undergraduate entrant in the same numeracy skills. All students completing the questionnaire were asked to indicate formal mathematical qualifications. The questionnaire was produced using Surveyor by ObjectPlanet software, hosted online and distributed via a URL link from the University virtual learning environment, WOLF (Wolverhampton Online Learning Framework) and the University email system. Statistical analysis using Mann-Whitney U Test was performed in SPSS version 11.5.

RESULTS

Summary of Questionnaire Findings

160 fully completed questionnaires were returned, from across the School of Applied Sciences, which comprises four Divisions: Biomedical Sciences, Biosciences, Environmental Sciences, Analytical Sciences and Geography (EAS) and Psychology. 31 academic staff, all involved in year 1 undergraduate teaching returned fully completed questionnaires.

Prior Experience and Attitude to Numeracy in year 1 undergraduates

67% of the student respondents were female, and 33% male, which mirrors the gender demographic of the School. A significant proportion of the students (85%) have passed GCSE maths or equivalent, with 28% of students having studied maths at AS level and 8% at A2 level. This prior learning profile is similar to that reported by Mackenzie (2002). The age profile of the students is 18-41 years; hence non-traditional entrants may well have more distant experience of maths; however 8% of students have gained a qualification in maths during an Access course, and 17% report Key Skills qualifications in maths.

The majority of students (75%) report having enjoyed maths at primary/first school; this positive view of maths is continued at secondary/high school, with 67% of respondents agreeing with the statement. Half of the students (57%) say that they find doing number skills (sums) easy, and 61% intimate a willingness to learn new number skills.

Although fewer than half of the students (49%) report that they like working with formulae and equations (mathematical constructs), there is widespread acknowledgement and recognition that numeracy is implicit both in terms of academic study and employability, with students expecting to use number skills in modules (92%) and at work (95%). Expectation to work with formulae and equations in modules (83%) and at work (71%) is also recognised.

Approximately a third of students agree with the statement 'I am concerned about learning new number skills', 29% are male and 71% are female congruent with the respondent demographic. There are identical percentages for 'concern' shared by Bioscience and EAS students (39%) with a smaller, yet still significant proportion of Biomedical Science students reporting 'concern' (32%). Data for Psychology students demonstrates a markedly lower percentage of 10%. 'Avoidance' as evaluated by agreement with the statement 'I avoid formal number work' demonstrates a similar trend overall with 21% admitting to such avoidance, of which 22% are male and 78% are female.

Student and Staff Perceptions of Confidence with Numeracy Skills

Students generally express high levels of confidence about basic statistics; these might be termed basic numeracy skills. Low levels and no confidence are noted for unit conversion, integration, differentiation, molarity and modelling, a common factor being the applied nature of the numeracy skills.

Differences in student and staff perceptions of confidence in numeracy application are evident in 9 out of the 28 numeracy skills. There is a dissonance in perception of the fundamental skills of multiplication, division, decimals, the size of numbers and communicating data, with staff expectation of

Table 1: Prior learning experience and attitude to numeracy of students expressed as percentage frequency (to nearest whole number) (after Mackenzie, 2002)

	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)
I enjoyed doing maths at primary/first school	36	39	13	8	4
I enjoyed doing maths at secondary/high school	27	40	12	13	8
I find doing number work (sums) easy	19	38	27	13	3
I want to learn new number skills	19	42	29	8	2
I am concerned about learning new number skills	9	23	40	23	5
I avoid formal number work	4	17	28	40	11
I use number skills in everyday life	24	59	13	4	-
I expect to use number skills in the world of work	42	53	4	1	-
I expect to use number skills in modules for my degree	46	46	5	3	-
I like working with mathematical constructs (formulae and equations)	16	33	26	17	8
I expect to work with mathematical constructs (formulae and equations) in my degree	34	49	12	5	-
I expect to work with mathematical constructs (formulae and equations) at work	23	48	23	5	1

Table 2: Percentage frequency (to nearest whole number) of students agreeing or strongly agreeing with statements relating to maths anxiety and avoidance (Mackenzie, 2002) analysed by Division. Male (❍) and Female (▲) students.

	❍	▲	All students (%)	Biomedical Science (%)	Bioscience (%)	Environmental & Analytical Science & Geography (%)	Psychology (%)
I am concerned about learning new number skills	32	29	71	29	39	39	10
I avoid formal number work	21	22	78	17	26	22	10

confidence in ability to apply such skills significantly higher than students' perceived confidence. Conversely, compared to staff, students report higher levels of confidence in the more advanced skills of integration, differentiation and basic statistics.

Differences in perception analysed by Division using a Mann-Whitney U Test indicated a significant difference in staff and student perceptions in all four Divisions of the School.

DISCUSSION

The study revealed that a majority of students demonstrated positive attitudes to their prior learning experience in mathematics at both primary/first school and secondary/high school, 75% and 67% respectively (Table 1). This is consistent with previously reported findings for primary/first schools (Mackenzie, 2002); however the two-thirds of students reporting to have enjoyed maths at secondary/high school is in contrast to Mackenzie's findings. This may be a reflection of the cohort surveyed, in this study the students are level one entrants onto an applied sciences based degree programme; consequently a more pragmatic view might be anticipated, with students viewing maths as integral to pursuing their chosen future studies, whilst Mackenzie (2002) draws respondents from a range of disciplines that include English, Design and Technology and PE. This pragmatism is reflected by the widespread acknowledgement and recognition that numeracy is implicit both in terms of academic study and employability. This has positive implications for embedding appropriate quantitative tasks in teaching and learning activities, as there appears to be a clear expectation that numeracy skills will be required, a recognition that numeracy skills are important in an academic and broader context that includes employability, Edwards and Ruthven (2003) have reported that young people are more aware of the mathematics embedded in everyday activities than previously thought.

Lack of confidence and negative attitudes, sometimes bordering on the irrational fear of 'all things numerical' (Tariq, 2003; Mackenzie, 2002), is reported by 32% of the students. A greater proportion of those reporting concern were female (71%). Highest levels of concern are shared by Biosciences and EAS students (39%), a trend that is mirrored for avoidance, this may be linked to students opting to undertake academic studies in these areas with the notion that this is a way of studying science whilst avoiding the maths.
Despite the high level of confidence reported

Table 3: Differences in student and staff perceptions of confidence in 28 numeracy skills analysed by cohort and Division

Numeracy skill	Complete Cohort P < 0.05 (two-tailed)	Biomedical Science P < 0.05 (two-tailed)	Biosciences P < 0.05 (two-tailed)	EAS P < 0.05 (two-tailed)	Psychology P < 0.05 (two-tailed)
Addition	n/s	n/s	n/s	n/s	n/s
Subtraction	n/s	n/s	n/s	n/s	n/s
Multiplication	sig.	sig.	n/s	sig.	n/s
Division	sig.	sig.	n/s	sig.	n/s
Fractions	n/s	sig.	n/s	n/s	n/s
Decimals	sig.	sig.	n/s	n/s	n/s
Percentages	n/s	sig.	n/s	n/s	n/s
Ratios/Proportions	sig.	sig.	n/s	n/s	n/s
Probabilities	n/s	n/s	n/s	n/s	n/s
Logarithms	n/s	sig.	n/s	n/s	n/s
Calculating things mentally	n/s	n/s	n/s	n/s	n/s
Judging whether your answer makes sense	n/s	n/s	n/s	n/s	n/s
Basic Algebra e.g. rearranging and solving equations, using formulae	n/s	n/s	n/s	n/s	n/s
Using a calculator	n/s	n/s	n/s	n/s	n/s
Appreciating the size of number	sig.	sig.	n/s	n/s	n/s
Exponentials and Powers	n/s	sig.	n/s	n/s	n/s
Scientific notation	n/s	sig.	n/s	n/s	n/s
Unit conversion	n/s	n/s	n/s	n/s	n/s
Reading scales (measurements)	n/s	sig.	n/s	n/s	n/s
Integration	sig.	n/s	sig.	sig.	n/s
Differentiation	sig.	n/s	n/s	sig.	n/s
Interpreting/transforming data from Graphs	n/s	n/s	n/s	n/s	n/s
Interpreting/transforming data from Spreadsheets	n/s	n/s	n/s	n/s	n/s
Interpreting/transforming data from Charts and Tables	n/s	n/s	n/s	n/s	n/s
Molarity	n/s	n/s	n/s	n/s	n/s
Basic Statistics e.g. mean, mode, median, standard deviation	sig.	n/s	sig.	n/s	sig.
Modelling e.g. understanding how variables interact, creating formulae	n/s	n/s	n/s	n/s	n/s
Communicating data	sig.	sig.	n/s	n/s	n/s

by the majority of the students, a dissonance in perception for the fundamental skills of multiplication, division and decimals is apparent, with staff expectation of confidence in ability to apply these basic numeracy skills significantly higher than students' perceived confidence. This is of particular disquiet given the widespread infusion of such fundamental mathematical concepts in quantitative tasks both within the context of both degree and workplace and links in with the declining standards in numeracy reported. Interestingly,

compared to staff, students report significantly greater levels of confidence with the more advanced mathematical skills of integration, differentiation and application of basic statistics. However evidence from practice and diagnostic tests suggests that there could be an overconfidence expressed. Dissonance in appreciating the size of numbers is also of concern, as many quantitative tasks are underpinned by this concept. Some students appear to have difficulty conceptualising and rationalising calculated values, demonstrating a greater trust in a calculator display, than their own judgement. Staff also expected a higher level of confidence to be displayed in communicating data a key skill for scientists.

Dissonance is most prevalent in the Biomedical Science Division. A high degree of correspondence is noted for the other three Divisions; as a caveat, response rates for students as a percentage of the total student cohort are: Biomedical Science, 49%; Biosciences, 34%; EAS, 11% and Psychology, 6%. This dissonance has implications for both learning and teaching activities and learner support, and will inform appropriate intervention strategies.

CONCLUSION

This study contributes to the debate on attitudes and confidence in applying numeracy and the wider discourse considering declining standards of numeracy in HE entrants. With an agenda for widening participation and lifelong learning, students will enter university with different conceptions of and approaches to learning; and this will be no different for numeracy and mathematics. Clearly negative attitudes and low levels of confidence are incompatible with deeper approaches to learning so staff must avoid perpetuating gender stereotypes. Reassuringly the majority of students in this study report positive attitudes to maths and appreciate the academic and vocational relevance of numeracy; however there is evidence of concern about and avoidance of maths and lower levels of confidence in 'applied numeracy'. Appropriate support and intervention strategies are required to empower the students, and the results from this study will be used to shape the process. The relationship between students perceived levels of confidence in numeracy application, actual skills and progress need further investigation as the 'problem' of numeracy is a potential barrier to effective learning.

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