Bills, L. (Ed.) Proceedings of the British Society for Research into Learning Mathematics 19(1) February 1999

PRIMARY TRAINEES' MATHEMATICS SUBJECT KNOWLEDGE: AN UPDATE REPORT

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At a previous BSRLM meeting, we reported that we had failed to find any connection between the strength of primary PGCE students' mathematics subject knowledge (as audited in the course) and their performance in school after two terms. Our findings for the final school placement were very different, however, when there appeared to be an association between subject knowledge and competence in teaching number.

BACKGROUND

Recent changes in the curriculum for Initial Teacher Training incorporate a stronger focus on trainees' subject knowledge (DfEE, 1997, 1998). In an earlier paper (Rowland, Heal, Barber and Martyn, 1998) we described our approach to the audit of the mathematics subject knowledge of a cohort of 154 trainees following a one-year primary PGCE course, and the dimensions of our research.

In particular, we investigated whether a significant link between subject knowledge, as measured by the audit, and students' performances on teaching practice could be identified.

Students were assigned to a 2-way classification:

I: Audit scores (maximum score being 32).

Category A, B or C corresponding respectively to audit score above 30 (i.e. perfect or near-perfect), between 30 and 24, below 24 (explanation of these 'scores' is given in Rowland *et al.*, 1998)

II: Teaching practice performance

Students were categorised as 1 (very strong/strong), 2 (capable) or 3 (weak). For the Spring Term teaching practice this was decided on the basis of a formative grade profile for planning, teaching and assessment. It should be noted that these grades did not relate solely to the teaching of mathematics.

These data were entered into a 3x3 contingency table. A chi-square test applied to these grouped audit and teaching practice data supported the hypothesis that teaching practice performance and audit performance are independent. (Rowland *et al.*, 1998)

UPDATE: THE FINAL SCHOOL PLACEMENT

For the final school placement, specific assessments of the students' teaching of number were made, and used with the original audit scores to compile a 3 by 3 contingency table similar to that for the first teaching practice. These data are shown below, together with expected frequencies (in brackets) based on the null hypothesis that audit performance and teaching performance are independent.

Perhaps unsurprisingly, tutors' (moderated) assessments of practical teaching for the final teaching practice were less tentative than those for the first. Whereas, on the Spring practice, two-thirds of the students had been assigned to the middle ('capable') category, this reduced to a little more than one third in the Summer, when tutors were more prepared to make assessments at the extremes of the competence scale. It must be borne in mind, of course, that the first teaching assessment had been of a general kind, the second assessment used for the analysis which follows focused narrowly on the teaching of number. Five students from the cohort in the original analysis had withdrawn from the course, leaving a population of 149 students.

	TEACHING PRACTICE PERFORMANCE			
SUBJECT KNOWLEDGE AUDIT		1 (strong)	2 (capable)	3 (weak)
	A (high)	**20 (12.7)**	**12 (13.5)**	**5 (9.6)**
	B (middle)	**28 (24.1)**	**28 (25.5)**	**14 (18.2)**
	C (low)	**5 (14.5)**	**16 (15.3)**	**21 (10.9)**

The same chi-square test was applied to these data to test the null hypothesis that initial audit performance and final performance in the teaching of number are independent. This time it turns out that $\chi^2 = 24$, with probability virtually zero (8×10^{-5}), and the hypothesis of independence does not stand up to the data. There appears to be an association between mathematics subject knowledge (as assessed by the audit) and competence in teaching number.

Some striking aspects of the contingency table – notably the 'extreme' cells A1, A3, C1, C3 - intuitively support this conclusion. In particular, students with high audit scores seem much more likely to do well in school (as over half of them did) than the cohort as a whole (A1), and much less likely to do badly (A3). The converse is the case for students with low audit scores (cells C3 and C1), no fewer than half of whom were assessed as 'weak' in school.

These intuitions can be quantified. For example, the actual number of C3 students is double that 'expected'. Is then a low audit score, in particular, a *significant* predictor of weak teaching performance? It is, in the following sense: on the hypothesis that the distribution of the 42 students with low audit scores across the three teaching grades is the same as that for the whole population, a binomial model $B(42, {}^{40}/_{149})$ gives the probability of 21 or more category C3 trainees to be 0.0012. This is far too small to be attributable to chance (i.e. it is highly significant) and supports the alternative view that students with a low mathematics audit score are more likely to be poor teachers of numeracy.

The polar opposite case – that of A1 students – is less striking but significant nonetheless. A similar binomial analysis (on a similar null hypothesis) shows the probability of as many as 20 of the 37 high-scoring students being strong teachers of number to be only 1.6%. The evidence suggest that students with a high mathematics audit score are more likely to be strong teachers of numeracy.

The nature of the relationship between the levels of subject knowledge and those of teaching performance can be analysed further, to yield a more refined understanding of that relationship, following a procedure proposed by Goodman (1964). The 3x3 contingency table gives rise to nine 2x2 matrices of cells (A,B/1,3 being one such matrix, for example), from each of which a statistic (denoted z^2) can be computed (see Goodman, 1964 for details), the significance of which is ascertained by comparison with critical χ^2 values for the original contingency table – in this case 9.5 for df=4 and $p<0.05$. In fact, only two of the nine 2x2 matrices give rise to significant z^2 values, namely B,C/1,3 and A,C/1,3 with $z^2 = 12.76$ and 16 respectively. (The next most significant, A,C/1,2, fails to attain even 10% significance). From this, it is possible to infer (not merely intuit) the source of rejection of the original null hypothesis, as follows. Students obtaining high (or even middle) scores on the audit are more likely to be assessed as strong numeracy teachers than those with low scores; students with low audit scores are more likely than other students to be assessed as weak numeracy teachers. Put simply and bluntly, there is a risk (statistical, at least) which is uniquely associated with trainees with low audit scores. This finding does not, in fact, contradict the well-known King's study (Askew et al, 1997) which found that the possession of 'higher' mathematics *qualifications* (as opposed to current knowledge or professional training in mathematics) did not in itself appear to improve teachers' effectiveness.

Incidentally, Goodman's analysis bears out what we might surmise from inspecting the middle column of the original contingency table: audit score is not a useful predictor of a 'so-so' – capable but not strong - numeracy teacher

DISCUSSION

Our next task is to try to gain some insight into the nature of the association established above. For the moment, we briefly speculate on what might be going on. We raise and consider some of the possibilities that come to mind.

The most obvious is that secure subject knowledge, as assessed by the audit, really does underpin and enhance teaching in the primary years; that, all things being equal, it is better for the teacher to be knowledgeable about mathematics *per se*, than to be ignorant. A high proportion of students scoring poorly on the audit do indeed fall within the weak teaching practice category. This could indicate that these students' knowledge and understanding of mathematics did not allow them to plan effectively, teach numeracy effectively or monitor pupils' achievements and misconceptions with accuracy, in order to plan well-matched and challenging work. This is an attractive argument, and may well be sustainable, but it is not the only possibility. It is also no surprise to find – as the five 'A3' students give evidence - that a high level of mathematics subject knowledge is not in itself sufficient to ensure a strong or even a capable level of competence in teaching it.

There is also the possibility that those knowing themselves to be weaker in understanding of number may have been differentially disadvantaged through the anxiety or lack of confidence caused by both the test and the teaching practice situations. The audit may have been self-fulfilling in terms of students' self-belief and performance. The effect of a poor result on the audit and the subsequent requirement to improve in this area, through self-study and peer tutoring sessions, could have had a considerable de-motivating and demoralising effect on these students, contributing to their difficulties in teaching in this area.

It is only responsible, of course, to observe that the statistical relationship between subject knowledge and teaching competence (in number) need not be causal. The sheer complexity of the task of teaching and the wide range of contexts in which it is carried out and assessed, point to the danger of restricting attention to just two of the many variables in play.

An additional piece of information gleaned from this study also points to caution in assuming a causal link. The same students' subject knowledge was also audited in English, and a similar analysis to that above was applied to uncover evidence of a link between knowledge of *English* and competence in teaching *number*. It is salutary, if bizarre, to note that the statistical link was marginally stronger ($\chi^2 = 28.7$) than that between knowledge of mathematics and number teaching competence. A Goodman-type analysis identifies the same crucial link between weak/strong performances in school and low/not-low audit scores.

Such evidence leads us to speculate about possible fundamental personal and interpersonal factors underpinning success (or lack of it) in all areas – academic and professional - of a PGCE course. Intangible factors such as 'commitment' and 'motivation' may have contributed to success in both the audit and during the final teaching practice.

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