SKE courses and bursaries: examining government strategies to tackle mathematics teacher quantity and quality issues

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The shortage of secondary mathematics teachers is a concern for UK government. In order to increase the supply of teachers, the government has sponsored subject knowledge enhancement (SKE) courses for non-specialist graduates ('SKE Policy'). Additionally, the government has offered financial incentives to attract high attaining graduates into teaching through differentiated bursaries ('Bursary Policy'). Existing research into the efficacy of these measures is limited but studies on two individual teaching courses suggest that student teachers who have taken SKE courses do no worse in their teaching course and that those who achieve more highly in their first degree do not achieve significantly higher outcomes in their teaching course respectively. This study corroborated results of these smaller studies through testing over 100 secondary mathematics student teachers on a sample of 'mathematical knowledge for teaching' (MKT) items, designed by the University of Michigan. Results suggest that whilst the SKE Policy may be a good strategy in that there was no overall significant difference in MKT scores between SKE students and mathematics graduates, the Bursary Policy may be a flawed since there is no evidence that higher degree classes lead to greater success on PGCE courses.

Keywords: mathematical knowledge for teaching, trainee secondary teachers, SKE courses, PGCE courses, bursaries, policy

Background

There is a shortage of secondary mathematics teachers within the UK (Department for Education, 2013). In order to address this problem the government have implemented two strategies. Firstly, they have introduced 'subject knowledge enhancement' (SKE) courses to graduates without mathematics degrees to enable them to 'top-up' their mathematics knowledge and subsequently take a PGCE (teaching) course (TDA, 2010). Thus, PGCE students can be divided into two groups: traditional entry students (those with mathematics related degrees) and those who have taken an SKE course beforehand. Secondly, attractive bursaries are offered to graduates to train to be teachers. However, in an attempt to avoid compromising teacher quality, larger incentives are offered to graduates with higher degree classes (Department for Education, 2013). These two strategies will be referred to as the SKE Policy and Bursary Policy respectively within this paper.

Limited research exists regarding the efficacy of these strategies. Regarding the SKE Policy, a report evaluating the effectiveness of SKE courses at equipping students to meet teaching standards as well as comparing SKE students with traditional entry trainee teachers was commissioned by the Teaching Agency (see Gibson et al., 2013). This evaluation involved surveys and interviews with SKE candidates from a range of subjects (not just mathematics), PGCE students and course tutors. The report concluded that whilst "SKE courses provide trainees with a high

level of subject knowledge and confidence…" (p. 11), the SKE students felt they had a lower level of subject knowledge than their peers who were subject graduates. Nevertheless, SKE students felt their knowledge may be more relevant to a school context than subject graduates (Gibson et al., 2013). Further, a small study with a single cohort of mathematics PGCE students by Stevenson (2008) compared final PGCE scores between SKE students and the whole group. Although mean grades for SKE students were lower than for the whole group the difference was not significant.

With regard to the Bursary Policy, Tennant (2006) investigated the relationship between first degree classification and final PGCE course grades of students at one institution and found no correlation. At another institution, Stevenson (2008) also found no correlation. These studies suggest that prior attainment as measured by formal qualifications does not necessarily predict success on a teaching course. However, sample sizes were small and final PGCE scores are not standardised across institutions but are determined by course tutors and school-based mentors.

The above studies suggest that whilst SKE students' feel their subject knowledge is at a lower level than their traditional entry peers, having a higher degree classification does not predict higher PGCE scores. Perhaps the results found by Tennant and Stevenson are not representative of the national picture. However, the research literature since Shulman's (1986) introduction of 'pedagogical content knowledge' recognises that teachers need more than just knowledge of the subject matter they are to teach in order to be effective teachers. Indeed, researchers at the University of Michigan have defined the construct 'mathematical knowledge for teaching' (MKT) which includes sub-divisions of Shulman's categories of 'subject matter knowledge' and 'pedagogical content knowledge' (Ball, Thames and Phelps, 2008). Further, a pool of multiple-choice questions has been developed to measure teachers' MKT (Learning Mathematics for Teaching, 2007). The MKT questions are kept secure but one of the 'released' questions is included for illustration (see Figure 1). It could be hypothesised that SKE students possess higher levels of MKT - "the *mathematical knowledge that teachers need to carry out their work as teachers of mathematics"* (Ball, Thames and Phelps, 2008: 4) - which would then compensate for their lower level of mathematical content knowledge allowing them to achieve similar PGCE course results. To test this hypothesis, a sample of the MKT questions was administered to PGCE students in England as a pre- and post- (PGCE course) test in the academic year 2012-13. A pre-post test design was used to investigate the effects of both prior experience and the PGCE course itself on MKT. Participants' degree classifications as well as final PGCE grades were also collected to refute or substantiate Tennant and Stevenson's findings in a larger sample of PGCE students.

Mathematical Knowledge for Teaching (MKT) questions

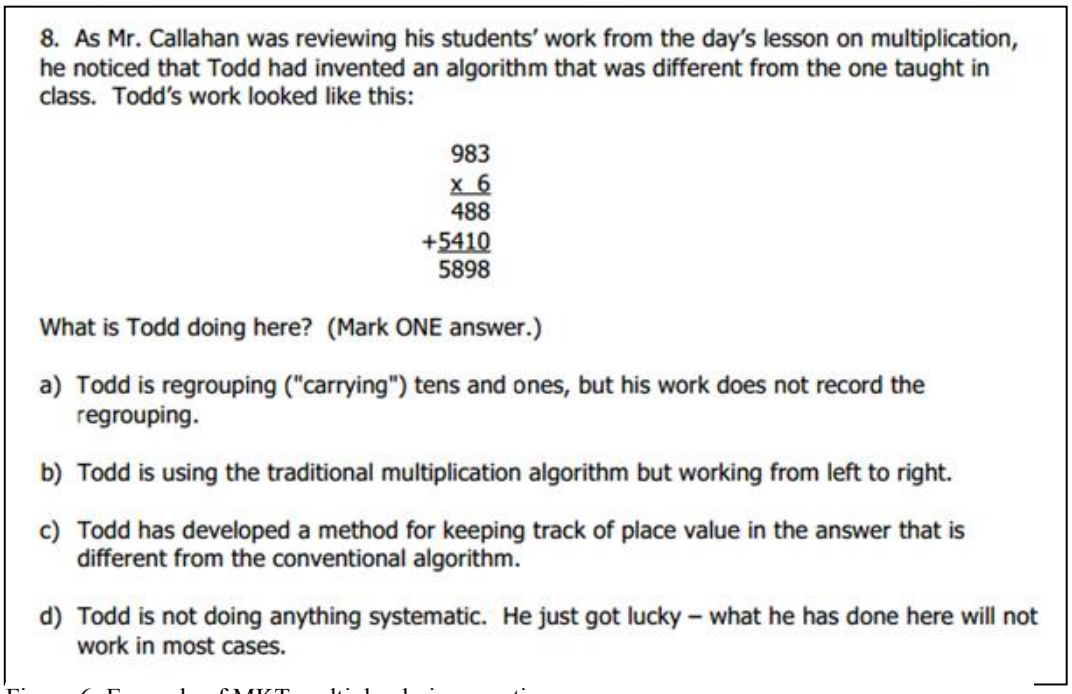
The MKT questions were chosen to compare knowledge between SKE students and traditional entry PGCE students as they were designed "to make statements about how content knowledge differs among groups of teachers, or how a group of teachers performs at one or more time points" (Learning Mathematics for Teaching, n.d.).

The MKT questions have been extensively validated by the authors and other researchers by psychometric analysis (Hill, Schilling and Ball, 2004; Warburton 2013a). Further, scores on the questions have been shown to positively correlate with the 'mathematical quality of instruction' of teachers in the classroom (Hill et al., 2008) as well as positively predicting pupil achievement (Ball, Hill and Bass, 2005).

The MKT questions have primarily been used within the US but have also been used in other countries, namely, Ireland, Norway, Ghana, Indonesia, and Korea (see Ball, Blömeke, Delaney and Kaiser, 2012) where the MKT questions were adapted to the new context. For this study, instead of adapting the questions, those which required alteration were omitted (for example, if a 'state exam' or 'dollars' were mentioned). This approach was taken due to a caution from the question authors:

> Changing items – even by making small alterations in wording – means the psychometric properties no longer hold... Even small wording changes (e.g., changing a preposition) can make the item mathematically ambiguous, and thus unusable in a measurement context (Hill, Ball, Schilling and Bass, n.d.: 2).

This left a sample of questions felt to be appropriate for use in England. Twelve item stems, some consisting of several parts, were used for this study; 18 questions in total.



8. As Mr. Callahan was reviewing his students' work from the day's lesson on multiplication, he noticed that Todd had invented an algorithm that was different from the one taught in class. Todd's work looked like this:

983
x 6
488
+5410
5898

What is Todd doing here? (Mark ONE answer.)

a) Todd is regrouping ("carrying") tens and ones, but his work does not record the regrouping.

b) Todd is using the traditional multiplication algorithm but working from left to right.

c) Todd has developed a method for keeping track of place value in the answer that is different from the conventional algorithm.

d) Todd is not doing anything systematic. He just got lucky – what he has done here will not work in most cases.

Figure 6: Example of MKT multiple-choice question.

Method

65 institutions in England were initially allocated[14] by the Training and Development Agency for Schools (TDA)[15] to run full-time PGCE secondary mathematics courses in 2012-13. All institutions were contacted and their students invited to respond to a two-part questionnaire either on paper or online both at the beginning and end of their PGCE course. The first part sought biographical information including date of birth, gender, degree class, and whether an SKE course had been taken. The second part comprised the MKT questions.

[14] Those allocated small numbers of students (<10) may not have run their courses in 2012-13.
[15] Now the National College for Teaching and Leadership (NCTL).

Results

Out of the initial allocation of full-time secondary mathematics PGCE places (1,773 students) 141 PGCE students responded meaningfully[16] to both the pre- and post-questionnaire (8%)[17] from 18 different institutions. Out of these respondents, there were slightly more females (n=72, 51%) than males (n=69, 49%). There were 69 (49%) respondents who took an SKE course prior to their PGCE and 72 (51%) respondents who did not. However, since lengths of SKE courses vary from two weeks to one academic year, the PGCE students were grouped as follows for this study: 43 (30.5%) respondents took an SKE course of five months or longer ('Long SKE'); whilst 98 (69.5%) took either no SKE course or took a short (two or four week) SKE course ('Non SKE'). These groups were chosen as short courses are typically for refreshing specific aspects of knowledge. Indeed, most short course candidates had mathematics degrees. Since mean scores on both tests were very similar for those taking a short SKE course as for no SKE course, this suggests this division was justified. Further, short courses are no longer funded by the government from 2013-14 but "incorporated as part of the normal refresher learning that forms part of an ITT course" (NCTL, 2013:2).

Since a sample of the MKT questions was used in a new context (student teachers in England) the reliability was calculated and found to be reasonable (0.67 – pre-test, 0.71 – post-test) as measured by Cronbach's alpha. A dichotomous Rasch model was used to analyse the psychometric properties of the questions. It confirmed that the questions can be used appropriately in England and that they measure one underlying construct (for further details of the Rasch analysis, see Warburton, 2013a).

Differences between SKE and non-SKE PGCE students (SKE Policy)

PGCE scores

138 final PGCE teaching scores (Ofsted style grades) were collected and, similar to Tennant's study, awarded points as follows: Outstanding = 3 points; Good = 2 points; Working towards good = 1 point; Cause for Concern = 0 points. In addition to scores being unstandardised across institutions, anecdotal evidence from PGCE course tutors suggests that due to inspection by Ofsted students must achieve high grades.

Similar to Stevenson (2008), final PGCE scores were compared between Non SKE and Long SKE groups. Long SKE students did better on average (M = 2.18 points, SE = 0.135) than Non SKE students (M= 1.96 points, SE = 0.115) but this difference was not significant ($t = 1.184$, $p = 0.238$, $r = 0.102$).

MKT scores

A repeated measures ANOVA was used to analyse any changes in MKT scores (dependent variable) over time (between pre-and post-test - within subjects factor) and by group (Non SKE and Long SKE - between-subjects factor). There was a significant increase in overall scores of 1.34 marks[18] (7.4%) between the pre- and post-test ($F(1, 139) = 25.088$, $p < 0.001$ with a medium effect size: partial $\eta^2 = 0.153$). Both other effects were non-significant, but the difference between groups (Non SKE and Long SKE) in mean scores was sustained over time (Figure 2).

[16] For example, those who only responded to the first few questions were not counted.
[17] For further details on the pre-questionnaire results (n=239) see Warburton (2013b).
[18] The terms of use of the MKT questions state that raw scores, including mean scores, cannot be reported so are omitted here. Instead, differences between mean scores are provided.

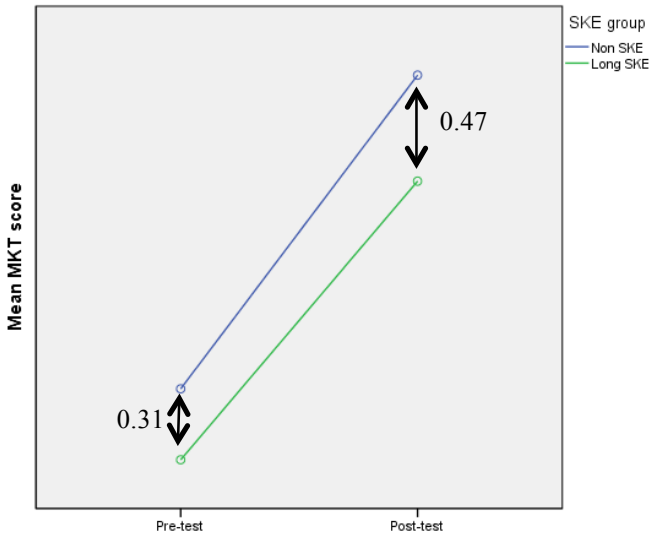


Figure 2: Graph showing differences in mean scores on MKT questions for the pre- and post- test for Non SKE and Long SKE groups.

MKT score sub-analysis

Some of the older MKT questions selected for use in this study had been categorised by the authors as assessing specific components of the MKT construct. This practice was discontinued as it was found to be difficult to place questions into mutually exclusive categories. Thus, more recently developed questions are not classified. I attempted to classify those questions which had not been classified by the authors, as assessing either 'common content knowledge' (CCK) – mathematics knowledge

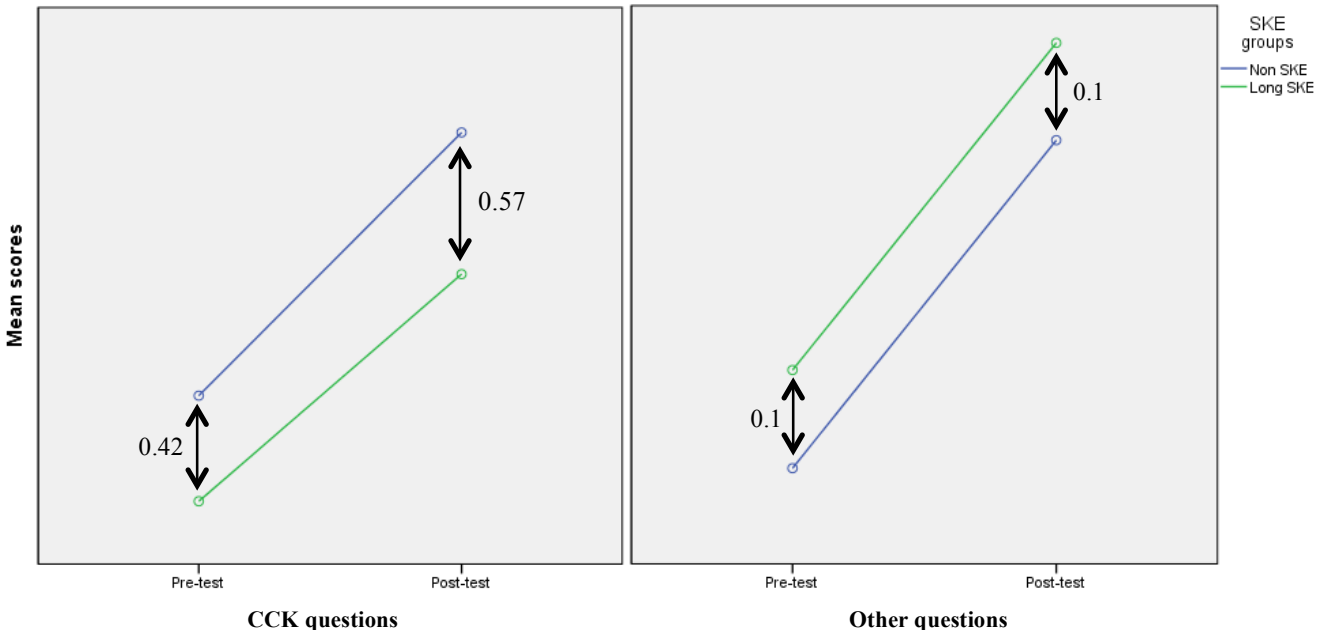


Figure 3: Graphs showing differences in mean scores on the CCK and Other questions on the pre- and post- tests by SKE group.

which any well-educated adult should know - or other aspects of MKT (Other) beyond that expected of an educated adult but specific to the work of teaching (see Ball, Thames and Phelps, 2008 for their other sub-categories of MKT). Whilst the

following results provide some insight, they should be treated with caution given the difficulty of classifying questions as recognised by the question authors.

Thirteen questions were classified as requiring CCK in order to answer them correctly, with only five felt to require additional knowledge related to teaching (Other aspects of MKT). The repeated measures ANOVA was reiterated twice with scores on the CCK questions and Other MKT questions respectively as the new dependent variable. For CCK questions there was a significant increase in overall scores of 1.01 marks ($F(1, 139) = 24.04$, $p<0.001$, partial $\eta^2 = 0.147$), yet the other effects were non-significant at the 0.05 level. The same was true for the Other questions, that is, there was a significant increase in overall scores of 0.32 marks ($F(1, 139) = 6.24$, $p = 0.014$, partial $\eta^2 = 0.043$) and the other effects were non-significant. Although there was no significant effect of group on CCK and Other scores, Figure 3 shows that, on average, the Long SKE group performed worse on the CCK questions, but better on the Other questions than the Non SKE group. These differences are small, but were sustained over time.

Relationship between degree class and PGCE/MKT scores (Bursary Policy)

Using methodology similar to Tennant (2006), the correlation between prior degree classification and final PGCE teaching scores was calculated to be $r = 0.185$. This correlation is small and similar to Tennant's ($r = 0.11$), corroborating Tennant (2006) and Stevenson's (2008) conclusions that there is no connection between degree results and success on the PGCE. Indeed, whilst a linear regression established that prior degree classification could statistically significantly predict PGCE scores, $F(1, 135) = 4.804$, $p = 0.03$, degree classification only accounted for 3% of the explained variability in PGCE scores. The regression equation was: PGCE score = 1.04 + 0.254 x(degree classification). However, this equation should be treated with caution as the assumption that residuals of the regression line are approximately normally distributed was violated. Further, there are potential issues with PGCE grades as discussed above. Given these issues, the correlations between degree class and scores on the MKT questions were also calculated and also found to be small: $r = 0.189$ (pre-test), $r = 0.128$ (post-test). Alternatively, another reason provided by the Department for Education (2013) for implementing the Bursary policy is that: "Degree class is also a good predictor of whether a trainee will complete their course and achieve QTS". However, there was no significant association between degree classification and whether or not the student completed the course ($p = 0.07$, Fisher's exact test, Cramer's V = 0.155, small effect) for 244 PGCE students involved in this research.

Discussion and conclusion

The Efficacy of the SKE Policy

When comparing mean scores on the MKT questions, there was a significant increase in scores between the pre- and post-test. For this sample of PGCE students, this is good evidence that the PGCE courses helped to improve MKT and is reassuring. However, there was no significant effect of group (Non SKE and Long SKE) on MKT score, suggesting that SKE and traditional entry PGCE students have similar levels of MKT both at the beginning and end of a PGCE course. Further, this study corroborated the findings of Stevenson (2008) that there is no significant difference in final PGCE scores between SKE and Non SKE PGCE students.

These results provide evidence that SKE students commence their PGCE course with similar levels of MKT to their traditional entry peers and that PGCE courses help both groups to increase in MKT over the course and to achieve similar final PGCE scores. However, whilst overall MKT scores do not differ significantly between groups, SKE students performed slightly worse on average than traditional entry PGCE students on questions felt to be testing CCK but slightly better on questions related to teaching and pupils (Other aspects of MKT) over time. This fits with findings of Gibson et al (2013) that whilst SKE courses are intended to focus on subject knowledge, many SKE courses also include an aspect of pedagogy (though the amount varies between courses). Thus, PGCE students within the Long SKE group have potentially spent at least five months learning mathematics with the intention of teaching as well as acquiring some knowledge of how to teach it.

Nevertheless, further research is needed to understand the differences in types of knowledge between SKE and traditional entry PGCE students given the difficulties of classifying the MKT questions as discussed.

The efficacy of the Bursary Policy

This study, involving larger numbers of PGCE students across 18 institutions in England, corroborated results found by smaller studies at single institutions that degree classification does not strongly predict success on a PGCE course. Additionally, degree scores do not predict success on the MKT questions. Therefore the higher financial incentives offered by the government to graduates with higher degree classes may not be achieving the purpose of "[raising] the quality of new entrants to the teaching profession" (Department for Education, 2010: 20). Furthermore, this study suggests there is only a small effect of degree classification on whether a student completes their PGCE course.

The Bursary Policy awards £20,000 to graduates with a first class degree, £15,000 to those holding a 2:1 and £12,000 to a 2:2, regardless of degree title. This study suggests that awarding £5,000 more to first class graduates is perhaps not justified when predicted gains in PGCE and MKT scores are small. Additionally, as regression analysis suggests a linear relationship between degree class and PGCE scores, this raises the question of why increments in bursaries are not equal.

In conclusion, this study provides evidence that the introduction of SKE courses is a good strategy to address the shortage of mathematics teachers whilst not compromising on teacher quality. However, offering differentiated bursaries by degree class may be a flawed policy since there is no evidence from this and other studies conducted in England that higher degree classes lead to substantially greater success on PGCE courses.

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