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Teachers' Beliefs and Behaviors: What Really Matters?

Daniel Muijs
David Reynolds

ABSTRACT

In this study, we looked at the relationship between teacher behaviors, teacher beliefs, teacher self-efficacy, and teacher subject knowledge with student achievement in mathematics. Data was collected from 103 primary school teachers and 2,148 students in the UK using achievement tests, classroom observation, and questionnaires. Structural equation modeling was used to test the hypothesis that all these factors would have a direct or indirect effect, with the factors most proximal to student achievement (teacher behaviors) having the strongest direct effect while more distal factors (e.g., teacher beliefs) influencing student achievement indirectly. This hypothesis was not rejected by the data.

INTRODUCTION

That teachers as well as schools make a difference is a finding that has received increasing support from educational research over the past decades. Studies using large databases and multilevel modeling techniques have consistently found that teacher effectiveness influences students' achievement, and is one of the main indulgences on student progress over time. In their British study, Mortimore et al. (1988), for example, found classroom level to be more important than the the school level. Classroom factors were the main predictors of student progress over time. Likewise, Mujis & Reynolds (2000a; 2000b; 2001) reported classroom level variance to be twice as high as school level variance in student achievement in mathematics, and further reported that teacher behaviors were able to explain almost all the classroom level variance in their study in British primary schools. In studies based on the statistically sophisticated Tennessee Value Added Assessment System (TVAAS) teacher effects were significantly related to student performance, more so than factors, such as class size (Sanders & Rivers, 1996; Wright, Horn, Sanders, 1997). Furthermore, the effect appeared to be cumulative and additive, in that students taught by ineffective teachers for consecutive years do significantly worse in both gains and achievement compared to their peers assigned to effective teachers for consecutive years. A recent analysis of 8th graders using the NAEP data set likewise found classroom practices to be the main predictor of achievement (Wenglinski, 2001).

The questions that then remains is what is it that makes teachers more or less effective? This is a questions that has occupied educational research for several decades, with researchers looking at such factors as teacher personality, teacher behaviors, beliefs and attitudes, self-efficacy and motivation, subject knowledge, teacher beliefs and teacher self-efficacy and their relationship to students' achievement in mathematics.

TEACHER BEHAVIORS

Initially, researchers started to study teacher effectiveness by looking primarily at personality structures of teachers (such as authoritarianism) to explain differences in the performance of students taught by different teachers. The results of the research was unsatisfactory, however, no relations between these psychological factors and student performance being found (Borich, 1996). Researchers then turned to teacher behaviors as predictors of achievement, and have built up an ever-growing knowledge base on effective teaching, based on research using a so-called 'process-product model' to look at the relationship between teacher behaviors and student outcomes by identifying factors correlated to student achievement and attainment. Teacher behaviors are usually identified through either questionnaires or more common than classroom observation (Muijs, 2006). This research has led to the identification of a range of behaviors that are positively related to student achievement in basic skills (Doyle, 1986; Brophy & Good, 1986; Brophy, 1986; Creemers, 1994; Mortimore et al., 1988; Reynolds et al., 1996; Muijs & Reynolds, 1999, 2000a, 2000b; Borich, 1996; Croll, 1996; Evertson & Anderson, 1980; Galton, 1987; Galton & Croll, 1980; Good & Grouws, 1983; Mortimore et al., 1988). The main findings of this body of research can be briefly hierarchically summarized as follows:

1. Get the classroom climate right. Learning occurs when the classroom is an orderly, businesslike environment. Transitions need to be brief, lessons need to start on time, rules for student behavior need to be established early and be clearly understood by students (these elements could be termed *classroom management*). Student misbehavior needs to be corrected immediately, accurately (e.g., punish the right student) and constructively (e.g., no shouting, *behavior management*). The effective classroom is warm and supportive, characterized by high expectations and teacher enthusiasm (a factor one could term as *classroom climate*) (Doyle, 1986; Brophy & Good, 1986 (Doyle, 1986; Brophy & Good, 1986; Brophy, 1986; Creemers, 1994; Mortimore et al, 1988; Reynolds, et al, 1996; Muijs & Reynolds, 1999; Reynolds & Muijs, 1999).

2. Get the teaching right. Mathematics achievement has been found to increase when most of the lesson is spent teaching the whole class rather than letting students work through worksheets or schedules on their own. This whole class (direct) teaching needs to be highly structured, setting out objectives of the lesson, stressing key points of the lesson, making clear and structured explanations and summarizing the lesson at the end. Whole class teaching needs to be interactive; lecture style lessons are to be avoided. Teachers need to involve students in the lesson by asking a high number of questions, mixing higher and lower cognitive order questions according to the topic (but always using higher order questions, including open questions), using an appropriate wait time, which is short (3 seconds) for lower order questions and longer for higher order questions. Students must receive immediate feedback when they have answered a question. This feedback must be businesslike but positive, acknowledging correct answers and prompting when incorrect answers are given before going over to the next student. While whole-class teaching is important, students also need to have the opportunity to practice what they have learnt during seatwork sessions which should include cooperative small group work. During seatwork the teacher again needs to

take an active role, going around the class to help students and being open to student questions rather than remaining behind her/his desk (Borich, 1996; Brophy, 1986; Brophy & Good, 1986; Creemers, 1994; Croll, 1996; Evertson & Anderson, 1980; Galton, 1987; Galton & Croll, 1980; Good & Grouws, 1983; Mortimore et al, 1988; Muijs & Reynolds, 1999; Reynolds & Muijs, 1999, Muijs & Reynolds, forthcoming).

3. Effective mathematics teaching, however, is not rigid. Teachers need to use a variety of teaching strategies aimed at students with different learning needs. They need to vary the difficulty of questions and explanations to match students' levels, and need to use a variety of manipulatives and materials to engage students, address different learning styles and allow easier transferability of knowledge (Borich, 1996; Brophy & Good, 1986; Reynolds & Muijs (1999); Muijs & Reynolds (2000). Alongside this behaviorist teacher effectiveness strand a new paradigm has begun to emerge in mathematics education research that has challenged some of the assumptions underlying teacher effectiveness research. This 'connectionist' or 'constructivist' paradigm focuses more strongly on such factors as connecting knowledge to students'prior knowledge and other areas of the curriculum, cognitively challenging students in order to allow them to develop their thinking skills, allowing student input into the lesson, using real life materials, examples and contexts and correcting misconceptions.

These factors have been found to be related to mathematics achievement in a number of studies (Anghileri, 1995; Askew & William, 1995;Askew et al., 1997; Nunes & Bryant, 1996). It is likely that these methods will show stronger effects when higher-level and open-ended outcome measures are used. Use of correct mathematical language by teachers and students from the start has also been posited to have a positive influence on mathematics achievement (Burghess, 1998).

TEACHER BELIEFS

While these findings appear robust at least for basic skills instruction, this focus on teachers behaviors has been subject to criticism that has focused among other things on the lack of attention given to teachers' own beliefs about and attitudes to teaching and the subjects they teach, arguing that these deeper structures are more important to teaching quality than immediately observable behaviors. This has led to an increasing amount of research on the beliefs of teachers (De Corte & Greer, 1996; Fennema & Loef-Franke, 1992; Thompson, 1992; Askew et al., 1997). Belief systems are dynamic and permeable mental structures, susceptible to change in light of experience. The relationship between beliefs and practice is also not a simple one -way relationship from belief to practice, but a dynamic two-way relationship in which beliefs are influenced by practical experience (Thompson et al., 1992).

A difference with the behaviorist research is that most behaviorist researchers have focussed on a similar set of behaviors, while the belief structures that have been studied are more wide-ranging, as the universe of teacher beliefs is larger than the universe of in-class behaviors. This means that any study needs to restrict itself to hypothesizing one or a limited belief system as the object of study. One of the belief structures that have been found to underlie teacher attitudes was described by Askew et al. (1997) as a distinction between connectionist, transmission and discovery orientations. These ideal types can be distinguished on the basis of teachers' beliefs about what it means to be a numerate student, their beliefs about how best to teach Numeracy and their beliefs about students and how they learn to be numerate. We will discuss these three aspects in turn.

According to Askew et al. (1997) connection is teachers believe that being numerate involves being both efficient and effective, being able to choose an appropriate problem solving or calculation method and being able to make links between different parts of the curriculum. Connectionist teachers stress the importance of the application of number to

new situations by encouraging students to use realistic problems. Transmission oriented teachers believe in the importance of students obtaining fluency in a number of standard procedures and routines which apply to a particular type of calculation, and they believe that students need to learn to do routine calculations or procedures before applying them to word problems. The discovery oriented teacher believes that all methods of calculation are equally acceptable as long as the answer is obtained, whether or not the method is efficient.

They emphasize students' creation of their own methods, and believe that using and applying mathematics is based on the use of practical equipment. When the researchers looked at teacher beliefs about students and how they learn to become numerate, they found the following differences. Connectionist teachers believe that most students are able to learn math given effective teaching, and that students come to school already possessing mental calculation strategies. The teacher's role is then to work with the students to introduce more efficient strategies. Misconceptions are seen as important teaching tools. For transmission oriented teachers, who emphasize set rules and methods, what students already know before they come to class is less important. Students own methods do not form the basis of teaching. Students are believed to differ in ability, failure to learn once the teacher has explained the procedures to students resulting from lack of ability. Discovery oriented teachers believe that learning is an individual activity, which happens once students are 'ready' to learn a certain concept. Learning takes precedence over teaching, and students own strategies are paramount.

Finally, teachers were found to differ in their beliefs about how best to teach students to become Numerate. Connectionist teachers believe that teaching math is based upon dialogue between teacher and students. This helps teachers to better understand their students and allows students to gain access to teachers' mathematical knowledge. This leads to interactive teaching, with an extensive focus on discussion to help students explore more efficient strategies. Transmission oriented teachers emphasize teaching over learning, and introducing students to routines through clear verbal explanations. Interaction consists largely of the teacher checking whether the student can reproduce the taught procedure using mainly closed questions. Discovery oriented teachers believe in letting students discover methods for themselves, through extensive use of practical experience. In their study of 90 teachers, Askew et al. (1997) found that highly effective teachers were characterized by connectionist beliefs, while transmission and discovery orientations tended to characterize some of the less effective teachers.

STUDENT KNOWLEDGE

As well as behaviors and beliefs, teacher subject knowledge is widely believed to influence teacher effectiveness. The research findings on the effect of subject knowledge on teacher effectiveness and student achievement are more mixed, however.

In Askew et al.'s (1997) study, in which informal 'concept mapping' interviews with teachers were used to gauge their subject knowledge, it was found that the connectionist teachers, who were the most effective, had a wider knowledge of practical and formal methods of representation and of students' mental strategies than transmission or discovery oriented teachers. Teachers who made few conceptual links showed less'student gains in math achievement, although the relationship was weak. There was no relationship between gains and other content knowledge variables, such as fluency, scope explanation or understanding. Teachers did not differ in their understanding of mathematical concepts, although connectionist teachers seemed more inclined to link different numeracy concepts. Formal mathematics qualifications were likewise not linked to student gains.

In their review of research, Fennema & Loef-Franke (1992) make a distinction between teachers' knowledge of mathematics, teachers' knowledge of mathematical representations, teachers' knowledge of students and teachers' general knowledge of

teaching and decision making. Studies suggest that teachers' mathematical content knowledge is linked to both teacher behavior in the classroom and to student outcomes. Teachers' knowledge of mathematical representations refers to how mathematics should be represented in instruction. If teachers do not have this understanding, it will be hard for them to teach students to understand mathematics. In a study of British early years (infant) teachers, Aubrey (1997) found that teachers' lack of deep subject knowledge impeded their bringing into practice their knowledge of how children learn.

Mandeville & Liu (1997) studied the effect of teacher certification (partly based on subject knowledge) on U.S. seventh grade students' mathematics achievement by matching 33 schools in which teachers had secondary math certification with schools where this was not the case. They found that students from schools with higher levels of teacher certification performed better on thinking skills than their peers in lower level certification schools, but that there was no significant difference in performance on understanding and knowledge and competence in math. Teacher certification was also found to be significant in Darling-Hammond's (2000) study of U.S. state policies; teacher preparation and certification were the strongest predictor of relative achievement compared to other states, even after controlling for student poverty and number of students with English as their second language.

Not all studies have shown that teacher subject knowledge affects achievement, however. A number of American studies on the relationship between teacher's scores on the National Teacher Examinations and the performance of their students have found little or no effect (Darling-Hammond, 2000). In her review of research, Byme (1983) reported mixed results, some studies reporting positive effects, but others showing no effect. However, she pointed out that in many of the no effect studies there was little variation in teacher subject knowledge, attenuating possible relationships.

In a study of over 2800 students using data from the Longitudinal Study of American Youth, Monk (1994) found a positive but curvilinear relationship between teacher's subject knowledge as measured by courses taken and student achievement. This suggests that there may be a threshold effect operating, in that a minimal level of subject knowledge is necessary for teachers to be effective, but that beyond a certain point a law of diminishing returns may operate, which may explain the mixed findings in other studies.

TEACHER SELF-EFFICACY BELIEFS

With respect to teachers, two main areas of self-belief have been studied: teachers' self-concept and teachers' self-efficacy. Self-concept can be defined as 'a person's perceptions of him/herself, formed through interaction with the environment, interactions with significant others and attributions of behaviors.' (Shavelson et al, 1976). The self-concept is multidimensional, which means that one can have different self-concepts about different life-areas. For example, a primary teacher could have a self-concept of herself as a math teacher, and a different self-concept of herself as a physical education (PE) instructor. Teacher self-efficacy has been defined as 'a teacher's judgement of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated' (Henson, 2001). It is clear that the two concepts overlap to a certain extent.

Teacher self-efficacy has been linked to student outcomes in a number of studies. A variety of studies have found that students with teachers who score highly on self-efficacy did better on standardized tests of achievement than their peers who are taught by teachers with low self-efficacy beliefs (Moore & Esselman, 1992; Anderson, Greene & Loewen, 1988; Watson, 1991, cited in Henson, 2001). Low teacher self-efficacy beliefs have also been linked to low expectations of students, an important factor in student achievement as mentioned above (Bamburg, 1994). Teacher self-efficacy was found to be related to student self-efficacy in a study by Anderson et al (1988).

The self-concept of 16 male and female primary and secondary teachers was measured to study the possible influence of teachers' self-concepts on how they perceive the nature of mathematics and their attitudes to teaching and learning mathematics (measured through individual teacher interviews). It was found that the low mathematical self-concept of some teachers was related to their negative experiences with mathematics as a student. High self-concept teachers were more motivated, more inventive and more creative about how to conduct math lessons, while low self-concept teachers were more likely to be negative and to complain about lack of resources to implement what they considered to be effective ways of teaching mathematics (Relich, 1996). A study of 132 primary school teachers and their 4,535 primary year five and six students in Hong Kong showed that teachers' Social Self, Pedagogical Self and Personal Self were predictors of teacher behaviors, which in turn predicted student achievement (Chan et al, 1992).

SYNTHESIS

Therefore, there is evidence that student achievement is related to all these factors; subject knowledge, teacher self-efficacy, teacher beliefs and teacher behaviors. The evidence for the relationship is not equally strong in all cases, however. The evidence for the relationship with teacher behaviors would appear to be most robust, whereas that for subject knowledge appears mixed. Teacher beliefs as defined by the transmission-discovery-connectionist ideal types have not been widely studied yet.

Few studies exist of the relationship between all these factors taken together and achievement, however. As mentioned above, both teacher self-efficacy and teacher self-concept have been found to be linked to teacher behaviors, and teacher subject knowledge has been found to be related to less problems for beginning teachers and easier planning for them (Darling-Hammond, 2000), but models of the interrelationship between all four factors and achievement have not often been tested. More often than not these factors are presented as being in opposition to one another, belonging to different 'paradigms', with supporters of behavioral and belief-based models asserting the primacy of their chosen factor. This seems a somewhat unproductive stance from the point of view of educational policy and practice, as, if all these factors do impact on achievement at some level, then clearly all need to be addressed. Furthermore, from a theoretical perspective it is clear that the expectation of links between these factors exists.

We have proposed a model of teacher factors as they relate to student achievement, proceeding from the basis that it is those factors that are most immediately proximal to, and therefore most immediately experienced by students (i.e. teacher behaviors in the classroom) that will most immediately affect student achievement (see Figure 1). Teachers' motivational structures, as measured through teacher beliefs and self-efficacy as math teachers, are hypothesized to impact only indirectly on student achievement, through their impact on what teachers do. Teacher subject knowledge is hypothesized to have both a direct and an indirect effect, as it will hypothetically impact both teachers' behaviors and may be directly experienced by students, especially in the higher grades. Teacher personality variables will affect their motivational structures, but will not directly affect achievement. As this effect is hypothesized to be distal from student experience by two steps, and furthermore prior research has not demonstrated effects of personality on achievement, this factor was not measured in this study.

METHOD

The model proposed above will be tested using data from the second year of the evaluation of the Gatsby Mathematics Enhancement Project Primary. This project was initiated in primary schools in three English and Welsh Local Education Authorities

(schoolboards) in order to improve the standards of mathematics teaching in these schools. The Educational Effectiveness and Improvement Center at Exeter University (then Newcastle) was asked to evaluate this project, and a number of additional schools from another LEA were added as controls. As part of this evaluation students were tested twice yearly, using a Numeracy test designed by Leeds University for NFER.

Teacher effectiveness is measured through differences in the attainment of their students as measured by the change in age-standardized Numeracy test scores between the beginning and the end of the school year. Background data on the students (free school meal eligibility, gender, ethnicity and special needs status) was collected each year. In order to control for class social context as well as individual background, the percentage] of boys, the percentage of students eligible for free school meals and the percentage of students with special needs in each class was calculated and included in the analyses. Teacher behaviors were collected by observing teachers twice a year (fall and summer terms) using a standardized observation instrument developed for the project. This instrument consists of a rating scale of 59 behaviors culled from the effective teaching literature mentioned above.

Classroom observers were trained, and high levels of interobserver reliability were established, reaching a Cohen's Kappa of .84. Teacher beliefs' about teaching and mathematics were collected by means of a postal questionnaire, based on the factors according to the Askew et al (1997) study distinguished connectionist, transmission and discovery oriented teachers. The items of this scale reached a reliability coefficient (Cronbach's Alpha) of .78 in this sample. In this questionnaire teachers were asked a further 5 questions relating to their self-efficacy beliefs as teachers of mathematics. The Cronbach's Alpha reliability coefficient for these items in this sample was .83. Subject knowledge was collected indirectly through the questionnaire, with teachers being asked to indicate their subject knowledge of the five areas of mathematics specified in the English Framework for Numeracy for the primary years (number, calculations, probability, measurement and data handling). The Cronbach's Alpha reliability coefficient for these items in this sample was .81. The response rate to the questionnaire was 77 percent. The final total usable sample consisted of 103 teachers and over 2000 students from 36 schools. The model will be tested using quantitative methods to relate the teacher factors to student achievement controlling for student background variables.

RESULTS

In order to simplify analysis, the 59 teacher behaviors were reduced to 9 factors: the behaviorist factors classroom management, behavior management, direct teaching, review and practice, classroom interaction, varied teaching and classroom climate, and two factors derived from more recent research, constructivist methods and mathematical language. The means and standard deviations for the variables in the model are given in Table 1. What is notable in this table is that teachers perceive themselves to be more knowledgeable about and more effective in the teaching of number than in the other four aspects of the National Curriculum in math, the standard deviation also being lower for this variable. It has to be remarked that this is probably the least mathematically advanced topic in the National Curriculum. Most teachers did perceive themselves to be both knowledgeable and effective, although variance in teacher responses to these items was obtained. When looking at the results for the teacher belief questionnaire, it is apparent that teachers are most likely to subscribe to connectionist beliefs and least likely to subscribe to transmission oriented beliefs.

Correlations of the measured variables with achievement and gains over the year are given in Table 2. As can be seen, the teacher variables that are most strongly correlated to achievement and especially gains are the teacher behaviors measured through classroom

Table 1
Descriptive statistics

Item	Minimum	Maximum	Mean	Standard Deviation
Standardized scores of Fall 1998	69.00	131.00	97.14	14.73
Standardized scors of Summer 1999	69.00	131.00	102.43	18.42
Classroom management	4.00	20.00	14.44	4.79
Behavior management	4.00	20.00	14.51	4.69
Direct instruction	11.00	45.00	31.66	9.99
Review and practice	4.00	20.00	14.99	4.52
Classroom interaction	13.00	65.00	44.85	18.03
Constructivist methods	5.00	21.50	12.19	4.71
Mathematical language	2.00	10.00	6.74	1.70
Varied teaching	3.00	15.00	9.54	4.36
Classroom climate	11.00	40.00	29.54	8.57
Percentage free school meal eligibility	3.00	73.20	33.73	21.80
Percentage special education needs	11.90	52.70	28.75	9.02
Percentage boys	40.40	62.00	50.86	4.43
Knowledge of number	3.00	5.00	4.28	.70
Knowledge of calculation	1.00	5.00	3.86	1.01
Knowledge of probability	1.00	5.00	3.81	.81
Knowledge of measurement	2.00	5.00	4.00	.86
Knowledge of data	1.00	5.00	3.86	.86
Self-efficacy number	2.00	5.00	4.22	.66
Self-efficacy calculation	1.00	5.00	3.85	.82
Self-efficacy probability	1.00	5.00	3.75	.70
Self-efficacy measurement	2.00	5.00	3.97	.71
Self-efficacy data handling	1.00	5.00	3.83	.81
Connectionist orientation	.00	7.00	3.52	1.85
Discovery orientation	.00	7.00	2.12	1.69
Transmission orientation	.00	6.00	1.36	1.34
Sex	.00	1.00	.52	.50
Special Needs Status	.00	1.00	.25	.44

observation. The teacher beliefs show an interesting pattern: Connectionist beliefs are correlated positively with achievement, a transmission orientation is not correlated with outcomes, while a discovery orientation is negatively correlated with outcomes. The correlations are lower than those for the teacher behaviors, however. When we looked more closely at the structure of teacher beliefs, it was found that discovery and connectionist orientations were negatively correlated with one another, and that the same was true of discovery and transmission methods.

In order to form a suitable scale, a balance formula was used (Roe, 1983). Most of the subject knowledge and self-efficacy variables were significantly positively related to achievement, although the relationship was weak. Background factors were related to students' achievement (in particular special needs), but not to student gains. These findings provide some first support for the hypothesis that it is those factors which are most proximal to student experience that are most directly related to outcomes, with the effect of more distal factors being weaker. However, in order to test this model further, more sophisticated statistical methods are needed.

We decided to use structural equation modeling to test the model, as this technique is preeminently suited to this type of analysis. Structural equation modeling has been defined as 'a comprehensive approach to testing hypotheses about relations between variables' (Hoyle, 1998). This technique, which measures the fit of pre-specified

directional relationships between the variables to the covariance matrix used allows us to model directional relationships between variables, while also taking into account measurement error in the data.

One of the advantages of structural equation modeling is that it allows one to model the data as indicators of underlying variables. This is theoretically sensible, as in all cases measurement is indirect, questions on teacher knowledge and the sample of teacher behaviors measured through classroom being designed to be indicators of actual teacher knowledge and global teacher behaviors respectively, for example. In our model the seven behaviorist classroom observation scales were hypothesized to be the indicators of the latent variable 'behaviorist teaching' while constructivist methods and mathematical language were hypothesized to form a 'constructivist teaching' factor and 'mathematical language teaching' factor respectively. The percentage of boys, the percentage of students eligible for free school meals and the percentage of students with special needs were hypothesized to be indicators of the relative level of disadvantage in the school. The five knowledge areas were modeled as indicators of teacher subject knowledge, while the five self-efficacy measures were hypothesized to be indicators of teacher self-efficacy. Error variances were fixed according to estimates of measurement reliability (see Hayduk, 1997), with coefficients ranging from .05 (sex) to 0.2 (questionnaire and classroom observation data). The loadings of the latent variables on their indicators are given in Table 3. Figure 2 shows the tested relationships between the latent variables. As mentioned earlier, the basic theoretical model is that depicted in Figure 1.

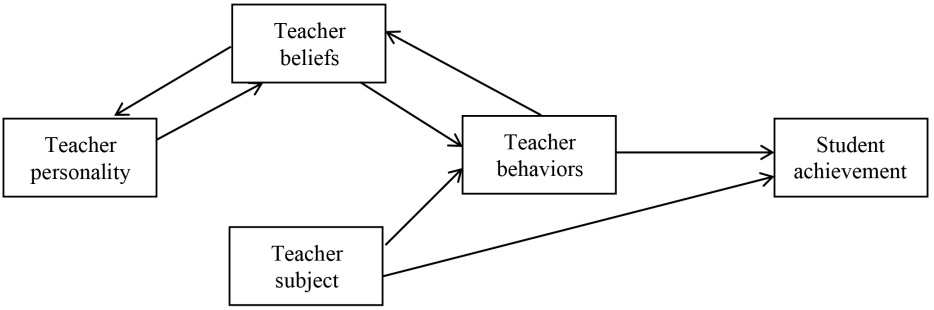
Table 2

Correlations of predictors with achievement and attainment

	End of the year scores	Gains over the year
Classroom management	**.18**	**.35**
Behavior management	**.20**	**.32**
Direct instruction	**.20**	**.35**
Review and practice	**.18**	**.32**
Classroom interaction	**.20**	**.36**
Constructivist methods	**.09**	**.16**
Mathematical language	**.14**	**.07**
Varied teaching	**.17**	**.34**
Classroom climate	**.15**	**.35**
Knowledge of number	**.07**	**.08**
Knowledge of calculation	**.09**	**.14**
Knowledge of probability	**.06**	**.11**
Knowledge of measurement	**.06**	**.12**
Knowledge of data	**.07**	**.09**
Self-efficacy number	**.07**	**.12**
Self-efficacy calculation	**.05**	**.11**
Self-efficacy probability	**.08**	**.13**
Self-efficacy measurement	**.06**	**.13**
Self-efficacy data handling	**.10**	**.10**
Connectionist orientation	**.10**	**.17**
Discovery orientation	**-.11**	**-.07**
Transmission orientation	-.00	-.01
Sex	-.01	-.02
Special Needs Status	**-.37**	-.03
Free School Meal Eligibility	**-.17**	-.00

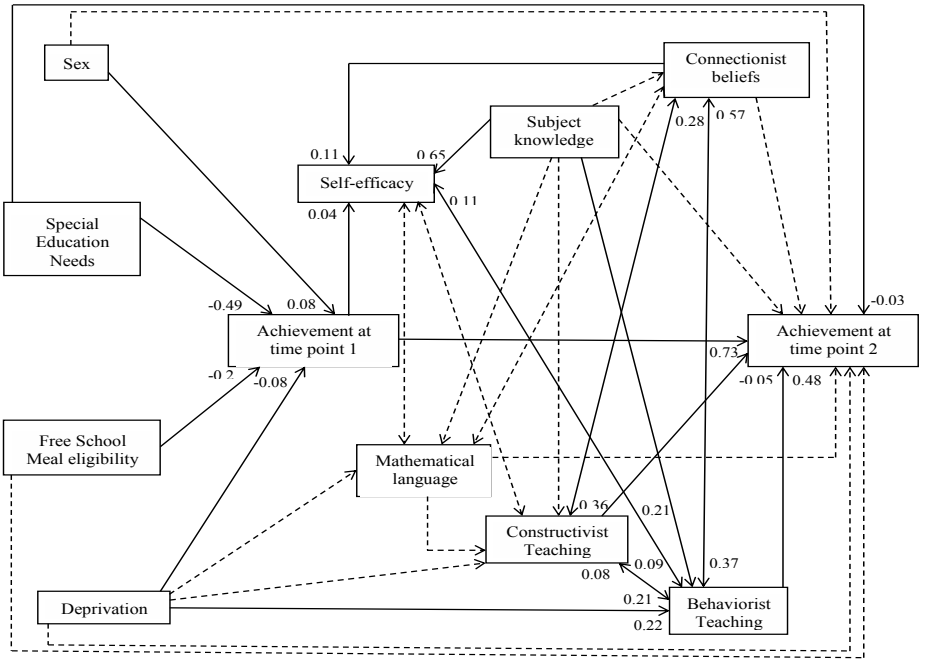
Note. Significant relationships in bold text.

Figure 1. Theoretical model of the relationship between teacher characteristics and



As can be seen in Figure 2, the background factors are hypothesized to influence achievement at both time points. Achievement at time point 2 is hypothesized to be influenced by achievement at time point 1, teacher behaviors and subject knowledge. In contrast to our theoretical model, a path from beliefs to achievement was included, in order to test our hypothesis more stringently. Behaviors are hypothesized to be influenced by beliefs, subject knowledge and self-efficacy, the relationships with self-efficacy and beliefs is hypothesized to be reciprocal. The three behavior factors were hypothesized to be related to one another. Self-efficacy is itself hypothesized to be influenced by achievement at time point 1. An arrow from deprivation to behaviors was

Figure 2. Background factors that influence student achievement



Note. Non-significant paths are represented with dashes.

Table 3

Loadings of latent variables on their indicators

Indicator	Latent	Loading
Classroom management	Behaviorist Teaching	.86
Behavior management	Behaviorist Teaching	.75
Direct instruction	Behaviorist Teaching	.76
Review and practice	Behaviorist Teaching	.79
Classroom interaction	Behaviorist Teaching	.93
Varied teaching	Behaviorist Teaching	.85
Classroom climate	Behaviorist Teaching	.97
Knowledge of number	Subject Knoweldge	.86
Knowledge of calculation	Subject Knoweldge	.88
Knowledge of probability	Subject Knoweldge	.89
Knowledge of measurement	Subject Knoweldge	.88
Knowledge of data	Subject Knoweldge	.87
Self-efficacy number	Self-Efficacy	.85
Self-efficacy calculation	Self-Efficacy	.87
Self-efficacy probability	Self-Efficacy	.86
Self-efficacy measurement	Self-Efficacy	.87
Self-efficacy data handling	Self-Efficacy	.86
Standard scores of Fall 1998	Achievement 1	.95
Standard scores of Summer 1999	Achievement 2	.95
Percentage FSM	Deprivation	.92
Percentage SEN	Deprivation	.92
Percentage boys	Deprivation	.57
Gender	Sex	.96
RecSEN	SEN	.77
RecFSM	FSM	.90
Constructionist methods	Constructivist Teaching	.89
Mathematical language	Math. Language Teaching	.86
Connectionist orientation	Beliefs	.95
Discovery orientation	Beliefs	-.75
Transmission orientation	Beliefs	.47

also included, based on previous studies on this sample which had shown a difference in teacher behaviors depending on the social composition of the classroom (higher teacher effectiveness in more deprived schools) (Muijs & Reynolds, 2001). Teacher beliefs are hypothesized to be reciprocally related to self-efficacy, and to be influenced by subject knowledge (as better subject knowledge should allow teachers to make more connections, etc.) We allowed a number of errors to correlate, where variables were expected to have some relationship due to methodological similarities. This was the case for the variables derived from classroom observation, and between the subject knowledge and self-efficacy variables which were similarly worded. Model-data fit was tested using a variety of fit indices. The fit indices in Table 4 show that, while not strictly fitting according to the Chi square test (the 2148 sample size produces very strong power to detect minor misfits) the alternative fit indices do indicate that the model fits the data quite well.

Some of the predicted relationships were not significant, however. Significant paths are indicated by full lines in Figure 2, non-significant paths are indicated by dashed lines. As predicted, all four background variables predicted achievement at time point 1, the strongest predictor being Special Needs Status (SEN), followed by free school meal eligibility (FSM) (both negative). Gender (boys doing less well) and classroom level deprivation were also significant, the latter pointing to the effect of classroom social composition over and above individual social background, students in classrooms with

Table 4
Fit indices

Chi Square	Df	RMSEA	CFI	GFI
2079.3	252	0.52	0.95	0.95

a more deprived population doing less well. As predicted, achievement at time point 1 predicted teacher's self-efficacy perceptions, thus teachers whose students had higher grades at time point 1 perceived themselves to be more effective.

Behaviorist teaching was a predictor of self-efficacy, which would suggest that teacher's own views of their efficacy and the rating of their behaviors by external observers correspond to one another, or, said otherwise, teachers are well able to judge the efficacy of their own teaching. Teachers (self-rated) subject knowledge was the strongest predictor of self-efficacy beliefs however, teachers therefore clearly believing that better subject knowledge makes them more effective. Having a connectionist orientation was the final factor to be related to teacher efficacy beliefs, teachers with connectionist beliefs seeing themselves as more effective. In contrast to what we had hypothesized, constructivist teaching was predicted by behaviorist teaching, but not by any of the other variables in the model. Connectionist beliefs were also a predictor of behaviors. They stronglypredicted constructivist behaviors, as hypothesized, and were the strongest predictor of behaviorist teaching as well. A variable that was not predicted by any of the variables in the model was the use of correct mathematical language by teachers and students as measured during the classroom observations. This factor also was not a predictor of any variables. The lack of a relationship with both subject knowledge and achievement could be due to the fact that the ability to observe this variable during lessons is strongly related to the specific topic of that lesson, and therefore, produces results that are too idiosyncratic to produce reliable findings.

Behaviorist teaching was, as mentioned, strongly predicted by teacher beliefs, as was constructivist teaching. Subject knowledge and self-efficacy were also significant predictors of behaviorist teaching, self-confident teachers scoring higher on the teacher behavior scales. The path from classroom level deprivation to teacher behaviors was positive, suggesting higher ratings on our classroom observation measures in more economically deprived environments. Finally, when looking at the paths to achievement at time point 2, it was found that prior achievement was (unsurprisingly) the main predictor. Of the student background variables, only special needs was (just) significant, the effect of deprivation and the other individual level background variables being partialed out through the inclusion of its effects in prior achievement. Behaviorist teaching was the most significant teaching factor to predict progress over the year, making a substantial contribution to explained variance, thus showing that teachers do indeed make a difference to student progress. Constructivist teaching was also weakly significant, but in a negative direction, constructivist teaching thus being linked with less student progress over the year. The other teaching variables did not have a direct effect on achievement, however. In many cases there was an indirect effect through teacher behaviors, though, as indicated in Table 5.

In order to look at the total contribution of the variables to the prediction of student achievement, the indirect, direct and total effects are given in Table 3. We can see that a number of variables have a significant indirect as well as a direct effect on achievement. When this is taken into account, achievement at time point I remains the most significant predictor, followed by behaviorist teaching, but SEN, through its strong relationship to achievement at time point 1, has the third highest total effect on achievement at time 2. Free school meal eligibility likewise has a significant indirect effect on achievement at time point 2. Teacher beliefs are also highly significant, indirectly affecting achievement

through teacher behaviors. The interrelationship between the teaching factors led us to hypothesize that we could identify teachers who were globally effective, i.e. exhibit effective behaviors, have connectionist beliefs, positive self-efficacy beliefs and good subject knowledge. In order to test whether this was the case, we used cluster analysis. Cluster analysis is a technique to classify objects or cases, in this case teachers, using a number of relevant variables (Aldenderfer & Blashfield, 1984).

As clustering techniques may be sensitive to differences in scaling between factors (the factors looked at here contain a different number of items), all the scales were standardized. Using hierarchical clustering, a two-cluster model was found to fit the data well. As can be seen in Table 6 (next page), the two clusters describe effective and less effective teachers well, with effective teachers being characterized by high scores on teacher behaviors, connectionist beliefs, subject knowledge and self-efficacy, and scoring negatively on discovery and to a much lesser extent transmission orientations. Teacher behaviors and connectionist beliefs most clearly distinguished the two groups. Forty-five percent of teachers were classified as belonging to the highly effective group, 55 percent were classified as belonging to the less effective group. Students taught by the highly effective group gained an average 6.7 points on the standardized test over the years, students taught by less effective teachers made an average 1.1 points gain. This difference is highly significant (T=6.2, sig<.001).

CONCLUSION

In this paper we set out to explore the contribution of a number of factors identified in the research literature as possibly leading to differences in teacher effectiveness, which has been found to strongly influence student progress (Wright, Sanders & Hom, 1997; Muijs & Reynolds, 2000; 2001; Mortimore et al, 1988). Teacher behaviors, teacher beliefs, teacher self-efficacy and teachers' (self-rated) subject knowledge were measured in a sample of 103 British primary school teachers for that purpose, and linked to student achievement controlled for prior achievement and background factors. We proceeded from a theoretical model that hypothesized that these factors would have an influence on student achievement proportionate to their proximity to student experience, with more distal factors influencing outcomes indirectly through their impact on the most proximal factor, teacher behaviors in the classroom.

This model was not rejected by the data, a structural equation model showing acceptable fit, and (behaviorist) teacher behaviors significantly directly affecting achievement at time point 2, controlling for prior achievement and background factors.

Table 5

Direct and indirect effects on achievement at time point 2

	Direct	Indirect	Total
Achievement at time point 1	.73	N/A	.73
Deprivation	-.02	.04	.02
FSM	.00	-.14	-.14
SEN	-.03	-.36	-.39
Gender	.00	.06	.06
Teacher behaviors - beh	.40	.06	.46
Teacher behaviors - con	-.05	.00	-.05
Teacher behaviors - mat	.00	.00	.00
Teacher beliefs	.00	.14	.14
Teacher self-efficacy	.00	.05	.05
Teacher subject knowledge	.05	.02	.07

Table 6

Cluster centers teacher factors

	Cluster Zscores	
	#1	#2
Teaching Behaviors	.77	-.60
Subject Knowledge	.15	-.37
Math Self-Efficacy	.50	-.41
Connectionist Orientation	.85	-.75
Discovery Orientation	-.75	.66
Transmission Orientation	-.20	.18

A connectionist orientation was important as well, however. Indirectly, this set of teacher beliefs had a significant influence on achievement, through their impact on teacher behaviors, of which they were the strongest predictor. Teacher self-efficacy and subject knowledge also impacted on teacher behaviors, and thus affected student achievement indirectly. A number of weaknesses and caveats need to be taken into account, however.

First, the structural equation model we used did not take into account the multilevel structure of the data. This means that standard errors could be attenuated and therefore lead to wrongly classifying certain effects as significant. However, the state of the art of multilevel structural equation modeling at present would lead to problems in the specification of a model of the complexity we were proposing, especially in the light of the relatively small sample size (103) at the second (classroom) level. Likewise, using multilevel regression models rather than structural equation modeling, while solving the aggregation problem, would not do justice to the structure of direct and indirect latent effects we proposed to test.

There is obviously also a weakness in the subject knowledge variable, as this was measured using a questionnaire to teachers, rather than directly measuring subject knowledge through testing (which would have been too sensitive to attempt) or in-depth interviews. Teachers' self-perceptions therefore may be more or less accurate, although the difference between self-perceptions of subject knowledge in number compared to more complex mathematical content is encouraging in this respect. This fact may of course partly explain the strong relationship with self-efficacy beliefs, as these were collected in a similar way, and therefore similar respondent response style effects could be operating.

The beliefs factor, based on Askew et. al's (1997) connectionist-discovery-transmission orientation ideal types of course represents just one of many possible teacher belief structures, which may have differing impacts on teacher behaviors and student outcomes. However, the results reported here certainly suggest this classification is useful, and that these beliefs play a part in determining teacher effectiveness in math. The outcome measure itself of course has its limitations. The tests used in this study, while reflecting the English National Curriculum, and the short-term nature of this study mean that we have studied typical short-term achievement gains only. It is not clear from this study whether these effective teaching behaviors are also, or as strongly, related to longer-term and more high-level cognitive outcomes, such as independent learning goals or metacognitive development. This does detract from the importance of these findings, as clearly basic skills are important to student learning.

Notwithstanding these weaknesses, these findings point to a number of consequences for teacher professional development and initial teacher training. First, while this paradigm has been the subject of much criticism recently, it is clear that the behaviorist teacher effectiveness approach is valuable. Teacher behaviors were not only the most significant predictor of student progress over the year, but also significantly affected

teacher beliefs and self-efficacy, showing their relationship to be reciprocal. It is therefore clear that a significant amount of initial teacher training should be devoted to behavioral factors. Although, as Brophy (1986) has pointed out, not all the results from this and similar studies are immediately easily transferable to the classroom, the fact that this research is based in naturalistic classroom settings, makes it more so than research based on experiments or surveys.

This does, of course, not mean that the other factors should be disregarded. Having connectionist as opposed to, in particular, transmission oriented beliefs will enhance effective teaching, and it is therefore encouraging that connectionist statements were more readily endorsed by teachers than discovery or transmission beliefs. Subject knowledge, while impacting quite strongly on teachers' self-efficacy perceptions, was less significant. We would hypothesize that the reason for this is that teachers generally possess the necessary math knowledge to teach in primary school, and that if there is a curvilinear effect as found by Monk (1994) the teachers we observed would fall outside of the area of significance for this factor. Also, as subject knowledge was measured by asking the teachers themselves, some may be overestimating their own subject knowledge. That self-efficacy beliefs were reciprocally related to behaviors is not surprising in view of previous findings, but it does suggest, as does most self-efficacy and self-concept research that improving performance (in this case teacher behaviors) is

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