DEVELOPING TEACHING EFFICACY FOR INQUIRY-BASED LEARNING

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This paper considers mathematics teachers' professional learning from the perspective of social learning theory. This exploratory study identified the effects of a professional development (PD) programme on teaching self-efficacy (TSE), a sub-construct of social learning theory. The PD involved materials that were designed to encourage inquiry-based learning and student discussion in secondary school mathematics lessons. A group of teachers who took part in one to three PD modules (n=18) showed increased TSE compared with a control group (n=18) using a post-test only design. This suggests that the PD might be effective in helping teachers change their practices. From a broader perspective this exploratory study suggests that social learning theory has potential in offering a theoretical framework for teachers' professional learning.

Keywords: Professional development, problem-solving, teaching self-efficacy, social learning theory.

Introduction

The evaluation of professional development (PD) is complex and difficult (Desimone, 2009) and consequently the evaluation of PD that promotes inquiry-based learning is also problematic . The difficulties associated with effective evaluation have been attributed to the problems of adequately theorising teachers' professional learning (Darleen Opfer & Pedder, 2011). An overriding issue in the conceptualisation of professional learning is the challenge of accounting for changes in individual teachers' thinking and beliefs while at the same time accounting for the social and contextual aspects of teachers' professional learning. Most approaches to understanding professional learning consider either teachers' knowledge and beliefs or social and community aspects, few attempt to integrate both. In this paper I consider how social learning theory (SLT) can be used to theorise professional learning, as it accounts for both individual teacher characteristics as well as social effects. I also illustrate how SLT be operationalized to evaluate PD for inquiry-based learning.

The study described here is part of an extensive exploratory study which drew on a variety of methods, the aim of which was to develop an efficient and cost effective way of evaluating PD in the 'natural' and complex setting of a secondary school. This study represents one aspect of this exploratory work. In this study it was identified that self-efficacy presented a useful construct for evaluation of PD and that SLT provides a useful approach to conceptualising professional learning. In the main, this paper presents the approach to the evaluation of the effects of the PD. Although, the relationship between self-efficacy and SLT is described and some implications of SLT for professional learning are discussed.

The results of this study indicate three things. Firstly, PD appeared to have an effect on TSE and therefore there is some evidence of the PD's effectiveness in promoting inquiry-based learning. Secondly, this study contributes evidence in supporting the value of observing changes in self-efficacy as an approach to the evaluation of PD. And finally that SLT, of which self-efficacy is a component, offers a useful framework for conceptualising PD.

I will begin with a description of social learning theory and its more well-known sub-construct of self-efficacy (SE) and how it can be applied to professional learning in the context of promoting inquiry-based learning. I will then describe the empirical study that draws on SLT to evaluate the PD. The PD was designed to support and encourage problem-solving and inquiry-based learning approaches.

Social learning theory and self-efficacy in the context of PD for inquiry-based learning

Social learning theory foregrounds observational learning and the modelling of behaviours as key components in the formation of behaviour. In the context of teaching, teachers observe and model other teachers' practices. The sources of the observed practice could be from the teacher's own experience as a pupil or from observing more experienced teachers at the beginning and through their teaching careers. In the context of the PD described here, the practices or approaches presented provide sources of behaviour to be observed. Extensive use is made of video of teachers using inquiry-based learning approaches. It should be noted that videos of examples of practice have been important in influencing teachers' practices in recent years [1]. SLT does not suggest that the relationship between observed behaviour and enacted behaviours is simply imitative. SLT affords agency, individuals are able to observe, model and construct behaviours through the use of mental models and self-regulative processes to decide a course of action. This is consistent with Rowlands, Thwaites and Jared's (2011) idea of a mental image of a lesson that a teacher has prior to going into that lesson. A teacher constructs a picture of, or imagines the lesson they are about to teach. Self-efficacy is the belief a person has in the level of success they will have with in particular domain influences behaviour. An individual in modelling behaviour takes account of their self-efficacy in determining a course of action. More efficacious teachers are more likely to experiment with their practices or adopt new approaches (Guskey, 1988).

An important feature of SLT is the idea of *reciprocal triadic determinism* (Bandura, 1977). This proposes that there is reciprocal relationship between behaviour; the social context and individual thinking (see Figure 1).

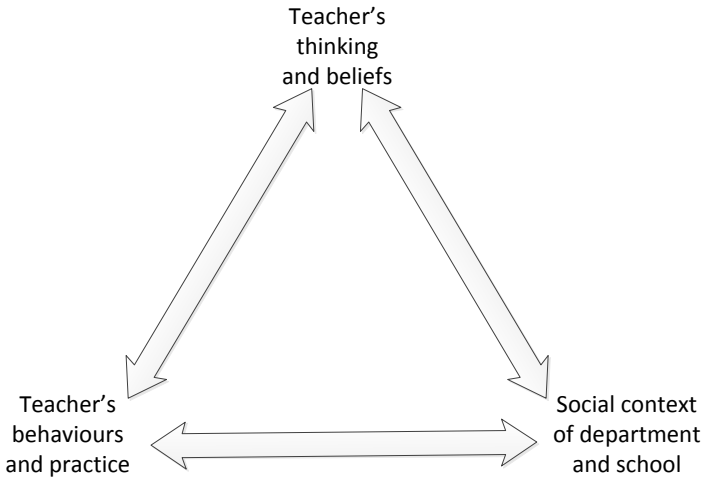

Figure 1: Social learning theory, reciprocal triadic determinism

This reciprocal relationship can be understood in terms of the effect the school and department has on individual practice. While at the same time, enacted behaviours have an impact on the social setting, they contribute to what is accepted to be the social norms in that department. In a similar way the reciprocal relationship between thinking and behaviour acknowledges the effect of thinking and beliefs on behaviour but in return, reflects how experience of our behaviour influences our thinking. Likewise our thinking contributes to establishing social norms and vice versa.

The important components in this process, according to Bandura (1977, 1997) are observed and modelled behaviours and the self-regulative construct of self-efficacy. Self-efficacy is the belief an individual has in the extent to which they will be successful in a particular domain. This plays an important mediational role in determining what behaviours are enacted by individuals, based on what behaviours they have observed and modelled. At the same time self-efficacy accounts for the individuals' level of skill as well as the social acceptability of the course of action. Individual's perceived self-efficacy beliefs reflect their '…capabilities to organize and execute the courses of action required to produce given attainments' (Bandura, 1997, p. 3). This in turn, reflects the individual's emotional disposition as well as underlying skill. Self-efficacy is a useful construct as it can be applied to teaching in order to assess a teachers' capacity or potential to implement a new approach to teaching. In the next section I shall describe self-efficacy in the context of teaching and how this has been used in previous research.

Operationalizing social learning theory: teaching self-efficacy scales

A teacher's self-efficacy beliefs (TSE) have been defined as '[a] judgment 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' (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783). While TSE emerges from strong theoretical ground, its validity has also been demonstrated empirically and it has been shown to be related to other important factors. For example, TSE is related to student achievement (Allinder, 1994; Ashton & Webb, 1986; Tschannen-Moran, Hoy, & Hoy, 1998). In addition, it has been shown to be related to teachers' willingness to experiment with and adopt new practices (Berman, McLaughlin, Bass-Golod, Pauly, & Zellman, 1977; Guskey, 1988; Stein & Wang, 1988). These present useful findings, as measures of TSE can also indicate levels of student achievement and teachers' capacity to develop their practice.

TSE is potentially a powerful measure but it has not been widely used in the evaluation of PD. However, Ross and Bruce (2007) conducted a randomized field trial using measures of TSE with grade six mathematics teachers (n=106) in the USA. It was shown that the PD had an effect on TSE. Karimi (2011) evaluated the effects of PD on EFL (English as a Foreign Language) teachers' efficacy, finding the PD had a positive effect on TSE. Desimone (2009) suggested that PD evaluation is underdeveloped—there is a need for more empirically valid methods—previous studies have relied on '…teacher satisfaction, attitude change or commitment to innovation rather than its results…' (p.181). A possible reason for the limited number of PD evaluations using TSE is that this aspect of PD research is in its infancy. TSE presents a suitable construct that goes beyond attitude change and commitment to change and has the potential to measure the effects of PD on student achievement, albeit indirectly.

Much work has been done in recent years in developing TSE instruments. Tschannen-Moran and Woolfolk Hoy (2001) developed the Teaching Self-Efficacy Scale (TSES). This instrument is often regarded as a standard. They tested the validity of the scale by comparing it with other measures of TSE and found high levels of correlation. They also identified three factors: *efficacy for instructional strategies*; *efficacy for classroom management* and *efficacy for student engagement*. *Efficacy for instructional strategies* includes items relating to assessment, questioning, providing explanations and differentiation. *Efficacy for classroom management* has items relating to the control of student behaviour, establishing classroom rules, getting students to follow them and dealing with challenging behaviour. *Efficacy for student engagement* is concerned with motivating students from

different backgrounds and encouraging them to value learning and to think critically and be creative. The TSES instrument was used by Ross and Bruce (2007) and Karimi (2011) in their evaluations of PD. While the development, validity and reliability work for the TSES had been carried out in the USA, the instrument has been shown to be valid across culturally diverse settings (Klassen et al., 2009).

Since this instrument is acknowledged as a standard it was decided to use the TSES in the evaluation of the Bowland PD materials. This was intended to determine the extent to which the PD had an impact on teachers' self-efficacy and at the same time assess teachers' capacity to experiment with practice. As part of this an inquiry-based learning specific efficacy instrument was also developed. Importantly, this small-scale study was also intended to consider the fit of SLT to professional learning. However, what is communicated in this paper are specific aspects of SLT i.e. self-efficacy and a more general view of how SLT might be applied to understanding PD. In the next section I will describe the professional development materials and follow this with a description of how efficacy data was collected and analysed.

The professional development materials

The Bowland PD materials were designed to encourage teachers to incorporate problem-solving, modelling and open-ended investigation into their teaching. The problem-solving cycle is referred to as the *key processes* in England. The materials were also designed to be used independently and autonomously by groups of mathematics teachers or mathematics departments. They provide full support for one of the teachers to plan and lead the PD. The materials include videos of classrooms as well as students and teachers talking about teaching and learning which is based on collaborative problem-solving. There are also printed materials with information based on research as well as example tasks and guidance for lessons.

There are seven PD modules each featuring a theme or aspect of problem-solving and teaching mathematics using unstructured tasks (see Table 1). The first module, *the case studies and mathematics* is the only module relating specifically to the Bowland case studies. The case studies with which the PD modules were released are learning materials designed for classroom use. They were designed to encourage problem-solving and to be engaging, while not always making the mathematical content obvious. This PD module addresses the concerns of teachers who believe that teaching using problem-solving, open-ended tasks and in particular using the case studies do not develop mathematical skills. The other modules focus on specific aspects of teaching problem-solving and supporting students' learning through engaging with unstructured problems. They include, developing discussion and collaboration between students; using ICT; questioning and developing reasoning in students, assessment and involving students in peer and self-assessment.

The materials are made available in the UK via a website, http://www.bowland.org.uk and are accessed through a flash-based `Bowland player'. Each module begins with an overview (the *fostering and managing collaborative work* module opening page is shown in Figure 1). From the initial screen there are links to a module handbook which provides a printed version of the module and guidance, lesson plans and a resource index for whoever leads the PD. All the modules are divided into three parts. There is an *introductory* session, in which teachers are guided through a sequence of activities which includes working on unstructured tasks, watching videos of lessons and engaging in discussion about teaching and learning using unstructured tasks. Teachers then prepare a lesson. In the *into the classroom* phase teachers try out the lesson with one of their classes. Finally, there is a *follow-up* sessions in which teachers reflect together, on their lesson experiences, there

are also further print and video materials. Each of the sessions was designed to take approximately one-hour.

Table 1: The Bowland PD modules

1	The case studies and mathematics
2	Tackling unstructured problems
3	Fostering and managing collaborative work
4	ICT: Using resources effectively
5	Questioning and reasoning
6	Assessing the key processes
7	Involving pupils in self and peer assessment

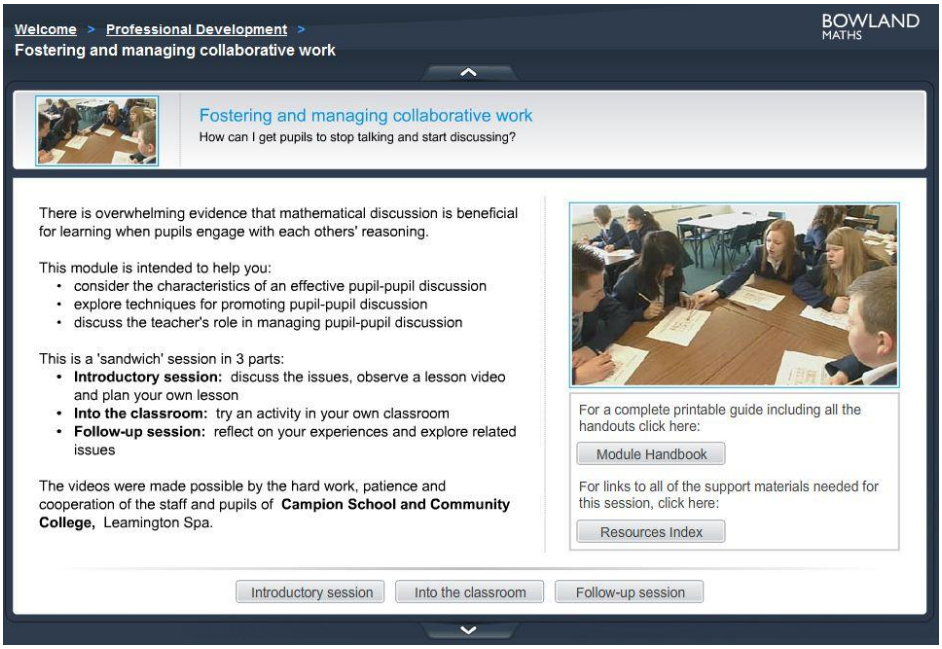

Figure 2: Bowland PD materials, fostering and managing collaborative work module screenshot of the opening web page

The PD trials

Two schools volunteered to take part in trials of the PD materials. The first, Westgate Community College (pseudonym), a 14-19 school began trials of the PD in December 2010. The second school, David Baxter School (11-16) began trials of the PD in April 2011. Both schools are mixed gender, with a predominantly white British intake. The student populations have above average socio-economic status as measured by the proportion of students eligible for free school meals. The public examination results (based on General Certificate of Secondary Education at age 16) are above average. There were eight mathematics teachers at Westgate and ten at David Baxter School. Both schools completed a PD module each half-term. When the TSE questionnaires were administered at the end of May 2011, Westgate had completed three PD modules: *Fostering and managing collaborative work*, *Assessing the key processes* and *Involving pupils in self and peer assessment.* David Baxter had completed one module, *Fostering and managing collaborative work*. At Westgate, the PD was led by the head of department and at David Baxter, the PD was led by an assistant head

of department. In addition to collecting TSE data, PD sessions were observed, lessons were observed and teachers were interviewed.

Evaluation method

For this study a post-test only design [2] was used with non-equivalent groups. The experimental group of 18 secondary mathematics teachers attended between one and three PD sessions as described in the previous section. The control group (n=18) was made up of teachers in the same district who had not experienced any of the PD. The long-form version of the Teaching Self-efficacy Scale (TSES) was used; this has 24 items and was found by the authors of the instrument to have three factors as described in the theory section. The three factors are: *efficacy for instructional strategies*, *efficacy for classroom management* and *efficacy for student engagement*. There are eight items relating to each factor. For each item, teachers were asked to rate the extent to which they believed they would be successful on a scale from 0– 100. This is the approach recommended by Bandura (2006). An additional four PD specific efficacy items were added. These had the same structure as the original instrument. For these four items, teachers were asked to rate their degree of confidence on a scale of 0–100, in: 1) *getting students to tackle open-ended problems;* 2) *helping students collaborate and discuss their problem solving;* 3) *supporting students use of ICT in problem solving* and 4) *encouraging students to explain their solutions to open-ended problems*. These four items were treated as a fourth factor, *PD specific efficacy.* The instrument was administered to the experimental and control groups at the end of May 2011.

Reliability analysis gave Cronbach's $\alpha = 0.95$ (n=36), for the 28-item instrument. This compared to $\alpha = .94$ (n=410) determined by Tschannen-Moran and Woolfolk Hoy (2001) for the 24-item long-form TSES.

Results

A repeated measures ANOVA determined that the means for the experimental and control group were significantly different for the factor, *efficacy for student engagement*, $F(1, 34) = 4.13$, $p < 0.05$. The groups that experienced PD also out-performed the control group on the other three factors but there was no statistical significance (see Figure 2 and Table 2).

Discussion

The effect of the PD on teachers' *efficacy for student engagement* was significant. This can be explained by considering the items in this efficacy factor in relation to the aims and content of the PD. This factor includes items about fostering student creativity, critical thinking as well as student motivation The PD was designed to encourage student-centred practices involving the use of unstructured, open-ended tasks in order to promote student problem-solving and inquiry-based learning. It could be expected that *efficacy for student engagement* would most likely be affected. If the PD had been successful, a teacher would have increased belief in their ability to foster students' creativity and critical thinking. Interestingly, the aim of the tasks and activities with which the PD was released was to promote student engagement, the PD appears to have contributed to this.

Although not significant, the factors; *efficacy for instructional practices*, *efficacy for classroom management* and *PD specific efficacy* were also higher for the experimental group. *Efficacy for*

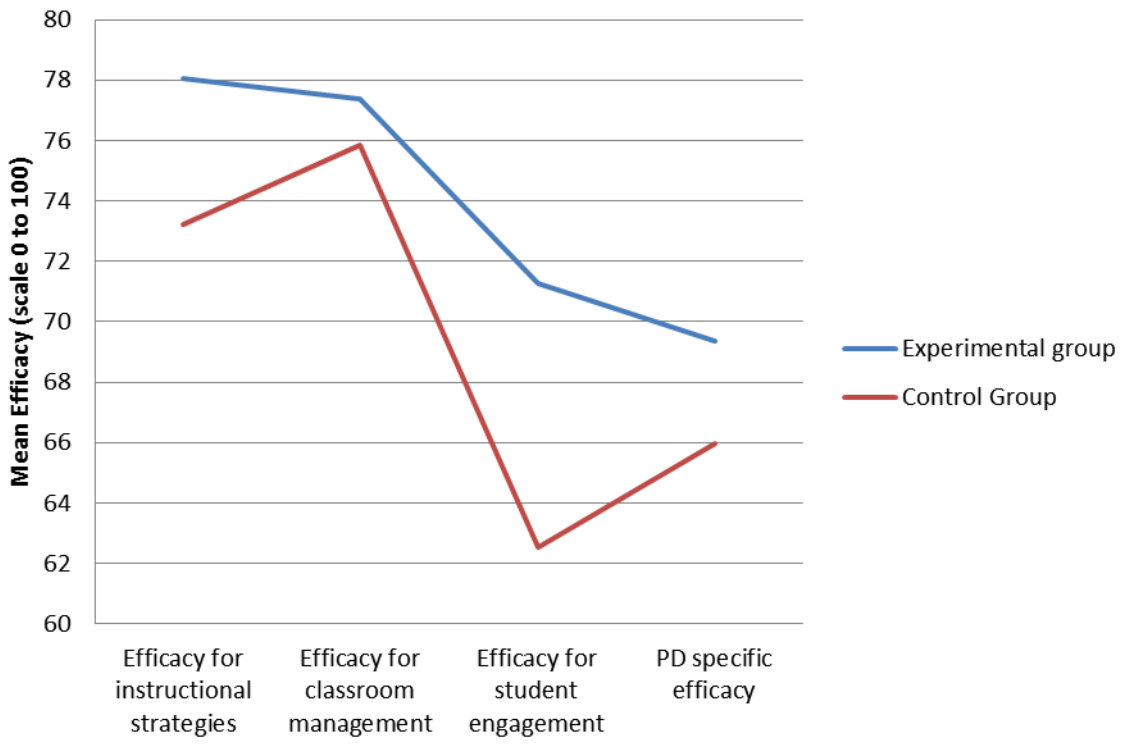

Figure 2: Mean efficacy for each efficacy factor, comparing post-test results of experimental (n=18) and control groups (n=18).

Table 2: Mean efficacy for each efficacy factor, comparing post-test results of experimental (n=18) and control groups (n=18).

	Experimental group	Control Group
Efficacy for instructional strategies	78	73
Efficacy for classroom management	77	76
Efficacy for student engagement	71	63
PD specific efficacy	69	66

instructional strategies had the second highest difference between the experimental and control group (see Figure 2 and Table 2). The PD was designed to enhance teachers' questioning and assessment for learning practices which is consistent with items in this factor. It is likely that these aspects of the PD are related to increases in this factor. *PD specific efficacy* resulted in differences between experimental and control group. Since PD specific efficacy items were devised to reflect the aims of the PD directly, it would be expected that there would be some difference in this factor. However, further work is needed in developing items and a scale specific to efficacy in relation to implementing the aims of the PD.

Finally, *efficacy for classroom management* indicated the smallest difference between treatment and control group—there is indeed almost no difference in this factor (see Table 2). This can be explained by considering that the aim of the PD is to support changes in practice that feature less order and structure. The shift from teacher-centred to student-centred approaches is not likely to be

accompanied by increase in teachers' capacity to manage students' behaviour. It would not have been surprising if this factor had not reduced for the experimental group.

This study provides evidence of the effectiveness of the Bowland PD materials. The significant difference between experimental and control group of efficacy for *student engagement* suggests a change in TSE overall. As result and based on the findings of other studies, teachers' capacity to adopt new practices (Berman et al., 1977; Guskey, 1988; Stein & Wang, 1988) and student achievement (Allinder, 1994; Ashton & Webb, 1986; Tschannen-Moran et al., 1998) will also have been influenced positively. However, this study has limitations; it is post-test only design and further studies using pre- and post-test and a control group, would be required to confirm these results.

Conclusion

There are three conclusions to be made from this study. This first is that evaluation indicates that the PD has had an effect teachers' self-efficacy if it is assumed that there was no difference between the experimental group and control group at the outset. Secondly that evaluating the effects of PD using self-efficacy has untapped potential in the evaluation of PD. Finally, this study suggests that social learning theory offers a useful conceptualization and theoretical framework for understanding, designing and evaluating professional development. I shall discuss each of these conclusions in more detail.

This study provides evidence that the Bowland PD materials are effective in developing teaching self-efficacy (TSE). This is an important result as it indicates that the PD has an impact on teachers' capacity to adopt new approaches and also on student achievement. The link between self-efficacy and teachers' capacity to innovate and experiment with practice has been shown in previous studies (Berman, McLaughlin, Bass-Golod, Pauly, & Zellman, 1977; Guskey, 1988; Stein & Wang, 1988). In addition it would suggest that if the PD had had an impact on teachers' self-efficacy then it is likely to have had an effect on student achievement, again this draws on the findings of previous studies (Allinder, 1994; Ashton & Webb, 1986; Tschannen-Moran, Hoy, & Hoy, 1998).

While there are limitations to this study—it is a small-scale exploratory study and post-test only [2]—it was important to report these findings because of the potential of this approach to evaluating professional development. A standard teaching efficacy instrument appears sensitive enough at smaller sample sizes to reveal significant changes. Further opportunities are also afforded in developing PD or inquiry-based learning specific self-efficacy instruments. The four items used to supplement the TSES instrument represents an initial attempt at the development of a teaching efficacy scale related to the teaching of problem-solving which features student discussion and collaboration. This is important since much previous evaluation of PD relies on looking at changes in teachers' beliefs, it has been suggested that this approach has problems because of the variety of definitions used and also debates about the nature of 'beliefs' (Goldin, Rösken, & Törner, 2009; Mason, 2003; Pajares, 1992). In all, there is still much work to do in developing approaches for the effective evaluation of professional development (Desimone, 2009), using self-efficacy approaches represents a contribution to that work.

This leads to one overriding aspect of this study and that is the potential of social learning theory (SLT) in conceptualising professional learning. SLT is concerned with observing and modelling behaviour and mental processes by which models of behaviour are formed into course of action and behaviours. The mechanism is understood in terms of reciprocal triadic determinism (Figure 1) which

simply put means that the social context of the department and school, the behaviour and practices of the teacher and individual teachers' thinking and beliefs have an influence on each other. And, the fundamental process that mediates and regulates behaviour is self-efficacy. In common sense terms this suggests the more confident teachers are more likely to adopt innovative practices. And this was also observed to be true in this exploratory case study schools. This has implications for the design of PD. PD should, as suggested by SLT, incorporate observable practice in order that teachers can model behaviours and produce changed practices of their own. Secondly the design of PD should also be designed to develop teachers' self-efficacy and the indication is that in this exploratory study that objective has been met in the case of these PD materials.

As a final comment, self-efficacy has been put to use as a theoretical framework in the education of teachers, yet the use of SLT has not, and therefore further research is needed to investigate, adapt and develop this theoretical approach.

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1 For example, in England the National Strategies training materials for secondary teachers as well as a television programmes like for example 'From good to outstanding' on Teachers' TV.

2 This study was carried out as part of a lengthy exploratory case-study at the same time as theoretical work was being conducted i.e. a literature review. A post-test only design was opportunistic in that there were research participants and an opportunity to look at effects on efficacy. Clearly there could have been a prior difference between the two groups but I have also taken account of qualitative observations not reported here.

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