Developing teachers as leaders of science in primary schools

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Abstract

Children's experiences of science at primary school inform their decisions about studying science post-16, which impacts on the supply of STEM professionals. In England, the Primary Science Quality Mark (PSQM) award programme is a recognised way of addressing the reported decline in the profile given to science as numeracy and literacy have been prioritised. This programme aims to raise the profile of primary science by providing schools with a framework and professional support for developing science leadership, teaching and learning. This paper reports the views of twelve primary science leaders from schools involved in the PSQM scheme for the first time and explores changes in their attitudes to teaching and leading science. Data were collected through questionnaires, an interview and focus group and from documents submitted for the award. The findings suggest how the science leaders' perspectives shifted from science learning and practice in isolated classrooms to a whole-school vision.

Keywords: Continuing professional development; primary science; Primary Science Quality Mark (PSQM); science leaders; teacher leadership

Introduction

'Science and mathematics are essential skills for global citizens' (Royal Society and British Council, 2015, p.2). Although having plenty of future STEM (science, technology, engineering and mathematics) graduates is essential for meeting international business requirements, many countries are experiencing a shortage of graduates in STEM subjects (Royal Society and British Council, 2015). Research conducted within the UK suggests that, by the end of primary school, many children *'have already decided that the idea of studying science after the age of 16 and the idea of a career in a STEM area is "not for me"'* (ESRC, 2013, p.4). Hence, children's experiences of science at primary school are important. However, many teachers report that science has been given less of a priority in English primary schools over the past five years, often because it has been *'squeezed out with numeracy and literacy pressures'* (CBI, 2015, p.15, original emphasis). Recently, teacher leadership has gained attention as a way of achieving education reform through teachers' professional development (Poekert, 2012).

As a result of their survey of 180 primary and secondary schools in England, Ofsted (the Office for Standards in Education, Children's Services and Skills), an independent inspection and regulatory organisation in England, noted that many of the participating subject leaders had not received professional development targeted at providing science leadership (Ofsted, 2013). Ofsted (2013, p.7) recommended the provision of *'subject-specific continuing professional development for subject leaders and teachers that improves the quality of assessment and feedback for pupils in science'*, and recognised that some school leaders had addressed the issue of the declining profile given to science through engaging in the Primary Science Quality Mark (PSQM) programme.

The Primary Science Quality Mark programme

The aims of the PSQM award programme include: raising the profile of science in primary schools; providing schools with a framework and professional support for developing science leadership, teaching and learning; and celebrating excellence in primary science. Schools can achieve an award at one of three levels, bronze, silver or gold, by demonstrating that they have met thirteen specified criteria categorised within the following four areas: subject management; teachers and teaching; pupils and learning;

and broader opportunities (PSQM, 2015). The differences between the criteria that need to be met for each level of award are illustrated in Table 1, which shows the requirements for criterion A1.

Primary school science leaders apply to take part in the PSQM programme and are appointed to local networks, called PSQM hubs. These hubs are led by PSQM-trained experts in primary science who support science leaders through the year-long programme of professional development, school-based evaluation, action planning and implementation to develop all aspects of science teaching, learning and subject leadership. During the year, the science leaders attend face-to-face workshops and receive online mentoring support from the hub leader. Working with colleagues within their schools, science leaders identify a set of actions that need to be carried out in order to meet the PSQM criteria (Table 1) and document the impact expected and the evidence that will be collected to demonstrate that each criterion has been met. The scope of the impact required for each level of award varies from a focus on the science leader's classroom for schools achieving bronze (introductory) level, to encompass the whole school (silver level) and then, in addition, to have an impact beyond the school (gold level). The PSQM process culminates in science leaders making an online submission, via the PSQM portal, of a set of reflections and supporting evidence of practice in primary science in their school to meet the requirements for a bronze, silver or gold award. The PSQM programme is run twice a year, with 'rounds' starting in September and May.

Research methods

Research aims, participants and data collection

The main aim of the small-scale research study reported in this paper was to explore the impact of the Royal Society of Chemistry (RSC) bursary-funded PSQM scheme on the attitudes and aspirations of pupils and teachers with respect to science. The particular focus of this paper is the impact of the scheme on the attitudes of teachers towards their role as leaders of science and the findings presented here are selected from those available in the published report (White *et al,* 2015). This research study was carried out by three members of the research team at the School of Education, University of Hertfordshire. Ethical approval for the study was obtained from the relevant University ethics committee with delegated authority.

In total, twelve science leaders participated in this practice-focused study: eight from schools that started the PSQM programme in May 2014 (round 8) and four from schools that started in September 2014 (round 9). These schools were initially working at bronze level, but some of them submitted at silver level because they exceeded the descriptors for the criteria for the bronze award.

Table 1: PSQM Criterion A1: indicators for each level of award.

Criterion*	Indicators*
A1: There is an effective SL [subject leader] for science	**Bronze:** There is an identified member of staff who oversees the subject, may have a background in the subject and can demonstrate their enthusiasm for leading it. **Silver:** There is a named member of staff responsible for the leadership of the subject. They have received subject-specific training in the last three years and have shared this with all colleagues in the school. **Gold:** The SL has shared their training and subject knowledge with a broader audience beyond their own school.

*Criterion and indicators in Table 1 are taken from the *Framework for PSQM* (PSQM, 2015)

The data collection methods were as follows:

- *Self-completion questionnaire:* Two of the eight science leaders in the schools engaging in PSQM round 8 completed a questionnaire sent by e-mail.

- *Semi-structured telephone interview:* One science leader engaging in round 9 took part in a telephone interview with a member of the University research team.

- *Focus group:* Three science leaders (representing two schools registered for round 9) engaged in a focus group conducted by a member of the University research team. The PSQM hub leader and a representative from the RSC were also present during the session.

- *Data available from the PSQM portal:* Extracts from the documents submitted for the PSQM award by science leaders engaging in round 8 were reviewed for indications of attitudes towards science. As noted by Turner *et al* (2013, p.7) relating to data from the PSQM portal: *'The subject leaders are self-reporting to achieve a PSQM award. Professional and honest self-evaluation is expected, but the requirement to demonstrate that certain criteria were met might have influenced the content. Furthermore, the structure of the framework and the questions that the subject leaders responded to will have influenced their reflections.'*

Those participants who engaged in the telephone interview and the focus group were seen as *'conversational partners'* in the study (Rubin & Rubin, 2011, p.7, original emphasis). An interpretive approach was taken to understand the attitudes, behaviour and thinking of the participants. Attitudes describe *'the state of being prepared or predisposed to act in a certain way in relation to particular objects, persons or situations'* and are frequently measured by individuals reporting the extent to which they agree with like/dislike statements, rather than by observing specific behaviours (Royal Society, 2010, p. 65). In this study, attitudes to science have been evaluated through self-reporting of the science leaders and through their observation and monitoring of the engagement of teachers and pupils. The science leaders were able to observe teaching and displays, scrutinise pupil work, and listen to feedback from pupil panels and from their colleagues. They also observed informal interactions relating to the profile of science in their school.

Data management and analysis

The telephone interview was recorded and a partial transcription was prepared, which the interviewee was invited to review. The focus group was also recorded and partially transcribed. In order to preserve confidentiality when disseminating the findings, some identifiers have been removed and the following codes have been assigned: 'I/Q' for those data collected via the e-mail questionnaire, telephone interview and focus group; and 'S' for those contributed via the PSQM portal as part of the submission for the award.

The findings presented in this paper have been selected using 'purposeful sampling' (Patton, 2002, p.46) to enable a discussion of teacher leadership attitudes and activities. Some of the findings have been explored in relation to the 'Spheres of teacher leadership' conceptual model created by Fairman and Mackenzie (2012, p. 229) (see diagram on page 74 of this issue), which describes teacher leadership contexts and ways in which teachers demonstrate leadership with the goal of improving student learning. This model builds on the framework presented by York-Barr and Duke (2004), which conceptualised a route by which teacher leaders can affect student learning. York-Barr and Duke (2004, p.290) recognised formal and informal teacher leadership positioning and the fluidity of leadership functions, and suggested that *'As leaders, they influence the development of individuals, collaborative teams and groups, and organizational capacities (e.g. structures, policies, processes, resources) to improve teaching and learning in their schools'.* This fluidity of functions is apparent in Fairman and Mackenzie's (2012) portrayal of their model as nine spheres, A-I, denoting different types of leadership activity surrounding the central goal of improving student learning. This model is intended to be visualised in three-dimensions to represent the way teachers move between activities or simultaneously engage in activities within two or more spheres. Fairman and McKenzie's (2012) model has been selected as a way of exploring the findings in this study because the nature of the leadership activities, which include teachers working alone and with others both within their school and outside, aligns with the structure of the levels of the PSQM award.

Findings

Science leaders were asked about aspects of science teaching and learning (such as enjoyment and confidence), whether their attitudes to science had changed since they had been doing the PSQM programme and whether they had noticed any changes in the attitudes to science of others across their schools (other staff, pupils). For example, in the e-mail questionnaire, the science leaders were asked whether they could give any examples of specific changes that they had noticed in their own or their teachers' attitudes and thinking about science topics, or in the children's attitudes and understanding about science topics. The science leaders were also asked about changes in practice and were invited, where appropriate, to give specific examples. The findings suggest changes in the science leaders' attitudes towards the teaching of science in their own classrooms and to leading science across the whole school, as described below.

Science leaders' attitudes to teaching science

Many science leaders reported that they felt better equipped for their own teaching. Some comments were made relating to the development of subject knowledge, but most were related to science pedagogy. As one science leader said: *'I now feel much clearer about what excellent science looks like'.* As a result, science leaders reported feeling more enjoyment and confidence when teaching in their own classrooms. As one teacher reported: *'I have enjoyed teaching science more since working towards the PSQM as I am thinking more about my teaching'.* Some science leaders noted the impact that this change in attitude had on their teaching:
'I am more motivated to go away and look at things more deeply, learning on the way, with the children... I am more confident and willing to take risks [with my teaching] which is exciting because, before, I was stuck in a rut' (I/Q).
'I am far more critical of my own teaching, I want it to be as good as it can be. It has made me look further for materials, resources and ideas' (I/Q).

Science leaders' attitudes to leading primary science

A number of participants said that they had initially lacked confidence in leading science. One admitted it was *'quite a scary prospect'* before undertaking PSQM and another said: *'Before, I was ticking the boxes, doing observations, but I didn't really know what I was looking for'.* Undertaking the PSQM helped science leaders to understand their leadership role, which made them feel better equipped for leading others: *'The principles are there to support it [science teaching]. So now, when I'm looking at books, when I'm looking at planning, when I'm looking at lessons, when I'm doing my own planning, I keep that in mind and I think that gives me a clear vision. It gives us forward motion – all together'* (I/Q).

Science leaders described how they shared ideas with colleagues at staff meetings, supported other teachers with planning and teaching, and monitored learning in science. They were aware of changes in how they were leading science and felt more secure in their leadership role. Responses were typified by the following: *'I have developed professionally. I'm more confident, I'm more willing to lead staff meetings and drive things forward. I do learning walks, observe lessons, book scrutinies, which is something that I have never done before'* (I/Q).

Science leaders could see how their leadership was impacting on other staff and how the attitude of other teachers had changed. Many reported that other staff were talking more about science and were more confident about using resources for teaching primary science. They were excited by the fact that there was more consistency in the quality of teaching science across the school. Pupils were being given more opportunities to work scientifically, answer their own questions and lead their own investigations. They could see that other teachers were being inspired to teach science in a more engaging way because of their leadership and that they were working collectively to develop science: *'It is empowering because it feels like I'm not on my own. There are other people with you, working towards the same goal'.* However, they also recognised that changing the attitudes of some staff was much harder than others, especially in a year of curriculum change, and they acknowledged that, for some, this was still a 'work in progress'.

Finally, science leaders could see how their leadership was impacting on pupils' motivation and enthusiasm for science: *'It's really nice to see the children who were not excited by science more engaged. It is the whole class now, not just individual children who had a flair for science'* (I/Q).

They could see how developing a wider range of learning opportunities, such as learning outside, organising visitors, special events and science trips as part of their leadership role, had enriched science teaching and learning beyond the classroom. One science leader reported feeling pride in hearing pupils explain scientific concepts to their peers and parents during a science assembly and, another, pleasure at witnessing the '*wonder and excitement on the faces of Year 1 children when animals … arrived in their classrooms*'. Science leaders could see that their leadership had raised the profile of science within their school: '*…it's motivating because you feel like it is actually starting to work. It has taken a good six months but, slowly, through children's comments, you start to feel like I am actually making a difference*' (I/Q).

Science leaders' activities when leading primary science

To understand what the findings reveal about developing teachers as leaders of science, they were explored in relation to the nine 'spheres' of activity represented in the conceptual framework of teacher leadership developed by Fairman and McKenzie (2012). Table 2 shows some examples of the activities that the science leaders reported, categorised according to each of these spheres. This categorisation has been informed by the more detailed descriptions of the activities put forward by Fairman and McKenzie (2012). This approach to classifying the findings is tentative; it is recognised that some activities only partially meet the description and others overlap different spheres, reflecting the complexity of leadership activities in schools.

Discussion

This small-scale research study found evidence for changes in teachers' attitudes towards teaching and leading science due to their schools' engagement in the PSQM programme. Guskey (1985) suggested that changes in learning and teaching practice in class can precede changes in teachers' attitudes and beliefs, providing that this change is positively reinforced through evidence of change in pupils' learning outcomes. Thus, the changes in attitude noted in this study might have been preceded by or followed behavioural change (or both); the way that the science leaders were carrying out their role; what they were doing and how they were doing it.

Conclusion

The findings suggest that learning more about effective science teaching from the PSQM programme motivated science leaders to develop their own teaching, to 'take risks' and be more adventurous with their choice of resources. This reflects leadership activities described within spheres A and B of Fairman and Mackenzie's (2012) model (Table 2), where teachers engage with learning about, experimenting with and reflecting on their own practice. Support provided by the PSQM programme to develop subject leadership impacted on science leaders' understanding and confidence when leading science. The findings suggest that they engaged in activities described in spheres C-E: working across multiple classrooms, sharing ideas and learning with colleagues, with the aim of working collectively to develop science teaching across the school. There was also evidence that working towards the PSQM award encouraged science leaders to attend to the climate and culture of the whole school and to consider their role in the success of all students, showing engagement with activities in spheres F and G. This aligns with the aim of the silver PSQM award, which many of the participating schools achieved, even when they originally enrolled to do the bronze award. The activities described in spheres H and I align more closely with the aim of the gold PSQM award; although these might not be expected in this study, there were some indications that science leaders were engaging in activities that extended beyond their school (Table 2).

Therefore, participating in the PSQM programme facilitated movement between leadership spheres (Fairman & Mackenzie, 2012). Science leaders' perspectives shifted from a narrow focus of improving an individual teacher's learning and practice within one classroom, to broader goals of improving teacher and student learning school-wide. This relates well to the recommendation by the Wellcome Trust (2016) that: '*a primary science leader should have a whole-school vision for science and be able to lead its development by instigating appropriate initiatives, including providing continuing professional development to colleagues, monitoring progress and contributing to the strategic development of learning in school'.*

There is also evidence to suggest that the development of an effective science leader

Table 2: Science leaders' activities categorised according to teacher leadership spheres.

Spheres of teacher leadership action for learning A-I (Fairman & McKenzie, 2012, p. 231)	Examples of the science leaders' reported activities
A. Individual teacher engages in learning about his or her practice	*'I've got a degree in science so I don't think my subject knowledge has changed but I think how I teach it has definitely changed… I don't think my understanding of science has changed but I think my understanding of how children learn about science has changed.'* (I/Q) *'I have enjoyed teaching science more since working towards the PSQM as I am thinking more about my teaching…'* (I/Q)
B. Individual teacher experiments and reflects	*'At the start of topics I used to do the "What do you know and what do you want to find out?" But they don't really know what they want to find out until they have dipped their toes in. So now I do a lesson first and then I ask them if there is anything else they would like to know and they jot it down in their books. Then I try to cover this at some point or towards the end of a topic I ask what they still want to find out and we go and investigate it. I make a point that, if a child asks something that I don't know, we write it on the board and come back to it.'* (I/Q) *'This time I am doing separating materials, doing solids, liquids and gases, so in hindsight the way that I'm going to teach it is different to the way I would have taught it in the past by just putting the materials out there for the children to devise their own experiments. In the past I would have given a question such as "how can we make water evaporate faster?" but I will say something like "what effects evaporation?" Getting them to think of their own questions.'* (I/Q)
C. Teacher shares ideas and learning, mentors, coaches other teachers	*'For me the motivation comes from the fact that I am leading by example. You are the one that staff are going to come to, so you feel that you have to know things, or at least be willing to go and find out.'* (I/Q) *'In Y6 they were looking at buzzers and created a game like "Operation", they were so enthusiastic because the teacher was more willing to take risks. They feel like they are allowed to take risks. There doesn't have to be a write-up, where "it has to be like this". I have said to them that this is fine. So this has empowered them to do this.'* (I/Q)
D. Teachers collaborate and reflect together on collective work	*'One of the least popular areas of science learning was plant science. Since this survey, teachers have made much more use of the pond and other areas around school to develop children's understanding about plants and how they fit into the local food webs. Pupil enjoyment of plant science has increased significantly in the later survey.'* (S)

Table 2 cont.

E. Teachers interact in groups and through relationships rebuild the collaborative culture of the school	*'I think [I am more confident] because I have a clear vision. I feel that the staff are on board because they also see that vision. It is empowering because it feels like I'm not on my own. There are other people with you, working towards the same goal. It is all about the children; when you see the impact on the children, it's motivating because you feel like it is actually starting to work. It has taken a good six months but, slowly, through children's comments, you start to feel like I am actually making a difference.'* (I/Q)
F. Teachers question, advocate, building support and organizational capacity	*'Some staff are more willing to go on that journey and have a go. And some staff lack confidence. There is so much change [new National Curriculum] going on that they find it hard to grasp with everything else that they have to do. It is evident when you go on your learning walks that that some staff are willing to embrace it. There are more child-led investigations, they seem more confident, they are taking risks. They are allowing the children to have more control. Other staff stick to what they know best. And it's trying to move them all, slowly.'* (I/Q)
G. Teachers engage in collective school-wide improvement, focus resources, and distribute leadership	*'The involvement in the PSQM has given the school a clear vision for science. In developing key principles there is a strong commitment by the teaching staff and the pupils to ensure the science that takes place adheres to these principles. We have been able to look closely at the investigative science aspect of lessons and given children more autonomy in their learning.'* (S) *'The enjoyment of science across the school is evident whenever you walk into a science lesson – children are always engaged in their learning and completely on task. This can be seen in our lesson observations, learning walks and pupil voice evidence. During our Ofsted inspection in [date] the inspector commented that "Our learning is full of joy", which is evident from reception to year six across all subjects.'* (S)
H. Teachers collaborate with the broader school community, parents	*'During PSQM, stronger links have been made with a local secondary school, which has helped cater for the needs of more able scientists in Year 6.'* (S) *'I was collared in the playground by a parent saying "Did you know there is an eclipse on Friday?" So they know we are the people to speak to about science and they want to make sure that their children were involved in that process. We have never had that before.'* (I/Q)
I. Teacher (or group) shares work outside of school/in professional organizations	*'There was also the opportunity to work with the Science Adviser and other School Science Leaders, sharing ideas for best practice.'* (I/Q) *'I have enjoyed sharing good practice and expertise with colleagues from other schools.'* (I/Q)

impacted on the profile of science within the school and on the attitudes of pupils, echoing the view that: '*...where science has a good profile within the school as a result of dedicated leadership, and where staff are expected to teach exciting, investigative science with access to high-quality science expertise, children are likely to enjoy learning the subject'* (Wellcome Trust, 2013, p.3).

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