

Evaluation of the Primary Science Quality Mark programme - 2013-15

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Contents

1	Executive Summary	5
1.1	Context and aims of the research	5
1.2	Methodology	5
1.3	The contribution of the PSQM to raising the profile of science in primary schools	5
1.4	The contribution of the PSQM to providing schools with a framework and professional support for developing science leadership, teaching and learning	5
1.5	The contribution of the PSQM to celebrating excellence in primary science	6
1.6	The contribution of the PSQM to using networks to provide local support for science for schools	7
1.7	The contribution of the PSQM to assembling a rich database of current practice in primary science and making it accessible to the wider science education community	7
1.8	Understanding the process of implementing the PSQM programme	7
1.9	The Way Forward	8
2	Introduction	9
3	Research management	9
4	Research method	10
4.1	Overview	10
4.2	Documentary evidence	11
4.3	PSQM stakeholders	12
4.4	PSQM Director	13
4.5	PSQM hub leaders	13
4.6	Science leaders	13
4.7	Management and presentation of the findings	14
5	Research Findings	14
5.1	Evidence of outcomes and impact of the PSQM on raising the profile of science in primary schools	16
5.2	Evidence of outcomes and impact of the PSQM on providing schools with a framework and professional support for developing science leadership, teaching and learning	21
5.3	Evidence of outcomes and impact of the PSQM on celebrating excellence in primary science	33
5.4	Evidence of outcomes and impact of the PSQM on using networks to provide local support for science for schools	36
5.5	Evidence of outcomes and impact of the PSQM on assembling a rich database of current practice in primary science and making it accessible to the wider science education community	44
5.6	Understanding the process of implementing the programme	44

6	Discussion of Key Findings	51
6.1	Contribution to raising the profile of science in primary schools	51
6.2	Contribution to providing schools with a framework and professional support for developing science leadership, teaching and learning	51
6.3	Contribution to celebrating excellence in primary science	53
6.4	Contribution to using networks to provide local support for science for schools	53
6.5	Contribution to assembling a rich database of current practice in primary science and making it accessible to the wider science education community	54
6.6	Learning to support the further development and improvement of the programme	54
7	The Way Forward	56
7.1	Summary of possible ways forward for the PSQM team to explore	56
8	References	57

1 Executive Summary

1.1 Context and aims of the research

This large-scale research project was designed to explore the overall impact of the Primary Science Quality Mark (PSQM) Programme from 2013-15 and wider issues relating to primary science teaching, learning and subject leadership, and to evaluate the PSQM programme against its five aims. These aims are: raising the profile of science in primary schools; providing schools with a framework and professional support for developing science leadership, teaching and learning; celebrating excellence in primary science; using networks to provide local support for science for schools; and assembling a rich database of current practice in primary science and making it accessible to the wider science education community.

1.2 Methodology

This practice-focussed research took an interpretive approach to understand the experiences of the participants. Data collection methods included: email questionnaires to the Director of the PSQM, PSQM hub leaders and science leaders; semi-structured telephone interviews with PSQM stakeholders and a hub leader; a focus group with science leaders; and a review of some of the submissions available on the PSQM portal. The Ofsted report (2013) and the Impact of Royal Society of Chemistry bursary-funded PSQM on primary science teaching report (White et al., 2015) were also drawn on to provide further evidence for the impact of the PSQM.

1.3 The contribution of the PSQM to raising the profile of science in primary schools

The findings suggest that the PSQM has been playing an important role in raising the profile of science in primary schools, in a context where there has been a perceived emphasis on literacy and numeracy to the detriment of the other curriculum areas. There were examples of ways in which a commitment to the value of science was developed at all levels: the senior leadership team, the staff, the pupils, the parents and the governors. Typically, the profile of the science leader was enhanced, giving them the recognition with which to lead change.

The teachers grew in confidence to teach science, there was an increase in science-related talk in the schools and increased visibility through displays. The profile of science was raised through special science events sparked by the PSQM process. Some of the changes have introduced an element of fun and excitement around engagement with science, helping to create positive attitudes towards science teaching and learning in pupils and teachers. The PSQM may be playing a significant part in increasing the science capital of pupils through the extended reach to parents leading in some cases to engagement with science in the home.

PSQM submissions showed that the profile of science in these primary schools was raised through engaging in the PSQM programme at bronze, silver and gold levels. The characteristics of the award meant that silver and gold submissions had an impact beyond the science leaders' classroom to the whole school, and gold submissions had substantial impact beyond the school. The gold PSQM award that requires teachers to work with other schools provides a good mechanism to promote inter-school collaborative work to raise the profile of primary science more widely.

1.4 The contribution of the PSQM to providing schools with a framework and professional support for developing science leadership, teaching and learning

The PSQM was focussed on leadership development through providing a clear structure, developing understanding of the role and some of the key skills and creation of principles for a whole school approach. Reflecting on, and evaluating, practice was provoked by engagement with the framework and the science leaders were developing skills of modelling and team teaching to disseminate good practice through the school.

Science leaders were better equipped for their own teaching because they had good signposting to professional development. The development of science subject knowledge and pedagogy was largely through networking, access to the knowledgeable hub leaders and through the signposting to appropriate CPD opportunities.

The key principles for science teaching were developed as part of the PSQM programme through listening to the teachers and pupils, which provided a common vision. Action planning provoked review and development of teaching and learning strategies and the framework deconstructed subject leadership into manageable steps. The PSQM provided a legitimate space for teachers to reflect on science in their school and the resources and support to help them to develop science learning. It also provided a supportive sharing network across schools and a mentoring relationship between the science leaders and the hub leader.

There was a wider range of learning strategies and learning opportunities for children as a result of participating in the PSQM programme. These strategies were being implemented in conjunction with a focus on child-led and hands-on learning. Pupils were asking their own questions and working scientifically to answer them in their own investigations. There was more consistency in the quality of teaching primary science across the school. Changing pedagogy was a challenge for many of the science leaders and teachers where this approach was new. Listening to pupil voice had a powerful impact on the science leaders.

The PSQM was having a wider impact on teaching and learning in primary science beyond their own schools partly through providing resources for the Teacher Assessment in Primary Science (TAPS) project and the Exemplar website.

The programme required the commitment of the senior leadership team to giving the science leader time and support in developing science during the PSQM year. Sustained impact was largely dependent on the science leader and the long term commitment of the school. Some hubs carried on as a local network post-PSQM, but most hub leaders encouraged schools to maintain the network independently or via existing regional primary science networks.

Where science leaders had become hub leaders, they had a wider impact as they worked with clusters of schools to raise the profile of science. Some science leaders built on their PSQM success in their own or another school. The science leaders gained from the leadership development and this impacted their career development, and provided skilled leaders to support further school improvement, though not always focussed on primary science.

The submissions to the PSQM portal revealed a high impact on the leadership of science and on the breadth of learning and teaching experiences within and beyond the classroom. There was also evidence of changes emerging that would ensure the impact of the PSQM would be sustained beyond the programme year through planning and wider networking.

1.5 The contribution of the PSQM to celebrating excellence in primary science

The PSQM award ceremonies were greatly anticipated and publically recognised the work involved in achieving the award. They helped to raise the profile of primary science to a wider audience. Some science leaders who take their school through the PSQM go on to gain a Primary Science Teaching Trust PSTT award to recognise their individual contribution or win an ENTHUSE Celebration Award for their contribution to science education.

The Exemplar Material project is another way in which excellence in primary science is celebrated. Science leaders have not been well engaged in providing material for this site due to practicalities of

the uploading process and a need for affirmation from their hub leaders that the work is of the required quality. The Exemplar Material is useful for those doing the PSQM for the first time.

In some schools, engagement in PSQM has been associated with science teaching and learning being highlighted as successful by Ofsted.

1.6 The contribution of the PSQM to using networks to provide local support for science for schools

The PSQM is the only award available to recognise whole school achievement in primary science. The PSQM Director has close links with a number of organisations that promote primary science, and these organisations work together in the PSQM stakeholder group, seeking opportunities to further their common aims of developing primary science. This group has recognised expertise that gives it credibility in the world of science and education and was perceived as being very valuable to the members and their organisations. The PSQM stakeholder group has the potential to raise awareness at a governmental level and to bring about policy change, leading to science having recognition as a core subject.

A major benefit of this group for the PSQM is the 'critical friendship' that it provides to the PSQM leadership. The interactions are mutually beneficial for the organisations in terms of up-to-date awareness of developments in the field, marketing opportunities, building membership, and providing a rich interwoven network to enhance science teaching and learning through primary science leaders.

Recruitment to PSQM of new hubs may be through links with existing primary science networks or by new hub leaders being recruited by the PSQM Director from award winning schools and school improvement organisations. Schools are either recruited by hub leaders or come direct to PSQM having heard about the programme through word of mouth or publicity. Recruiting new schools can be challenging in the current climate of decreasing local authority networks.

1.7 The contribution of the PSQM to assembling a rich database of current practice in primary science and making it accessible to the wider science education community

There has been limited use of the database for research, but it is possible as the data is used more, for example, in this report and by other researchers including doctoral studentship holders focussing on this area, others might see the potential that is available to them. Currently the data is not easy to access, and it would need to be organised effectively for more extensive use.

1.8 Understanding the process of implementing the PSQM programme

A number of areas were identified in which the PSQM could develop to become more effective including financial support for the cost of doing the PSQM and for science CPD as needed, and protected time for the science leader to mentor and coach colleagues, do developmental work and complete the process.

The silver award was seen as very valuable because it requires whole school commitment to high quality science and a subject leader who is having impact on the science learning of all the pupils in the school. Progression to gold was seen as unrealistic for many schools and not essential for all schools as long as there are some excellent schools doing outreach. There was an identified need to monitor how the school is getting on after the award, if the science leader is still in place, and to offer further support as required. In future 'gold light' might be usefully introduced where the science leader has not changed, involving collecting evidence to show sustained impact in and beyond the school over the intervening years. The value of doing a complete resubmission was appreciated in some cases, especially where there had been a change of subject leader, staff or curriculum. A platinum award may be a future development for gold schools that would like to

develop primary science further. This could include practitioner enquiry to develop science teaching and learning further within the school or beyond. Where science leaders move on some of the rich experience and learning goes with them into a new setting. This is good for the school system as a whole, but may constrain the sustainability of the PSQM within the original school, unless there are opportunities for renewal, for upskilling the new science leader, or for a teacher to shadow the science leader to be able to transfer skills smoothly.

The need to monitor the quality of hub leaders and to support their on-going professional development was seen as vital if the PSQM is to expand further, as more hub leaders will be needed. Identifying key hub leaders to move the work forward in areas which are identified as needing targeted support would lead to strategically planned growth of the PSQM into areas where the impact will be very significant. Time in hub meetings was usually focussed on procedural aspects of the PSQM programme; a third day could provide more time to focus on primary science knowledge and pedagogy.

Further growth of the PSQM programme could be constrained by the capacity of the core leadership team and a review of the working of the central team may reveal a need for more investment in staff.

New networks will need to be explored in order to continue recruiting new schools, such as Teaching Schools Network and Multi-Academy Trusts. This could be in the remit of the PSQM Director and the hub leaders.

The PSQM framework was widely accepted as appropriate. A number of suggestions were shared by the hub leaders and the science leaders for developing the framework and documentation further. The science leaders felt that there should be more inclusion of pupil voice and pupil impact rather than focussing on the science leader and the teachers. It is also notable that there is nothing in the framework explicitly regarding pupil progress in science.

The PSQM stakeholder group might want to consider providing a shared primary science website as a starting point for all things to do with primary science as a resource for primary teachers and hub leaders who are finding the information fragmented.

The PSQM programme may be a good model for other subject areas and consideration could be made as to whether the framework and resources could be repackaged as a franchise for other subject areas for school improvement.

1.9 The Way Forward

A summary of possible ways forward that had been suggested on the basis of the findings, is provided at the end of the report, for the PSQM team to explore. A number of ideas for future research were also identified.

2 Introduction

This large-scale research project was designed to explore the overall impact of the Primary Science Quality Mark (PSQM) programme from 2013-15 and wider issues relating to primary science teaching, learning and subject leadership, and to evaluate the PSQM programme against its five aims. The findings will be used to support further programme development and improvement. The PSQM award recognises excellence in primary science. The PSQM programme promotes the learning and teaching of science and contributes to public engagement in science. It is a national programme across the United Kingdom. It is funded by the income from schools and by the Primary Science Teaching Trust.

Primary school science leaders apply to take part in the PSQM programme and are appointed to local PSQM hubs. These are led by PSQM-trained experts in primary science who support the subject 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. This culminates in subject leaders submitting a set of reflections and supporting evidence on practice in primary science in their school into a portal, for hub leaders to assess against the framework. Since the launch in 2010 more than 1500 schools have been awarded Primary Science Quality Marks. There are three levels of award: gold, silver and bronze. Rounds 6 and 7 were completed in 2014; rounds 8 and 9 were completed in 2015. A condition of schools taking part in the PSQM programme is a commitment to the evaluation process.

The PSQM programme was set up to achieve the following five aims:

1. to raise the profile of science in primary schools
2. to provide schools with a framework and professional support for developing science leadership, teaching and learning
3. to celebrate excellence in primary science
4. to use networks to provide local support for science for schools
5. to assemble a rich database of current practice in primary science and make it accessible to the wider science education community.

3 Research management

The research was carried out by the following members of the research team at the School of Education, University of Hertfordshire (UH): Dr Liz White, Research Lead in Initial Teacher Education (Project Lead); Dr Roger Levy, Associate Dean, Research; Dr Claire Dickerson, Research Fellow; and Julia Mackintosh, Primary Science Tutor.

Ethical approval for the study was obtained through the University of Hertfordshire Social Sciences, Arts and Humanities Ethics Committee with Delegated Authority. Protocol numbers: EDU/SF/UH/00067 and aEDU/SF/UH/00067(1).

The research was funded by the Primary Science Teaching Trust.

4 Research method

4.1 Overview

An overview of the research method is provided in Table 1.

Table 1 Research method overview

<i>Evidence base/ data source</i>	<i>Data type/collection approach/ activity/sample</i>	<i>Sample size/ number of respondents</i>	<i>Other</i>
Documentary evidence			
PSQM portal, reports, research and published literature			
PSQM portal	Submissions section E – rounds 6 and 7	20 random	
Ofsted report 2013	OFSTED, 2013. <i>Maintaining Curiosity: A survey into science education in schools</i> . Report No. 130135. London: Ofsted.		Available from: https://www.gov.uk/government/publications/maintaining-curiosity-a-survey-into-science-education-in-schools
Research report (White et al., 2015)	WHITE, E., DICKERSON, C. and MACKINTOSH, J., 2015. Impact of Royal Society of Chemistry bursary-funded Primary Science Quality Mark on primary science teaching: final report. University of Hertfordshire		Available from: http://vuh-la-risprt.herts.ac.uk/portal/en/projects/evaluation-of-rsc-bursary-funded-psqm(cdd1fbd0-0609-48f8-a554-c6f910a543c8).html
Survey methods			
PSQM stakeholders			
Key informants	Interviews	4	
Director PSQM			
Director PSQM	Questionnaire	1	
PSQM hub leaders			
Hub leaders	Questionnaire to hub leaders from rounds 6 and 7	6	
	Interview	1	
Science leaders			
Science leaders	Focus group with science leaders from rounds 8 and 9	3	
Renewal schools	Questionnaire to science leaders from rounds 6, 7, 8 and 9	2	

4.2 Documentary evidence

4.2.1 Documentary evidence from submissions to the PSQM portal

Sections of the final submission documentation (Criteria E, questions 8-10) provided by twenty schools that registered for rounds 6 and 7 were identified from a list of 373 schools using random sampling (<https://www.randomizer.org/>). These twenty schools, six from round 6 and fourteen from round 7, represented approximately 5% of the total sample of schools (round 6 = 111; 30% and round 7 = 262; 70%). Each of the twenty schools has been assigned a code A-V (excluding I and O). Some extracts of the submissions that were thought to relate to PSQM aims 1 and 2 (to raise the profile of science in primary schools; and to provide schools with a framework and professional support for developing science leadership, teaching and learning) are presented in this report. Some identifiers have been deleted, including any extracts from Ofsted reports. Tables 3-6 include some direct extracts and some paraphrased text. Some of the direct extracts are shown in quotation marks.

The random sample included schools that were submitting at bronze, silver and gold levels: four at bronze level; thirteen at silver and three at gold. Table 2 shows Criteria E, questions 8-10. A table showing the complete set of PSQM criteria for bronze, silver and gold levels is available from: <http://www.psqm.org.uk/about-psqm>.

Table 2 Criteria E, questions 8-10

Criteria and questions
<p>Criteria Plan: E</p> <p>You are invited to submit an illustrated short account (of no more than 1000 words) of how Science as a subject has developed and prospered during the lead up to your work on this award as relevant, and most especially during the time spent working towards this award. (It will be recognised that you may be a new subject leader in undertaking this.) We would also be interested in hearing of any challenges you have overcome and any successes you have enjoyed.</p>
<p>E (questions 8-10 all levels)</p> <p>(Criteria E questions 1-10 relate to 'Science at your school')</p> <p>Please answer the following questions about your school:</p> <p>8) Have there been any particular developments/circumstances in the last three years that you feel you would like to alert the reviewer to?</p> <p>9) Looking back through this PSQM year, are there any specific science highlights you would look to headline?</p> <p>10) What do you feel the school's and your involvement in PSQM this year has done for science at your school</p>

Evidence was drawn from the submissions to the PSQM portal in response to section E of the PSQM award criteria. In all cases the submissions were completed by the science leader except for school E, where it was completed by the head teacher. When analysing this data it is important to remember that:

'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' (Turner et al. 2013, p. 7).

This evidence was collected through book and planning scrutinies, lesson observations, learning walks and by identification of new activities and ways of working. In some cases these were observations from the head of the school or from Ofsted that have been reported by the science leader. All of the schools in this sample provided evidence that involvement in the PSQM programme had raised the profile of science in the school except for school B. In this case there was evidence that an approach to monitoring the profile of science had been employed by the science leader, but there was no explication of the evidence found.

The submissions were reviewed by two of the researchers, highlighting where there was evidence of the profile of science being raised in the school. These sections were extracted along with a little text before and after the evidence. The extracts were reviewed and organised into themes:

- Evidence of impact on how science is led (Table 4)
- Evidence of impact on how science is planned (Table 5)
- Evidence of impact on science learning and teaching (Table 6)
- Other evidence of impact (Table 3)

Where the evidence was linked to comments on the perceived benefit of this impact, these were also included in Tables 3-6, to give a broader picture of how the PSQM is having an impact on primary science. The contributions of science leaders participating directly in the research through a focus group and through completing questionnaires, were used alongside the submission data to provide a more complete perspective.

4.2.2 Documentary evidence from reports

Data relevant to the research was identified from the following reports:

1. Ofsted (2013) *Maintaining curiosity. A survey into science education in schools*. Manchester: The Office for Standards in Education, Children's Services and Skills (Ofsted) (Age group: 4 to 19. Reference no: 130135)
'The report sets out the findings of a new survey of science in 91 primary and 89 secondary schools, which was carried out between 2010 and 2013. This report will support schools in implementing the new National Curriculum.' (p. 1)
2. White, E, Dickerson, C & Mackintosh, J (2015) *Impact of Royal Society of Chemistry bursary-funded Primary Science Quality Mark on primary science teaching: final report*. University of Hertfordshire.
'This small-scale research project was carried out to evaluate the impact of Royal Society of Chemistry (RSC) bursary-funded Primary Science Quality Mark (PSQM) on the teaching of science, and especially chemistry, in the primary schools involved in the PSQM scheme for the first time. Of particular interest were any changes in the attitudes of primary teachers and pupils towards science and chemistry as a result of this focus.' (p. 4)

4.3 PSQM stakeholders

Telephone interviews were carried out between June and September 2015 with four key informants. The interview questions were tailored to each individual's area of interest and expertise. The interviews were recorded digitally and partially transcribed and the interviewees were sent the relevant transcription so that they could add, remove or amend any of the text. Interviewees were also invited to indicate any aspects of their responses that they wanted to remain confidential when the findings are disseminated.

4.4 PSQM Director

In December 2015, the Director of the PSQM programme completed a questionnaire sent via email.

4.5 PSQM hub leaders

PSQM hub leaders who had taken part in rounds 6 and/or 7 of the programme were invited to take part in the evaluation by completing an email questionnaire. The questionnaire was finalised in the light of feedback from pilot testing and comments arising from a telephone interview with a hub leader. The revised questionnaire was further pilot tested with four hub leaders known to the research lead; one of whom responded. The questionnaire was revised again and sent out to the remaining hub leaders in phases between November 2015 and February 2016. In total, six hub leaders responded to the questionnaire.

One further hub leader took part in a telephone interview in August 2015. The interview questions were designed to focus on particular areas of interest and expertise. The interview was recorded digitally and partially transcribed and the interviewee was sent a set of 'key points' so that they could add, remove or amend any of the text and indicate any confidential aspects of their responses. The key points included some text as paraphrase/note form as well as verbatim quotations.

In total, eight hub leaders (coded HL1 – HL8 in the research findings section) contributed in different ways to the research: six responded to the questionnaire sent via email; one took part in a telephone interview and one of the science leaders (section 4.6.2) was also a hub leader. One of these eight contributors also took part in the focus group with science leaders.

4.6 Science leaders

4.6.1 Focus group

A PSQM hub leader and the science coordinators from the primary schools within their hub that took part in the PSQM in rounds 8 and 9 were invited to take part in a focus group to share their experiences. The hub leader and a science coordinator from each of three schools attended the group.

4.6.2 Email questions

Science coordinators from schools that had previously completed the PSQM and returned in rounds 6, 7, 8 or 9 to renew the award were invited to respond to three questions sent via email between July and December 2015. Potential contributors in other ways to the research, for example, focus group participants were excluded from this sample.

In total, five science leaders (coded SL1 – SL5) contributed in different ways to the research: three took part in the focus group and two responded to the three questions sent via email, one of whom was also a hub leader.

Where data has been collected from science leaders (focus group and questionnaire), the voice of those who have been unsuccessful or who are not enthusiastic enough to participate in the research has not been directly listened to. However the hub leaders were able to express indirectly some of the feedback that they had received from those who had struggled with the PSQM.

4.7 Management and presentation of the findings

Some identifiers have been deleted from the findings presented in the next section of the report and minimal editing has been carried out. Most of the data (interview transcriptions and key points, questionnaire responses and portal submissions) are shown as quotations.

5 Research Findings

The research findings are organised in relation to the five aims of the PSQM programme, identifying the outcomes and impact of the programme; with a further section on understanding the process of implementing the programme, identifying learning to support the further development and improvement of the programme.

The PSQM Director's vision is that the best teaching of primary science is underpinned by the following principles:

- 'Working scientifically, asking questions and testing ideas against evidence, is the most effective and appropriate way for children to develop an understanding of the nature and processes of science and the key scientific knowledge and concepts.
- A curriculum should embody a clear progression of conceptual 'big ideas' to ensure that children are continually building on their prior learning as they systematically develop their understanding of key ideas and their scientific skills. This requires teachers to be confident in the subject understanding.
- Children's curiosity should be sustained and they should be actively involved in a range of authentic, purposeful science investigations that lead to greater understanding of the world around them. There must be opportunity to reflect on what has been learned from the observations made or evidence collected.
- Children should engage in a wide range of practical activity both indoors and outside, using a variety of observation and measuring equipment including data loggers and digital microscopes, everyday items and materials, natural and living things and electrical components.
- Assessment is an integral part of science teaching that enables children to understand the purpose of their activities and to improve the quality of their work.'

These principles are developed from the 'wealth of academic research evidence and inspection and accountability data that informs current practice. This, combined with empirical data from PSQM schools and the learned experience of hub leaders has shaped the vision for good teaching and learning in primary schools that PSQM promotes.'

One member of the PSQM stakeholder group had the following vision of good science teaching and learning in primary school:

'Good teaching and learning goes beyond just the bones of the curriculum and ticking boxes, it's about inspiring young people to be great at noticing, to understand the role of science in their lives and how their curiosity can be kindled and explored further. So what I would see as evidence of good teaching and learning in science is girls and boys thinking it is for them, that science matters, understanding that you can be curious and there are ways to find out things about the world around them, wanting to do that, and the skills to ask questions to come up with ways of testing their ideas and investigating their ideas, to be able to have the confidence to use appropriate equipment and vocabulary ...'

When asked 'What, in your opinion, is good science teaching and learning in primary school?' a hub leader explained, it is:

'Hard to say in a sentence. But to me, good science learning is about equipping children to explore and find out about their universe. Children need to be able to ask their own questions and have the scientific skills to be able to independently go and investigate. Good science is full of awe and wonder ... good science pushes boundaries and nurtures thinking minds and a joy of discovery'. (HL5)

In relation to developing teaching and learning in primary science the Director of the PSQM felt that the PSQM programme could be improved by:

'A stronger emphasis on articulating purpose of science and subsequent analysis of practice. There is a danger of schools demonstrating plenty of activity which without thorough evaluation could have superficial impact.'

The value and perceived success of the PSQM programme

A member of the PSQM stakeholder group commented that the PSQM's:

'... reputation is making some schools wonder "what's this all about, perhaps we ought to do it then"'.

The value of the PSQM is further indicated by the same member of the PSQM stakeholder group:

'... PSQM isn't the only way of doing it [developing good science provision]. It is just the, by far the easiest way for a school to get serious about science because it is straight forward in terms of what you do, there are very stringent but easily followable criteria. And the school has to put its money where its mouth is as well. That helps, I think, having to pay for it ... It's another indicator that primary school leadership is important ...'

This participant went on to emphasise the difference between the PSQM and other quality marks:

'There are [quality] marks out there that don't require evidence-based portfolios, a change in practice, or sharing of that practice, which is really one of the strengths of PSQM, the notion that practitioners share, the collegiate approach with local schools, the dissemination of good practice to other schools, that's unusual, and that's why we think it's ... worthwhile, because we've all seen the benefit in terms of improvement.'

'Again so far as I understand it, most bronze award winners will have a go at silver the next year, and gold so it does seem to further improve the [development] of science, particularly silver [and gold] ... it's got that 'sharing of your practice with other schools' element. So that's becoming a school improvement tool and as far as I know, it's the only quality mark that has that element in its design. You can't be a gold PSQM school unless you're working with another school and their science improves as well. And that's enormously good as a sort of model.'

In terms of the way the PSQM programme helps to develop teaching and learning in science the same stakeholder noted:

'The standards required to get it [PSQM award] are high ... vetting the submission and working with schools to ensure the submissions meet the criteria of the various gold, silver and bronze levels. That level of rigour is a key strength of the programme. Unique in my experience of the quality marks. These tend to be about the quantity of stuff the school is doing. The PSQM seems to be linked more to the quality of the science work. And that's one of its strengths.'

Within sections 5.1, 5.2, 5.3 and 5.5 the findings are presented in the following sequence where relevant data is available: documentary evidence from Ofsted (2013) and the findings from the RSC bursary-funded PSQM evaluation (White et al. 2015); PSQM stakeholders and the Director of the PSQM; PSQM hub leaders (HL); science leaders (SL) in schools engaging with the PSQM award and submissions to the PSQM portal (see Table 1).

5.1 Evidence of outcomes and impact of the PSQM on raising the profile of science in primary schools

This aim links closely with aim 3 (to celebrate excellence in primary science) and some of the data reported here supports both aims.

5.1.1 Documentary evidence from reports

Ofsted (2013) reported that the profile of science is declining in primary schools, and that some schools choose to do PSQM in order to address this issue:

‘School leaders who recognised the likelihood of a declining profile for science were able to mitigate the risk by, for example, seeking accreditation through the primary science quality mark (PSQM). The process of gaining the award brings benefits beyond the certificate, because it requires school leaders to evaluate their provision and justify their science curriculum as being fit for promoting good learning. It also connects school science leaders to other primary school leaders who have successfully raised the subject’s profile in their schools’ (p. 21).

The Ofsted report went on to comment that in some schools the

‘Science development plans varied in quality, depending on the accuracy of the underlying monitoring and evaluation. Too often, they were not ambitious enough to drive up standards. However, some school leaders found that the process of gaining the PSQM helped to raise the profile of science’ (p. 21).

This was supported by the findings in the RSC bursary-funded PSQM evaluation (White et al., 2015) where the science leaders revealed a number of reasons for choosing to do the PSQM including raising the profile of science in their school. White et al. (2015, p. 10) reported from interviews and questionnaires with science leaders, that the PSQM provided:

‘an opportunity to celebrate all the things we were already doing well but it gave us an extra incentive to make science teaching and learning in the school even better.’

‘We just felt that science had got a low profile since we’ve been so heavy on numeracy and literacy ... no-one really spoke about it. All we really spoke about and had staff meetings about were maths and literacy.’

‘... introducing PSQM at the same time as the national curriculum [for science, new in 2013] meant that everyone had to start something new, so why not start with a bang!’

5.1.2 PSQM stakeholders

One member of the PSQM stakeholder group:

‘... felt it [PSQM] was a great way to get recognition for what you are doing: to demonstrate to parents; to demonstrate to your governors how important science is; and to also ensure that it becomes an integral part of your curriculum. There is a danger I think that science will become an ‘also ran’ unless you give it a particular focus. And the advantage of doing PSQM is that it communicates to the entire staff how important it is to the school rather than just

you personally. So I think it's a fantastic opportunity for schools that really want to demonstrate their commitment to science and are able to do so and I also think if you're ... a teacher who is really passionate about science, and had a school leadership team who might be less convinced that it's a good way to get some buy-in from your school leadership team to develop science as well'.

5.1.3 PSQM hub leaders

One hub leader shared the following personal reflection relating to the wider impact of the PSQM on raising the profile of science in primary schools in their region:

'PSQM has been hugely valuable both to me personally and to science teaching, learning and leadership in this area. I have professionally developed a great deal by meeting with other hub leaders, seeing other schools submissions in reviews, and building close relationships with my hub schools and seeing their exciting initiatives. Due to PSQM the profile of science has been significantly raised in [X] and [Y] at a time when the profile of science has been flailing nationally. Teaching, learning and leadership has benefited at nearly every school. It has not been sustainable at a few schools which is due to the science lead leaving the school. If they had stayed at the school the improvements would have definitely continued. The benefits have also been seen at non PSQM schools due to extra training, initiatives and higher profile'. (HL6)

A hub leader commented, in response to a question about whether they thought the PSQM programme produces sustainable school improvement in teaching and learning science, that:

'Through completing a PSQM the profile of science is always raised. Schools value science and want to teach it well. Many heads attending the [PSQM award] ceremony state this as making the biggest long term impact'. (HL3)

A further comment from a hub leader was:

'The PSQM process encapsulates good practice in science leadership and helps to raise the subject's profile. This is especially important when science is struggling to maintain its position as a core subject alongside English and mathematics'. (HL 4)

5.1.4 Science leaders in schools engaging with the PSQM award through the focus group

Particular school issues that led to them doing the PSQM

All three science leaders who took part in the focus group identified issues relating to raising the profile of science in their schools in response to a question about whether there were some particular issues and attitudes in their school that they wanted to change when they started the PSQM programme. One participant explained the role of the PSQM in the amalgamation of an infants' school with the junior school in which s/he worked; one school with a PSQM award and one without so:

'... it was a case of pulling one up and maintaining one so that's what it's been about, so the amalgamation has helped join us all and doing the PSQM helped to join us a bit more ... it's not that we've cracked it but we know that we are on an upward trend and we need to maintain that.' (SL2)

When asked how they were going to do that s/he responded:

'By bringing some of the practice from key stage 2 down to key stage 1 ... and the staff realising that it's not that this isn't okay for key stage 1 to do, they *can* do this. ... Also, the science coordinator in key stage 1 has, I think, got more empowered and has more knowledge and she feels more developed and able to lead things down there as well.' (SL2)

A second science leader reported that they had wanted to make changes in implementing lessons:
'... People realise they bring back the love for science in how to teach the lessons and it is fun and we made a lot of connections with other schools, with secondary schools and the teachers now feel a lot more comfortable with us having visitors in; we share a lot of practice ... The teachers are more happy now for people to come in where before they didn't want to ... now they are really happy to get involved and to feed back to me and let me know ...' (SL1)

The third science leader identified the profile of science in the school as a concern when they started the PSQM:

'Our issue really was science had a really low profile ... We changed from IPC (the International Primary Curriculum where everything is taught on a topic basis). We had a year where we didn't do IPC but we hadn't switched to the new curriculum ... so we had a year where everyone floundered and did their own thing ... So when the new curriculum came in, it was we've got to do it; nobody was really feeling the love; some people weren't doing any and some people were doing it once a month; it was really, really inconsistent. So it was really just raising the profile and making sure everybody was doing what they should be doing, was the first hurdle anyway ...' (SL3)

Impact of doing the PSQM on staff in school

When invited to think about the staff in their school and consider whether the PSQM had changed the profile of science, the three science leaders all agreed that it had and provided examples:

'I had a visitor come to the school and I was showing them around the school and I went down to the ground floor, which is the infants' floor ... and every display down there was a science one and I thought 'wow' this is good ... And there is a lot of demand for resources now ... so I know that they are looking in a bit more depth at their planning and they're stretching a little bit further and asking for things that they maybe didn't want to try or didn't think that they were going to be using ...' (SL2)

'... the teachers are more confident to teach and they do talk about it and they like to share too, so we do homework projects; so every half-term we might set one small unit, which will be based on a science topic that they are teaching, and teachers are always happy to put them on display and share them with the children ... they are more than happy to share now, their knowledge and have people in; so it's a very big positive change.' (SL1)

The third science leader saw the change with the staff in the school as:

'... really having the raised expectation that science wasn't just something you can do when you feel like it, everyone's now on board – English, maths and science; you have to do all of them it's not optional. There's that expectation from senior leadership as well, that it's not just oh, if you haven't got time for science don't worry about it'. (SL3)

Impact of doing the PSQM on pupils in school

When asked whether the pupils felt differently about science; whether the profile for them had changed s/he gave some practical examples to illustrate what the change in profile meant for both staff and pupils:

'... we did a big science week thing this year, which we haven't done before, science week before has just been and gone. We've had people in and we all taught each other's classes and just the excitement; the fun of it has come back it's not just writing in the book ... I think the staff as well have got away from: you do the practical and then next week you have your

book and write about it. They are a little bit more creative about how you record things...'
(SL3)

This creativity meant that now the pupils:

'... never know what's coming' whereas previously, they had two books, one for the practical work and then the following week one for writing and the pupils would ask '... is it the good week or the writing week?' (SL3)

Wider Impact

Later in the session, the same science leader commented on the wider impact of the PSQM programme on the school:

'... it was focusing on looking out a little bit more. We ended up with a link with the community garden so we started using that for plant sessions and a gardening club. It made you look outside the classroom a little bit more ... Even then going further afield and linking it to trips and also linking the cross-curricular side of it as well, because we always seem to be so pushed for time to cover everything, so it is a bit of a focus to see what you could link it to ...' (SL3)

A second science leader also reported that staff were using more creative pedagogical approaches in the classroom and had established more extracurricular activities relating to science:

'... We had a problem with writing in books where some teachers liked to give out worksheets and take them in and the children hated that but then using the scientific enquiry and the teachers then being creative with the lessons and saying this is what we want to get to – how will you create a question, how are you going to solve it, these are the resources you can pick from; the children have all that ownership and they loved it because it was their project and they didn't mind to write it down because it was all their own doing ... We have a lot more after-school clubs running ... now we have three different types of science clubs running at the moment and the waiting list is two pages long ... At the moment we are doing rollercoasters and looking at all the forces behind them ... I do that with year 3 and 4 and then year 5 and 6 and then there's also a computer science club for girls which is run by the assistant head and they look at scientific inquiry but through data-basing and investigations; and then there's an eco-club run by another teacher so there's a lot of other teachers now starting to get involved with it'. (SL1)

The third participant drew attention to the pupils' views of science and the impact on pupils of the teachers' attitude to science:

'... I'll have teachers telling me the kids say that their favourite lesson is science. In key stage 1 it's the teaching staff are saying I'm enjoying the science now, which is nice because if the teachers are enjoying it the pupils will get more out of it too'. (SL2)

Impact on parents

Two of the science leaders were able to identify ways in which they thought completing the PSQM had had an impact on the parents:

'... we invite them to come in at the end of the science club ... the parents get involved with the kids, so the kids are the teachers then. So they go through the steps, everything that they had to do and the parents have fed back to say that they really enjoyed to see what the children are doing in after school club ... the parents came in and they really enjoyed it and they were doing some of the stuff at home, and I got letters from parents saying we've been doing this at home, which was really nice.' (SL1)

‘As part of our science week we did a presentation at the end of it to parents ... which the parents they’ve never experienced that before, and also we’ve now got a science club up and running ...’ (SL3)

How the PSQM was raising the profile of science

The PSQM framework criteria and the role of the framework in stimulating reflection were thought to have contributed toward raising the profile of science with teachers across the school and with the senior leaders. For example, one science leader reported that the greater engagement of the senior leadership team facilitated connections with other schools:

‘... I was making a lot of connections from my management team when they were going into other schools.’ (SL1)

In terms of reflecting on the teaching of science, they acknowledged:

‘... we had a staff meeting and all the teachers ... knew what we were aiming to get to, so they would bring a range of evidence together and it was really good because ... everyone sat in different year groups so people were able to see the different evidence, so we were able to reflect on our teaching practice and on the learning of the children at the same time...’ (SL1)

The award itself was also seen as important:

‘The history and geography teachers now want to get awards ... they say no-one cares about our subject like they care about science... They feel that the teachers care more about the subject when we are doing something like this, the process. (SL1)

The ongoing impact of the PSQM programme in terms of future planning of events was noted:

‘It’s good practice anyway for us. Even the calendar of events is great to keep up from now on; it triggers you to think we did this last year or do we want that?’ (SL2)

5.1.5 Science leaders in schools engaging with the PSQM award through submissions to the PSQM portal

The overwhelming evidence from submissions is exemplified by the following two quotations:

‘Science is in a good place’ (School A)

‘Staff feel that the greatest achievement associated with our work towards PSQM status is that we have raised the profile of science right across the school. Children are now much more positive about science using words like ‘awesome’ to describe their feelings.’ (School T)

In the PSQM submissions there is evidence of impact on science leadership, planning, teaching and learning, which will contribute towards raising the profile of science. This evidence is shown in Tables 4-6 included under aim 2.

There was evidence that the PSQM programme was making an impact on primary science, through external reports and the development of new links within and beyond the school (Table 3).

Table 3 Evidence of impact leading to raised profile of science across the school

Code	Evidence of other impact:	How this has helped:
<i>Developing new links within and beyond the school</i>		
S	'Science now has a high profile throughout the school and we have created strong links with the local community and other schools, which has strengthened our ability to proceed with the new curriculum in a confident and effective way.'	
J	Contact with school governor who works at local university conducting scientific research.	Voice for science on the governing body. Contact with the university's outreach service.
K	Strong long term links with organisations such as BP, Shell, Forest Schools and Friends of [School K].	Guarantee the sustainability of science projects for the future.
J	List of 'Science Experts' including people from a wide range of industries (parents of children currently in school, members of the school community, higher education establishments, organisations and industries).	Increased experience of real world science enhanced the teaching of science in the classroom.

5.2 Evidence of outcomes and impact of the PSQM on providing schools with a framework and professional support for developing science leadership, teaching and learning

5.2.1 Documentary evidence from reports

The RSC bursary-funded PSQM report (White et al., 2015) noted that:

'Science leaders were better equipped for their own teaching, as well as for leading others. The science leaders were aware of changes in how they were carrying out this role since starting the PSQM. They were more secure in their role and were working from key principles for science teaching in their school that had been developed through listening to the pupils.

'The science leaders had developed a wider range of learning opportunities including learning outside, having science visitors and going on science-based trips. These strategies to engage pupils were being implemented in conjunction with a focus on child-led and hands-on learning across the school. Pupils were being given more opportunity to ask their own questions and to work scientifically to answer their own questions and lead their own investigations. This had not been an easy transition for many of the science leaders or the teachers in their schools because the pupils were not used to working independently and some pupils did not do well at first. The teachers found it difficult letting go of controlling the investigative work.

'There was substantial evidence of enrichment in teaching, learning and assessment, and also of more consistency in the quality of teaching primary science across the school.' (p. 4-5 Executive Summary)

5.2.2 PSQM stakeholders

The impact of the PSQM on providing schools with professional support for developing science leadership was shown through the following comments by members of the PSQM stakeholder group. For example, the PSQM:

‘... gives good access to professional development.’

‘... one of the benefits of the PSQM; it turns a coordinator into a leader ... but science is *one* of the things they are coordinating very often to start with, it’s not the reason for their existence in terms of their professional development. *But* it becomes that through the PSQM approach, so they shift from being ‘have we got some filter paper in the cupboard?’ to ‘now we are going to share our practice with the school down the road’. That is another leadership development strategy that the PSQM brings to the school.’

Another stakeholder said the PSQM:

‘... supports teachers in understanding what they’re doing and why they’re doing it in a way that actually helps them do it better. Because by forcing yourself to ask better questions and because you have to submit to an external framework, you generally come up with better answers...’

Going on to identify the supportive nature of the PSQM for developing leaders:

‘But to me, it is the process I think that is of real value, it does not make explicit content judgements, it’s not like you have to run a science week, or do a thing where the parents are in, or you have to do this, now. You have to do good science within your school and beyond depending upon the level and we’re going to support you in looking at what you do and why, and whether or not that works. And I don’t see many things like that in education. Most of the judgements that are made operate in a sort of Ofsted performance management type domain which however nice leadership people are, is a judgment and a judgment that relates to your pay and those kind of other stuff that gets in the way of positive professional reflection in schools.’

One shared a good rationale for why the PSQM is needed for developing primary science leadership:

‘... most primary teachers are not science graduates, so they’re not naturally into the scientific way of thinking, they’re not naturally used to challenging evidence, doing experiments, refining and all of that scientific method approach. So they have to learn how to do that. Very often that comes through science leadership, professional development. It doesn’t come through generic school management stuff. So specialist leadership training is critical.’

However, it was noted that although ‘a science coordinator can usually make a difference’ in a primary school ‘they can’t unilaterally improve science if the leadership won’t let them.’

Another area of concern raised was that:

‘... in a subtle way you’re supporting teachers to be *leaders* ... I suspect that may well be a problem because of the way primary schools work, in that PSQM does a brilliant CPD job for science subject leadership and then they all go off and become literacy and numeracy leaders and make more money in schools for that.’

5.2.3 Director of PSQM

Leading a school through the PSQM award has become a significant part of the development of individuals as leaders of primary science. This is shown by the number of hub leaders who were science leaders for schools gaining the PSQM award (22 out of 81 i.e. 27% in April 2015).

5.2.4 PSQM hub leaders

Further evidence of the impact that the PSQM is having on teaching and learning in primary science came from Sarah Earle from Bath Spa University who commented that: 'more than two-thirds of the schools providing resources for the Teacher Assessment in Primary Science (TAPS) project were PSQM schools' (see <https://pstt.org.uk/resources/curriculum-materials/assessment>). As with the Exemplar website (see aim 3 below), this is a way in which schools involved with the PSQM are sharing their expertise with a wider audience.

Providing schools with a framework and professional support for developing teaching and learning

One hub leader felt that the PSQM programme helps to develop teaching and learning in science: 'By supporting schools with a focus on science and a process through which to develop it. By including criteria which focus on enquiry, approaches to teaching and learning and assessment. By each school starting with principles. By requiring science leaders and teachers to continue to develop through different types of CPD. By bringing science leaders together with each other and a knowledgeable hub leader so they can share good practice and find out about more about science teaching and learning'. (HL1)

Another recognised that it helped by developing the principles at the start of the process, as this: '... provides a common understanding of what science in the school should look like. In many schools this is the first time that science has been discussed with the whole staff. This brings everyone together with a common agreed purpose and vision'. (HL3)

They went on to appreciate the continued focus on teaching and learning in science facilitated by the structure and expectations of the programme:

'Subject leaders are encouraged at different stages of the process (action planning and submission) to think about teaching and learning strategies that are already present in the school or could be developed ... Subject leaders are also expected to monitor teaching and learning'. (HL3)

Other aspects of the PSQM programme that hub leaders identified as enabling for developing primary science teaching and learning were through providing:

'... a space in time for teachers to stop and to look at the science in their school. It provides a nurturing place where teachers ask themselves some hard questions about the effectiveness of their practice. PSQM provides resources, ideas, support to help teachers to then move science learning on in their school'. (HL5)

The opportunity for schools to be involved with more national initiatives through engaging in the PSQM programme was thought to benefit science teaching and learning too.

Sustainable school improvement in teaching and learning science

Evidence was given for the PSQM programme producing sustainable school improvement in teaching and learning science. In each case the impact seems to be focussed predominantly on the science leader rather than the whole school. This is illustrated by the following comments:

‘By developing the principles and putting these into action the ethos of the school often shifts. Asking the children what they think and seeing how acting on this makes an impact is also very powerful in changing the attitudes of teachers. Having an action plan for the year means that it is a longer term process and allows for new strategies etc. to become embedded. An award is not gained from a snapshot but by gathering evidence over a period of time. At the end of the process the subject leaders have grown in confidence and feel much more comfortable with offering guidance and support to others.’ (HL3)

‘... so much of the longer term success of PSQM rests on the wider school agenda and wider data within the school. Schools are fragile worlds!!! Where I think you can see long term improvements in teaching and learning is in those people who write the submission ... so many have gone on to lead science in other schools ... I have two people in my hub that have done it before and are continuing their journey ... In my own world PSQM entirely changed my career ... I did GOLD and now I lead a hub/lead ITT & CPD for primary science and many other things ... all triggered by PSQM.’ (HL5)

‘In many schools I have seen this, especially those that go on to do gold after silver or renew a silver or gold PSQM. New processes and practices become embedded in the school and the subject leader finds it easier to maintain standards or develop further. However there are others where this is not the case and there are several reasons:

- Tick box culture in the school – we have got the award so now all attention is switched to something else and science slowly slips back (this will take time if changes have been embedded over the PSQM year but things will slide if everyone takes their eye off them)
- ... Staff changes, especially if there is also a new science leader so a lot of experience is lost or a new head teacher with very different priorities and approaches.’ (HL1)

Providing schools with a framework and professional support for developing science leadership

Some of the ways that hub leaders identified that the PSQM programme helps to develop leaders in science include:

- Providing a clear structure, including creation of principles that provide a focus for whole school development
- Raising awareness ‘of the nature of science leadership, the importance of science and their role in moving teaching and learning forward’
- Developing some key skills in the science leaders ‘such as action planning, vision, reflection and evaluation’
- Directing towards relevant CPD
- Requiring commitment by the senior leadership team to giving the science leader time and support in developing science
- Supporting science leaders to ‘look closely, evaluate different changes they could make, consider impact and present what they are doing for external scrutiny’
- Developing confidence in science leaders to lead meetings and act through an understanding of the purpose of what they are doing
- Providing a supportive sharing network across schools
- Providing a contact point for science leaders to ask where they are unsure
- Providing a mentor for the science leader, in the form of a hub leader who can support them with tasks such as action planning, reflecting on impact, advice on assessment etc.

This last point was reinforced by the following comment from a hub leader:

‘The close mentoring relationship is vital ... a person that you respect, investing in you, listening to you and guiding you ... this is powerful stuff ... where else offers this?’ (HL5)

The PSQM programme develops leaders, but they may need some additional tailored CPD opportunities for understanding of subject knowledge and assessment beyond what can be included as part of the PSQM. The PSQM was viewed as being:

‘... often very successful when new science leaders are involved’. (HL2)

One hub leader claimed:

‘I am promoting PSQM ... especially to struggling schools, as I feel the process really helps the science leads understand what is expected of a science leader and how to promote and encourage science.’ (SL5/HL8)

Sustainable school improvement in leadership

The hub leaders identified that the PSQM programme can produce sustainable school improvement in leadership in science and beyond:

‘In some schools ... [the] science profile remains high and events and initiatives that started in the PSQM year continue. In some schools science leads remain on the senior leadership team when they hadn't been before and activities directly related to teaching and learning such as team teaching and monitoring activities continue post the PSQM year when they hadn't happened before. Relationships between schools started in the PSQM year continue post it in some cases.’ (HL6)

‘I have worked with strong science leaders who have built on their PSQM success in their own or another school – it provided structures, skills and confidence. One is now an SLE [specialist leader in education], another is a hub leader; others have taken on more senior roles where the skills have been used in different contexts. Schools which have done PSQM often say that they will try to use similar processes to help other subject leaders improve their area.’ (HL1)

But this depends on the stability within the school:

‘There is a great deal of change in leadership posts in some schools and when the science coordinator changes sometimes some of this improvement in leadership can be hard to sustain.’ (HL6)

There was further evidence that the science leaders themselves gained from the leadership development and that this impacted their career development, and provided skilled leaders to support further school improvement. One hub leader explained that one of the science leaders in their hub had become involved with supporting a Learning Trust, lectured at a local university and been awarded a Primary Science Teacher of the Year award from the Primary Science Teaching Trust. Other illustrative comments include:

‘The science subject leaders often become very successful and go on to be deputies or assistant heads.’ (HL3)

‘... many science leaders use their PSQM review comments as evidence to support job applications/promotion in their career development.’ (HL4)

The value of the PSQM programme was underlined by one hub leader:

‘I strongly believe that working towards a PSQM is the best way of improving science teaching and learning. This is why I promote it so strongly and have so many schools in my hubs. I do not promote things that I do not believe in and I wouldn't get the satisfaction that I do if it didn't make such a difference. It is hard work for a hub leader and I would[n't] do it if I didn't feel it was worth it.’ (HL3)

5.2.5 Science leaders in schools engaging with the PSQM award through a focus group and submissions to the PSQM portal

Providing schools with a framework and professional support for developing teaching and learning

One of the science leaders believed that her own teaching was developing, and this was having an impact on her colleagues through her modelling and team teaching:

‘In terms of my own teaching it was building up my confidence to show the others we can do practical work; we can get water out and we can get candles out and we can get equipment out, and every child can have these in front of them, and it’s doable and it’s safe. When they saw me doing that they thought, she did that lesson on Monday and there wasn’t a fire, so we can have a go and she’s resourced it. I teach science on a Monday so I have everything ready so they know she has organised it and she’s supporting us in the sense that I will pass it to my colleague, and she will do the lesson next as there is a line of colleagues; there’s four of us in a team. So that was building up my confidence and then they’re seeing me doing it, knowing it’s doable and that was helping raise them in their confidence. Then also the team teaching and they were observing me teach and so they could see how I am managing thirty children with these things because that was a worry for them, the behaviour and have we got equipment, and controlling the children in terms of what they are and are not allowed to do. So that has helped me and made me confident and also made me realise I can team teach, I can go in and model lessons and that’s been helpful for the staff.’ (SL2)

Not all science leaders had the flexibility within their school to be able to team teach due to the size of the school or other initiatives taking precedence. However, some expressed a willingness to be observed teaching science, to support the development of science teaching and learning. This was another stimulus to focus the science leaders on raising the quality of teaching and learning in their own classroom, as illustrated by the following comment:

‘... if I’m expecting everyone else to be doing this then I’ve got to be doing it even better ... It was a bit of a wake-up call really.’ (SL3)

Another aspect of the PSQM that the science leaders identified as having an impact on the teaching and learning of science was giving more opportunities for pupil voice to develop and be heard across the school:

‘I liked doing the pupil voice, the questionnaire, I liked doing that and I did it twice ... I responded to what they were saying because I wanted to support them; this is what the children were wanting and I can directly get that working in their classroom or tell them ‘you can’t have that now in year 3’; the children wanted Bunsen burners so I could explain ‘not yet but you may have that opportunity in year 6’ for instance. I found that really useful because it gave me targets for what the children want, that’s important to me, to know what are the children thinking about their science and what were the pitfalls for them, so the writing. They didn’t mind the writing so much but it was certain lessons and certain things. They didn’t like the PowerPoints ... so it was good for me to tell the teacher and raise that with teachers, which I thought that was powerful and important, which I wouldn’t have been able to do without the PSQM.’ (SL2)

One science leader felt that the PSQM had helped in developing his/her understanding of what happened in the different key stages and of progression across the science curriculum within their school. This was partly through introduction of different strategies, case studies and scenarios that had been shared in the hub. For example, one science leader used **K, W, L**:

‘What the children **K**now, then what they **W**ant to know, then what they have **L**earnt and then I have mine on the wall ... and when the children learn something new they can take a post-it note and stick it up, so it’s a good way of reflection; so we have a class one and they

have their own one as well. So it gives me a good idea that they have done that before...'
(SL1)

Providing schools with a framework and professional support for developing science leadership

For a new science leader the PSQM helped in developing their identity as a science leader, as other staff recognised his/her position and were able to work together. The following comment illustrates how the science leaders were developing their leadership skills and identity:

'For me it was the leadership, communicating with the other staff especially because I am quite young ... I found it quite intimidating to approach people who have a lot more experience than me and I know their knowledge is a lot greater, so I was quite intimidated to talk to them about things but once I did ... I realised they are just like me and want to share their knowledge too ... I had more of a reason to get out and have my voice heard ... it gave me the power to do that when before I would just email and sit behind.' (SL1)

Evidence of impact on how science is led

In 14 out of 20 (70%) of the sampled school submissions, there is explicit evidence of impact on how science is led (Table 4). There is evidence of the leadership of science being developed through engaging with the PSQM programme. In some schools science teams have been established, staff are sharing good practice and accessing more professional development to improve the learning and teaching of science. There is evidence of enhanced confidence in leading science by the science leaders and in teaching science by the science leaders and the other members of staff in their schools. In submissions that are not explicit about impact on science leadership, there is reported impact on science planning and on teaching and learning, which provides indirect evidence that implies that there has been development of science leadership as a result of the PSQM.

Table 4 Evidence of impact on how science is led

Code	Evidence of impact on how science is led:	How this is helping:
	<i>Developing science leadership</i>	
E	New science leader supported by CPD through course attendance, extended visits to a science mentor in a neighbouring school and regular one-to-one support from a science consultant.	Subject leader has grown in confidence, leading the changes needed to improve pupil experience.
L	Subject leader has developed a better understanding of their role and has enhanced knowledge of the approaches to the teaching and learning of science.	
R	Subject leader more confident. Teachers' and pupils' passion and enthusiasm for the subject reignited.	
V	Improved science leadership. Positive comments were made about the leadership of the subject in survey of staff by subject leader.	'She gives clear guidelines for expectations on coverage and objectives. Signposts appropriate CPD for staff. Easy to discuss matters, non-judgmental and always striving to help, great leadership on the new curriculum.'
Q	'The head teacher has taken over the science leadership which has increased its profile.'	
B	The science leader completed a book	'This was actually an excellent indicator as

	scrutiny and began to use learning walks.	to whether the subject is valued across the school.'
Implementing science teams		
H	Creation of a science team.	Greater awareness of the need to teach and learn science. Created a good momentum in changing the way that staff and pupils think about science.
G	Creation of a science team and multiple science-based staff meetings.	Increased teacher talk about science. Constant presence in school life.
Sharing good practice and accessing more professional development		
A	Increase in number of science staff meetings.	Enabled staff to be involved in the decision making process, planning science and engaging with the new national curriculum. The children benefit from '... creative and motivated staff who plan and implement a cross-curricular, experiential and hands-on science curriculum'.
C	Staff INSET.	Provided teaching strategies to support the teaching and learning of AT1 (new national curriculum: working scientifically) across the school.
C	Regular program of sharing good practice. Monthly display by staff of annotated examples of AT1 (new national curriculum: working scientifically) in the staff room.	'Staff are sharing their science ideas and learning with each other.'
M	Staff are sharing methods and evaluating together.	Increased teacher confidence
R	'staff are now volunteering to share their ideas and work, wanting it to be included in PSQM.'	
R	'Previously people very much worked in isolation with regards to their planning and teaching of science. However PSQM has instigated a regular timetable of meetings where ideas are discussed analysed and reflected together, as well as creating a supportive environment.'	'a greater sense of teamwork within those members of staff taking science and their own interests in this subject have been renewed.' It has also meant that ideas are pooled and new resources that have worked well are discussed.
T	Use of team teaching, challenge questions and 'techniques for promoting investigative learning. Six minute science activities ... Year three and four shared the same activities and this provided greater opportunities for group discussion and development of ideas.'	'Staff very quickly felt as curious as the children about some of the possible outcomes. Children looked forward to these short tasks and they would often come and talk to staff members about their ideas.' This played a significant part in developing staff subject knowledge and confidence.
J	Involvement of staff in all aspects of working towards PSQM, including the Primary Engineer Project.	Increased positivity and confidence in teaching science. Staff other than the science leader have opted to further develop their expertise by attending CPD and leading STEM projects.
K	Parallel projects of PSQM and SSERC Mentoring project and Education Scotland	Buzz created during conversations in the staff room. 'People are talking about science

	Moderation Projects.	and bouncing ideas off each other’.
K	All staff have had CPD and effectively implemented it.	More meaningful learning and teaching. ‘I can honestly say that science is probably our strongest curricular area now with regards to assessment’.
G	Links with PSQM hub to share best practice.	Improved teaching and learning in science.

Evidence of impact on how science is planned

The submissions demonstrate that the PSQM programme has had an impact on the vision and future planning for science in nearly half (9/20) of the sampled schools (Table 5).

Table 5 Evidence of impact on how science is planned

Code	Evidence of impact on how science is planned:	How this is helping:
	Formal planning	
A	‘a clear vision for the future.’	‘plenty of ideas in the pipeline’.
C	Main areas for science development are identified.	Science leader has clear picture of where science is and next steps for further development.
D	Features on the School Development Plan to a greater extent than before.	More focus on science, taught as rigorously as literacy and maths.
G	PSQM action plan is alongside the School Development Plan for science.	‘ensured constant small steps in improving science provision.’
H	Ambitious plans for science in the School Development Plan.	Continued momentum for further development.
	Informal planning	
N	‘It has highlighted areas of good practice and prompted discussions about areas for future development.’	
P	Staff members eager to participate in science CPD next year	Will sustain the development of science in the school
J	The assessment for learning system used in English and maths will be used in science.	Increased value and importance of science in school.
P	Agreement to fund resources for next year (data loggers).	
U	‘The profile of the subject has been raised not only with the teachers but also the pupils and the parents. This is something we want to expand on in the coming year getting parents more involved in clubs and during lessons. We have parents who are in the science field for work and are willing to come in and talk about their jobs and how to pursue a career in science.’	

Evidence of impact on science learning and teaching

There is evidence of a broad range of science-related activities that have extended the curriculum and provided extra-curricular opportunities. Together these changes are leading to a science-rich

environment, where science is valued by staff and children and there is an impact beyond the school into the wider school community. Table 6 shows evidence from the submissions of impact on science learning and teaching.

Table 6 Evidence of impact on science learning and teaching

Code	Evidence of impact on science learning and teaching:	How this is helping:
	<i>Classroom</i>	
S	Quality and enjoyment of learning and teaching of science has improved throughout the school. We have moved 'from a school that simply followed a prescribed science scheme to a setting where both the staff and children value science, especially the practical aspects'.	
R	'there is now a real buzz about science, and this is evident in the type of work and investigations the children are undertaking, such as the robot challenge (Year 4), cracking contraptions (Year 3) waterproof hats (Year 1) and a large queue of children wanting to be chosen to take part in science challenges, to name just a few'.	
R	'all pupils actively take part in science; they ask more questions to develop their knowledge, often go and research things for themselves and are excited when it is time for science!'	Passion and enthusiasm for the subject.
M	Science is taught creatively with more enriching opportunities.	
V	'teachers put investigative and practical science at the heart of their lessons through the development of the Science Principles Poster ... Science Principles are embedded within each class.'	"the children can follow them and self-assess, this helps with the planning of the next lesson" "allows the children ownership over the subject" "they ensure science is more interactive"
T	Children with special educational needs 'access the science curriculum and actually feel inspired to carry out experiments at home and share their findings with the class.'	
T	'more engagement of children through cross-curricular work and they have learnt that science permeates all aspects of everyday life. They are increasingly curious about how different things work and impact on them and others.'	'Science holds a bigger presence in their lives.'
F	More cross-curricular teaching and learning; stimulating and exciting science curriculum.	Children getting 'the best science teaching that we can offer.'
L	Cross-curricular links are developing, as well as collaborative and outdoor learning opportunities.	
V	'Pupil voice – listening and acting upon their	

	requests – more investigations & outside learning.’	
K	A learning community has developed, by involving all the pupils and staff.	Science has progressed, and science outreach has surpassed expectations.
K	Science is probably the strongest curricular area now with regards to assessment.	
J	‘Science displays in every classroom, corridor as well as shared areas of school.’	Science more evident throughout the school. The children are positive and enthusiastic about science.
<i>Enrichment through visits, visitors, special events and technology</i>		
Q	A timetable of enrichment to support teaching and learning has been established.	‘A considerable rise in standards is evident and pupil engagement is high.’
R	‘The children particularly enjoy having regular visitors to the school and participating in science based school trips and residential.’ The annual science week ‘is always a massive hit!’ This year parents were ‘involved in their children’s learning of science and this all came to fruition during science week when parents were invited to various workshops, to work and learn alongside their children. The feedback from parents was amazing, and they were pleased they were able to share these moments with their children.’ Science beyond the school is developing by working with visitors and with link schools.	Memorable experiences have been created for the children and the school’s ideas about science have been spread to others.
T	‘Highlights include science-based outings, science-themed cross-curricular work, external visitors, year group science days, science week and much more positive feedback from children.’	Science-based outings were developed ‘with staff meetings exploring possible science venues. This in itself was a very productive exercise because staff became enthusiastic about the wide range of possibilities.’
Q	Achievements are publicised. ‘The children are taking a more leadership role in their learning, which was very evident in the Science Fair initiated by our Year 4 children.’ The school grounds had previously been under-utilised and through CPD they are now a rich and valuable resource.	
H	Celebrations in National Science and Engineering week.	Enhanced the subject in the curriculum.
V	‘Organising science week. Leading a workshop at a local primary science conference. Positive feedback from both staff and pupil questionnaires.’	
D	More science-focussed activities: science day, visit from Einstein, science fair, science quiz, trip to science festival, Forest schools.	More enjoyment and enthusiasm around learning science.
E	Whole school science event for National Science and Engineering week.	Head observed ‘significant improvement in science enquiry skills progression and teacher subject knowledge (and confidence)’ compared to previous year.

J	Introduction of STEM week.	Raised profile of science.
G	Rocket Day.	Teachers and students talking about science teaching and learning.
C	Science fair.	Last year only a handful of parents, this year over 30 parents attended.
T	'using the Learning Dome in school. The children were fascinated by the structure of the dome itself and couldn't wait for their turn to visit. Those children that had visited were going out in the playground and saying how good it was.' It was linked to work on Sicily with whole school science work on volcanoes.	'The sensory impact of the dome was incredible; the children were immersed by both visual and auditory stimuli. It left them full of excitement, gave rise to many questions, leaving them all eager to go off and research and develop their understanding of volcanoes.' Responses were incredible and the activity will be repeated on a three yearly cycle. 'Staff agreed that this resource created a real wow factor!'
J	New opportunities for school trips identified which link to the current science units and those of the new national curriculum.	
F	Visitors, science themed visits.	Better links with local and wider community. Enhanced children's learning in science.
T	'Use of external visitors has also been a highlight. Seeing owls up close as part of our work on habitats, working with coaches from Saracens on healthy living, learning African drumming as part of our work on sound and having the opportunity to work on chemical changes with secondary school pupils and teachers have all been incredible and really worthwhile experiences.'	'The secondary school science ambassadors found this an equally rewarding experience as it enhanced their skills with regard to engaging with younger pupils. They are keen to pursue and develop this in the future.'
T	'The children in year four said that their outing to Cuffley Camp was the "Best Outing ever!"'	'Teachers were also very positive and felt that this particular outing offered the children excellent hands on experiences for the whole day!'
Q	New school pets have proved invaluable to the growing knowledge base of the children.	By creating those experiences that the children would otherwise not experience at home, as the children are highly mobile and experience of growing and having pets is limited.
A	New clubs with science focus: science and gardening.	Generated interest from children and staff. Ideas have transferred into the classroom. More hands-on experiences.
A	Creative homework based on science, home learning packs, science stall at summer fayre.	Generated genuine interest from adults and children. Increased motivation. Supplementary learning experiences. Involvement of community.
K	Use of ICT has developed.	Able to promote science on the website, 'taking it forward through pupil contributions.'
T	There are a good number of children who say that they enjoy accessing science	

	activities through their school website.	
	External Reports	
E	Recent Ofsted inspection noted that the standards and the engagement (especially of boys) in science had improved using the new science curriculum.	
S	'practice in science has moved from good to outstanding – ratified by our recent OFSTED inspection result.'	'the whole school, staff and children, are seeing and feeling the benefits of the improvements that have been made.'
S	A local authority Pre-OFSTED review commented ... [extract deleted to preserve anonymity]	

5.3 Evidence of outcomes and impact of the PSQM on celebrating excellence in primary science

This aim of celebrating excellence in primary science links closely with the first aim (raising the profile of science) and some of the data supports both aims, for example, where parents had been invited in to see the science activities that had taken place in science clubs.

Three specific ways in which excellence in primary science was celebrated, that were facilitated by the PSQM leadership were: the PSQM award ceremonies; the Exemplar Material project; and the Primary Science Teaching Trust PSTT award. There were examples of the PSTT award being achieved before or after the science leader had taken their school through the PSQM award. The PSTT have an annual conference which brings together college fellows. At the PSTT conference the PSQM Director has presented about the PSQM with some of those who led their school through the PSQM award, and encouraged PSTT fellows to go on and do the PSQM programme.

One hub leader commented:

'Schools that have done a PSQM or are going through a PSQM are well equipped to deal with Ofsted. With schools that have been visited during their PSQM year science is often highlighted as a success. This is not often the case with other schools.' (HL3)

Some of the science leaders have celebrated excellence in primary science through publishing their schools' achievements in obtaining the PSQM (Parks, 2014; Ridley, 2014) or have featured in press reports or blogs.¹

A school with the Gold PSQM was the winner of the Science, Technology and Engineering Team of the Year at the 2015 TES Schools Awards.² Science leaders who had successfully led their schools through the PSQM programme have been winners of the ENTHUSE Celebration Awards, which celebrate education professionals who have made a significant impact on science teaching in their schools.³

¹ <http://blogs.royalsociety.org/associate-schools/2014/09/11/getting-a-primary-science-quality-mark-at-john-ball-primary/>

http://www.thetelegraphandargus.co.uk/news/14482596.National_honour_for_teacher_who_helps_pupils_develop_love_of_science/

<http://www.newsguardian.co.uk/news/local/formula-for-success-as-school-wins-award-1-6212331>

² <http://www.ogdentrust.com/about-us/news/post/1337-celebrating-success>.

³ <http://www.wellcome.ac.uk/News/Media-office/Press-releases/2014/WTP056706.htm>

5.3.1 PSQM stakeholders

The PSQM award ceremonies

Science leaders from schools that have successfully completed the PSQM programme are invited to attend a PSQM award ceremony and to take a guest with them, usually a colleague from their school. The ceremony is attended by PSQM stakeholders and members of staff from other schools that have also achieved the award and comprises a drinks reception followed by the presentation of certificates.

Interestingly, one of the PSQM stakeholder group responded warmly to this by saying:

‘... the award system is lovely ... it’s really nice for those teachers ... Primary teachers these days, nobody stops to praise them for what they do and going to a really nice evening like that with someone saying “you know what, we know how hard you worked”, I think is really a really good aspect of it’.

Another PSQM stakeholder from this group commented:

‘It is really quite important, the awards ceremony ... it is a way of public recognition for the work of schools ... they’ll bring their head teachers along, and get that celebration of what [is] done, and that’s a boost to the individual involved and helps them carry on to the next stage’.

Further noting that the award ceremonies are:

‘... unique, so far as I understand, in the quality mark world. Most of them, you stick your stuff in an envelope, and you get a letter back saying ‘yes, you can use our logo’. You don’t get invited to a cocktails evening at some prestigious location to receive your award, with the local press there as well. So that’s important I think, in terms of celebrating science and science leadership ... Why are you spending that much on canapés, it is science, but when you’re there you see the effort that delegates put into attending. They take it very seriously. They’ve not turned up in tee-shirts, they’ve come in evening dress basically to an award that they’re proud to receive, I know it’s emotions I’m talking about, it’s not scientific etc. etc., but at the end of the day, it’s another way of celebrating science leadership. And of course, that message gets back out into the schools’ community as an important thing to do. So yes, it is worth it.’

The Exemplar Material project

The Exemplar Material project:

‘is an ongoing PSTT funded project in collaboration with PSQM to develop an on-line collection of examples of good practice in the teaching, learning and leadership of primary science. Thirty areas of importance have been identified and material is being gathered and collated from the extensive high quality activities generated by schools during their participation in the Primary Science Quality Mark, quality assured and made available for those interested in primary science.

‘The main project aim is:

‘to celebrate and utilise good practice in primary science teaching and learning from schools participating in the PSQM award scheme by creating an on-line collection of downloadable exemplar material that would be of value to the wider primary science education community’ (Available from: <http://www.pstt.org.uk/science-teaching/primary-science-teacher-college/college-projects.aspx>).

The project arose from an appreciation of the quantity of material produced and used by schools when they carried out the PSQM programme in order to show their improvement and progression in science. Thirty areas of importance were identified that encapsulated the essence of primary science. The material is meant for science leaders in any school, not just PSQM schools, although most of the resources were developed as a result of the programme. In the original project the aim was to have 50-60 examples, of which about forty were available at the time of this evaluation. The Exemplar Material project is managed by a PSQM hub leader who is also an independent primary science consultant and a fellow of PSTT.

The Exemplar Material submission process. Schools are approached and invited to submit work for inclusion in the online collection once they have completed the PSQM programme. The process of engaging science leaders at this stage can be difficult, possibly due to the time required to submit the material and having it readily available. In general, four or five schools or fewer of approximately two hundred schools that engage in the programme submit their work to the collection. Schools are informed about the thirty areas of interest and asked to choose something that has been particularly successful in their school, or an area they are particularly proud of or that has worked particularly well for their school. This might be something participants have learnt from the process or something they have done within the school and would like to share. The material is compiled by the Exemplar Material project manager and verified with the schools before it is disseminated through the website in either a pdf or PowerPoint format. Each resource has a similar structure (with a general introduction, an aim and then the material) so that it is easier to read. Where possible the examples are as specific as possible rather than being too generic. The privacy of the schools and the teachers and pupils concerned is taken very seriously and the head teacher from each school represented has to sign a consent form.

Overcoming barriers or challenges to submission. Personal contact was thought to be a very good way of encouraging schools to contribute exemplar material to the website.

Using the Exemplar Material. Although intended for use by all schools, the material is being used widely by schools that are engaging in the PSQM for the first time and hub leaders direct schools to look at the materials as examples of the type of work schools carry out when they take part in the PSQM programme.

5.3.2 PSQM hub leaders

The PSQM award ceremonies

A hub leader gave an example of an approach to celebrating the award:

‘... there’s a little banner on their school website saying thanks to the hard work we’ve got this award, which is really nice for everybody because it’s not just celebrating the award it’s naming the teacher and saying thank-you for all the work they’ve done.’ (HL1)

The Exemplar Material project

One hub leader explained that:

‘It always helps if you have personal contact with somebody or you have been their hub leader and I say that would be really good, do you fancy doing that as an exemplar? That would be excellent to share.’ (HL7)

Another hub leader commented that whilst acknowledging that s/he ‘probably should have recommended it’ s/he found that access to the exemplar material was inhibited by the repetitive nature of the logging in requirements.

5.3.3 Science leaders in schools engaging with the PSQM award through the focus group

The PSQM award ceremonies

The three science leaders taking part in the focus group were planning to attend the forthcoming PSQM award event for their school with one or more of their colleagues including a head teacher, an assistant head and a key stage 1 coordinator. They discussed different ways in which their school's PSQM award would be publicised, for example, on the school letter head and school website, via Twitter and possibly through a news item in the press.

In addition to informing the schools' governors and reaching a wider audience there were examples of ways in which the pupils were informed about the award. One of the schools represented had:

'... visitors from [overseas] in so we had a very big assembly and they presented the award and other awards ... so they presented everything on that day so the children already know about that.' (SL1)

A second participant thought s/he might:

'... do an assembly because we do an assembly where we share so the children know what they achieved so that they celebrate with us.' (SL2)

The Exemplar Material project

When the science leaders were asked whether they had heard of the exemplar website during the focus group there was a mixed response: one science leader had heard of it; one had not and the third participant was not sure. The science leader that was aware of the website had not submitted any resources commenting:

'No, I wouldn't dare submit anything ... I haven't submitted anything and to be fair I haven't looked at it either because I've done the process the second time ... If I don't know now what it looks like when am I going to know?' (SL2)

On further discussion it was disclosed that s/he had assumed that 'someone else', the hub leader, would identify resources that were suitable for submission because they were aware of work in other schools:

'I think it does have to be the hub leader because we're only thinking about our school, we don't know what other evidence people have got and how can I put something forward and there might be a better example from another school.' (SL2)

5.4 Evidence of outcomes and impact of the PSQM on using networks to provide local support for science for schools

Organisations and formal networks promoting primary science education

There are a number of networks across the country that focus on supporting primary science education. These include the Primary Science Teaching Trust, The Ogden Trust, the Science Learning Partnerships linked to the National STEM Centre, the Wellcome Trust and the Association for Science Education. The following sections include a brief description of the purpose and functioning of these organisations in relation to primary science education.

Primary Science Teaching Trust

The Primary Science Teaching Trust (PSTT) 'strives to facilitate the development and dissemination of excellence in primary science, be that via ideas, resources or continuing professional

development, with the main aim of raising the profile of primary science across the UK' (Primary Science Teaching Trust, 2016, p. 3). The PSTT funds a range of innovative and cluster projects focussed on science teaching.

The PSTT employs and finances fellows to create clusters of up to ten schools. They send a newsletter out on a regular basis and have a national conference promoting primary science with keynote speakers. The PSTT provides money for the fellows to attend CPD of their choosing, and an increasing number now present at various conferences. The PSTT also funds fellows to undertake projects; 'to do interesting and exciting things in primary science'. (A hub leader)

The Primary Science Teacher College is part of the PSTT. All the people that are in the College are teachers who have won the Primary Science Teaching award. The College was set up to enable the individual science teachers to meet regularly and develop primary science beyond their own schools.

The Ogden Trust

The Ogden Trust is: 'a charitable trust that exists to promote the teaching and learning of physics. We do this by providing individual scholarships to talented sixth formers and undergraduates and by enabling innovative physics teaching to take place in schools, often forging links to universities. We also address the shortage of physics teachers in the UK by funding programmes that encourage young graduates and career changers to go into teaching...'⁴

The Ogden Trust supports science education across all phases, but in the last few years they've been expanding their work in supporting primary science. Traditionally their teacher fellows, one of the roles they have based in secondary schools, have to build a network with primary schools. It originally began with 'Phiz Labs' where The Ogden Trust would pay to have a room in a primary school turned into a science lab and pay for equipment. The Ogden Trust's primary work has expanded in two ways: the provision of these Phiz Labs and also the development of a CPD programme.

The Wellcome Trust

'The Wellcome Trust is a global charitable foundation dedicated to improving health by supporting bright minds in science, the humanities and social sciences, and public engagement.'² The Education and Learning team lead the work on primary science, 'including the evaluation of a primary science professional development programme run by the National Science Learning Centre.'⁵

The Association for Science Education

'The Association for Science Education (ASE) is the largest subject association in the UK. As the professional body for all those involved in science education from pre-school to higher education, the ASE provides a national network supported by a dedicated staff team. Members include teachers, technicians and advisers. The Association plays a significant role in promoting excellence in teaching and learning of science in schools and colleges. Working closely with the science professional bodies, industry and business, the ASE provides a UK-wide network bringing together individuals and organisations to share ideas and tackle challenges in science teaching. The ASE is an independent and open forum for debating science education, with unique benefits for members. It

⁴ Available from: <http://www.ogdentrust.com/>

⁵ Available from: <http://www.wellcome.ac.uk/News/Media-office/Fact-file/> and <http://www.wellcome.ac.uk/Education-resources/Education-and-learning/The-team/index.htm>

provides a unique range of services to promote high quality science education by developing resources and fostering high quality Continuing Professional Development.’⁶

The National STEM Centre

The National STEM Centre provides support for science, technology, engineering and mathematics (STEM) learning through:

- the National STEM Learning Centre, York - providing intensive, residential professional development alongside a library of STEM teaching resources, both on- and off-line
- the network of 50 Science Learning Partnerships in England - providing locally available DfE supported science focussed professional development
- our partners in Scotland, Wales and Northern Ireland - providing locally available professional development through SSERC, Techniquest and Education Authority Northern Ireland’⁷

‘... Science Learning Partnerships (SLPs) combine local expertise in teaching and learning in science, facilitating CPD, and providing school-to-school support. They are led by local teaching school alliances, schools and colleges with excellence in science, higher education institutions, and other local partners with cutting-edge expertise in science ...’⁴

5.4.1 PSQM Director

The PSQM Director described briefly how she was working with some of the primary science networks (Table 7).

Table 7 Examples of ways in which the PSQM Director is working with primary science networks

Organisation	Ways of working
The Association for Science Education (ASE)	The PSQM Director has been a member of the ASE for more than fifteen years; and an active national primary committee member for more than five years; regularly presents at the ASE conferences and has represented the ASE at national level. The ASE was part of the original project team for PSQM, so there has been a close working relationship between PSQM and ASE. The ASE is a member of the PSQM stakeholder group.
Institute of Physics (IoP)	The PSQM Director has been a member of the IoP Education Board for the last year. The IoP is a member of the PSQM stakeholder group.
The Ogden Trust	The PSQM Director works at a strategic level with The Ogden Trust senior team. The Ogden Trust is a member of the PSQM stakeholder group.
Primary Science Teaching Trust (PSTT)	PSQM is a strategic partner with PSTT and an active collaborator.
Royal Society of Chemistry (RSC)	The RSC is a member of the PSQM stakeholder group. The RSC provides bursary support to PSQM. There is a close working relationship between PSQM and the RSC education team.
Science Learning Partnerships (SLP)	The PSQM Director works closely with the London and SE and Central England Science Learning consortia and presents at

⁶ Available from: <http://www.ase.org.uk/about-ase/>

⁷ Available from: <https://www.stem.org.uk/about-us-test> and <https://www.stem.org.uk/science-learning-partnerships>

	events regularly. They are represented on the PSQM stakeholder group.
Royal Society of Biology (RSB)	The PSQM Director is a member of the RSB primary curriculum working party. The RSB is a member of the PSQM stakeholder group.

The PSQM is also promoted through local authority science advisers and independent consultants.

How these networks inter-relate

Networking in the PSQM stakeholder group creates opportunities for these organisations to work together towards aims which they have in common, of developing primary science and there are mutual benefits in this, for example:

The PSQM increases the primary membership of the ASE by offering subsidised membership to PSQM participants. From round 11 there were more than 160 new members joining the ASE. The PSQM is always represented at ASE conferences and given space in the ASE journal. It was thought that because some of the hub leaders are local authority advisors, the PSQM may be promoted through the National Advisers and Inspectors Group for Science (NAIGS), a special interest group of the ASE.

Some PSQM hubs are now situated at The Ogden Trust Phiz Labs bringing additional schools into these networks. The Ogden Trust has made available some funding towards doing the PSQM award to The Ogden Trust partnership schools that wish to enter PSQM. They have chosen to recommend to their schools to use the PSQM process as an evaluative tool for the impact of the Phiz lab and CPD that they have received. Also, PSQM schools may be using The Ogden Trust resources and subject-specific CPD to support their development towards achieving the PSQM award.

The PSTT conference provides an opportunity to share the experience of science leaders who have completed the PSQM and to encourage more schools to start the process. PSQM promotes Primary Science Teacher Awards (PSTA)⁸ to all awardees. By February 2015 there were 97 teachers in the Primary Science Teacher College as a result of winning the PSTA, and 47 of these teachers had also taken their school through the PSQM, therefore 48% of Primary Science Teacher Awardees came via this route.

Royal Society of Chemistry local coordinators visit all the RSC bursary-funded hubs and raise awareness of RSC activity.

The PSQM promotes relevant activities and resources of all the stakeholder organisations to their science leaders, via direct email or their website, and these organisations include information about the PSQM on their websites.

How hubs relate to other formal networks

Science leaders meet with hub leaders regularly throughout the PSQM year (for a minimum of two days; most hub leaders provide four or more half days) to participate in the PSQM training programme. Training events are held in a central venue or rotate round members' schools. The hub leader provides additional mentoring support throughout the year, particularly in giving feedback on action plans and submissions. The hub leaders assign levels at the start of the process and approve submissions before they are submitted for review. Some hubs carry on as a local network post-

⁸ Available from: <https://pstt.org.uk/what-we-do/primary-science-teacher-awards>

PSQM, but usually hub leaders encourage schools to maintain the network independently or via existing networks e.g. the ASE or PSTT clusters.

The PSQM programme is growing new hubs by linking with existing or developing networks (PSTT, The Ogden Trust, Science Learning Partnerships set up through the National STEM Centre, Welsh Local Authority consortia), to provide a framework for redevelopment and/or evaluation of a network. New hubs often start by new hub leaders being recruited by the PSQM Director from award winning schools and school improvement organisations. Schools are either recruited by hub leaders or come direct to PSQM having heard about the programme through word of mouth, local science events, Ofsted, PSQM publicity or other organisations including, but not exclusively, stakeholders.

How the PSQM award compares to other primary science awards

The PSQM differs from other awards available for primary science because it is accreditation for a school not an individual. It provides evidence of curriculum development and subject leadership that can then demonstrate the eligibility of a science leader for the Primary Science Teaching Award, conferred by PSTT or the Chartered Science Teacher (CSciTeach) awarded by ASE. There is a programme of CPD at the National Science Learning Centre, the Primary Science Specialist Programme (now called Developing Primary Science Leaders), which has been undertaken by science leaders who are doing the PSQM, or after they have done the PSQM. This CPD has no accreditation.

5.4.2 PSQM stakeholders

PSQM interaction with other networks

The PSQM stakeholder group includes people who have experience of primary science teaching, science leadership, school leadership, scientific research and quality assurance. One of the group felt that this meant other organisations and societies could trust the messages from the group, because of the experience in education and leading and the credibility of having scientists in the group.

The members of the PSQM stakeholder group shared a desire for primary science education to be as good as it can be, and recognised that the PSQM programme supports that aim. This group is important for identifying links between the stakeholder organisations for mutual benefit. Several of the members of the PSQM stakeholder group commented on the quality of their relationship with the Director of the PSQM. They are invited to PSQM award events which gives first-hand contact with the science leaders which is good for building relationships. One of the stakeholders recognised that they were:

‘... a support and critical friend’ for the PSQM.

One of the PSQM stakeholder group felt that because the PSQM doesn’t make specific subject content requirements, it is a flexible framework that is easy to integrate with the way other science education networks operate. This is good for schools because they can supply the content to suit their context. This stakeholder from another science network continued:

‘Clearly PSQM have a good understanding of what is good primary science and they spend more time and effort thinking about that than we necessarily have the capacity to do, so we can learn from them’.

An example was given of how science leaders might access subject-specific CPD through another network so that they can be more able to:

‘... go beyond the school and fulfil the expectations [of the gold award]’.

The member of the stakeholder group from the PSTT felt that:

‘... it’s very much a partnership, many of our fellows have achieved PSQM and several of them are hub leaders for PSQM ... We promote PSQM and PSQM promote us. In my mind we are different but very complementary in that we acknowledge outstanding teachers and PSQM is an audit for the school that acknowledges outstanding teaching in the delivery of science and what we are hoping more and more is that those who are fellows will become PSQM [schools] and more of the PSQM schools will be housing potential fellows ...’

As the PSTT fellows have been awarded a Fellowship for outstanding teaching of primary science, they are often approached by the Director of the PSQM to take on hub leadership. Also many teachers going through the PSQM process will be, or will become, outstanding teachers, and so can be recommended to the PSTT, to become fellows.

This stakeholder explained that:

The PSTT fellows ‘get allocated ... an amount of money now ... so if they’re going through the PSQM process and they feel they’re becoming overwhelmed with whatever else is going on in school and they want some quality time to actually complete that pro forma then we would sanction that and they would get supply cover in to allow them to give quality time to complete this PSQM process.’

Furthermore PSQM is promoted by PSTT fellows ‘identifying schools within their own area ... where science is a low priority. So it might be somebody they have met for a CPD course, or it’s a school already in an existing cluster ... somebody they know is quite interested in science but their school, their senior management team, may not be.’ They will encourage them to go to PSTT cluster meetings and to have the confidence to consider PSQM. Some of the fellows are independent consultants and they can take the printed publicity material when they’re out delivering CPD or visiting schools.

The PSTT promote the PSQM by inviting science leaders who have already gone through the PSQM programme to speak at their conferences, to encourage the others and explain the process that they had gone through and offer support. They also promote it to trainee and newly qualified teachers by directing them to the documents for the bronze level, as they are useful for new science leaders. They suggest to enquirers, where appropriate, that they contact PSQM. The arrangement is probably reciprocal in that the PSQM suggest outstanding science leaders to be nominated for the PSTT award.

The member of the stakeholder group from the Wellcome Trust explained that they promoted PSQM through Twitter and through advertising to primary schools alongside their own resources. They had produced a couple of reports recently which included links to PSQM for teachers to facilitate access to resources and support for teachers to become good primary science leaders.

This member explained that there was collaboration with the PSQM leadership in order to develop an ‘understanding of how primary science works as well’, to raise awareness at a governmental level and to bring about policy change. The desire was that science should be treated properly as a core subject. The contact with the PSQM provides a way ‘to make sure that some of the comments we would make about primary science are accurate’.

Relationship between the Developing Science Subject Leaders Programme at the National Science Learning Centre and the PSQM

The relationship between the Developing Science Subject Leaders programme (formerly called the Primary Science Specialist Programme) and the PSQM is complementary because it ‘is about giving

teachers who have very little background in primary science the CPD they need to increase their expertise and understanding of subject content knowledge, of pedagogical content knowledge, to teach and how to lead science.’ People doing the course are told about PSQM and encouraged to apply and get their certification. Science leaders who have done the PSQM but want some support with their subject knowledge are told about this course.

Informal – PSQM networks

The value of local networking through the hub was also recognised because it was bringing together science leaders from different schools, leading to the sharing of good practice. The PSQM provides a way of facilitating primary teachers to be able to collaborate, where this would not arise naturally across schools. As suggested by one of the PSQM stakeholder group, perhaps:

‘... an appropriate question to ask is if the expectation for the higher [gold] PSQM award of teachers working with other schools is actually just a nice gentle nudge to get more of that collaborative work with schools happening. That people might be *keen* to do it, but might not always know how to go about it.’

Another commented that:

‘... one of the unique things about primary science is this ability to share, there isn’t this hierarchy within primary ... and one school, having achieved PSQM, are quite willing to go and talk to another school who are just starting out...’

A member of the PSQM stakeholder group commented that in order to develop a scientific enquiry approach:

‘... the key for that to happen is professional development *usually* externally led because schools never have the capacity to do that and that’s where PSQM is quite helpful because it networks people with an interest in developing their teaching skills in that respect, the networking means teachers will meet those at different stages of development and that’s naturally helpful. Networking and supporting collaboration between schools used to be the preserve of the local authority. That’s less the case now ... There are local authorities that have lost their science coordination completely. There is no science leadership within the local authority at all. That just leaves a cluster of schools to get together, and PSQM is one way of doing this, because it links schools together and provides a collegiate focus even if it is only for schools in the cluster’.

5.4.3 Documentary evidence from the RSC bursary-funded PSQM evaluation report

The RSC bursary-funded PSQM evaluation report (White et al., 2015) included evidence that one of the reasons that schools choose to do the PSQM is for the networking opportunities, to learn together with colleagues from other schools and hub leaders, as indicated by these quotations from science leaders:

‘There was also the opportunity to work with the Science advisor and other School Science Leaders, sharing ideas for best practice.’ (p. 10)

‘I have enjoyed sharing good practice and expertise with colleagues from other schools.’ (p. 11)

5.4.4 PSQM hub leaders

Typically, many of the hub leaders had additional roles in other networks that promote primary science. As one hub leader explained, for example:

‘I am a hub leader; an independent primary science consultant, and within that role I am a PSQM hub leader but I’m also a fellow of PSTT ... They all interlink – the overlap is complementary rather than being extra work. All those roles work together really well’.
(HL7)

How the hub leaders view the role of a PSQM hub

‘In some places there are strong networks already and the hub is primarily a support system for schools engaged in the [PSQM] process. It can also have a value in those circumstances in bringing together schools from different clusters or networks so that a greater variety of practice and experience is shared. In areas where there are fewer established networks and lack of leadership for primary science the PSQM hub can be the main way for the science leaders to make contact with others and establish school to school support e.g. from a gold school to the rest of the hub.’ (HL1)

How the hubs worked

‘We meet between four and six times during the year. The sessions are a combination of developing the subject leaders’ skills e.g. writing action plans, writing reflectively, gathering evidence, and also sharing good practice particularly when looking at core documents together. If requested we may spend time discussing particular issues e.g. assessment.’ (HL3)

‘Head teachers / senior leadership team members attended the first meeting to ensure they were aware of the requirements and on board.’ (HL2)

Sustainability of hubs

None of the hub leaders participating in the research had any experience of a hub continuing to meet after completing the PSQM. The hub leaders reported that individual science leaders have integrated into other local networks for primary science, for example, local authority networks and some hub leaders were aware that:

‘... some of the subject leaders from my hubs now lead sessions in their borough meetings.’
(HL3)

‘They encourage other schools to do the PSQM, share expertise and information and insights and are extremely valuable.’ (HL6)

One of the hub leaders felt they had no role in maintaining the hub as a distinct group, but many stayed in contact with individual science leaders within their hubs. One reason given was the geographical distribution of science leaders in the hub. Another explanation was shared:

‘Many of my first hub have now been promoted to different schools/areas. The ones that are left are integrated and extremely beneficial in my local subject leader network.’ (HL6)

One hub leader has Science Learning Partnership funding to set up a local network as there were no networks locally for the science leaders to join.

5.5 Evidence of outcomes and impact of the PSQM on assembling a rich database of current practice in primary science and making it accessible to the wider science education community

5.5.1 Director of PSQM

The Director of the PSQM has made the stakeholders aware of the PSQM database on current practice in primary science. Additionally, in 2013, a scoping report was published to demonstrate the richness of the data research/policy possible uses (Turner et al. 2013). Access has been shared with Bath Spa University, enabling a publication regarding assessment in primary science to be shared with the wider science education community (Davies et al., 2014; Earle, 2014), and in January 2016 a PhD student was appointed to investigate professional learning in the context of the PSQM, who will be able to draw on the database. It was recognised that in order to make the data more accessible it will be important to organise it effectively.

5.5.2 PSQM stakeholders

Comments regarding access to the database of submission evidence revealed awareness that it could be useful because it could provide evidence across a huge range of schools regarding practice in primary science. There was some confusion as to the nature of the database. Interest was also expressed in knowing the distribution of schools throughout the UK which take up the PSQM and comparing this to those who do science courses at the National STEM Centre and who take advantage of other science networks, as there may be significant crossover. This would reveal which schools to target support, who haven't taken up anything.

5.6 Understanding the process of implementing the programme

5.6.1 PSQM stakeholders

The cost of doing the PSQM

The cost to small schools as opposed to big schools may be an issue. If the school is in a well networked area they may have access to extra funding, but if the school is in an area where they are not connected into a network for extra funding, this may be a limitation in the very areas that it is most needed.

Getting buy-in from schools

It was recognised that there was a need to get head teachers and the senior leadership teams on board and that they needed to understand that this is quite a labour-intensive process so the science leader needs a bit of space and quality time to actually complete the process. A concern was expressed that:

'... often I hear that the [science leaders are] using up their holidays or burning the midnight oil trying to do it.'

'Unfortunately we know that from the research we did with the Primary Science Specialist Randomised Controlled Trial, if you don't get buy-in from school leadership teams, if they didn't commit to giving your science leader the time to do the job properly then they couldn't do it basically, you wouldn't get good science throughout the school. You do need buy-in from the leadership team.'

The challenge of actually being able to fulfil the role of science leader was further illustrated:

‘... you need dedicated management time and if you haven’t got it then it is going to be really difficult. You can’t do it in a piecemeal way. What you need to be able to do is work alongside your colleagues, offer peer support, mentor them, coach them if necessary. And unless you’ve got the opportunities to do that, unless you have got dedicated leadership time it is very, very difficult. It’s quite hard to have a conversation with somebody over a photocopier and to expect really good outcomes compared with being able to work with a teacher in their classroom ... I think the hardest thing in leadership in any school is it depends upon what responsibility and authority you are given and are permitted to have, and can carve out. So sometimes people are made subject leaders and they are more of a coordinator I would say than a leader ...’

One of these stakeholders believed that there is a good completion rate once a school has signed up for the PSQM:

‘... you definitely need buy-in from the schools and once you’ve got that then they usually fulfil the process.’

Another felt that the PSQM provided recognition of the work involved:

‘... if we invest in this as a school “what’s in it for us”, and I think the quality mark really does help with that overt demonstration of what’s in it for you. You’ve achieved something you’ve got recognition for it.’

Follow-up beyond the award

One of the stakeholders shared a concern about the follow-up after the award:

‘... what happens when the person who drove it forward leaves the school, do they backslide? There doesn’t appear to be anyone mopping that up. It’s all about achieving the award, and once the award is achieved, as far as I’m aware, they’re then left for three years until it comes time to resubmit. In a perfect world it would be really nice to think that someone occasionally got in touch to say - just in a way it would be doing a register check, “is the person still in place who got the school through the process”. If they’re not, does the new person in post need a bit of support? ... because if the staff has changed, when it comes to the resubmission process I can imagine you’re really starting again.’

‘What is important though is that the science continues to be high profile, that it continues to live up to that mark and that’s up to the school leadership team and the science leader who’s got that quality mark to continue to make that happen.’

Beyond the gold award

One participant observed:

‘What will be interesting is what will the gold school do next? You then run into the commercial viability, or otherwise, of it in terms of the financial sustainability of the programme ... I’ve got my gold medal. Do I carry on paying that every year or do I go onto the History Mark, or whatever it might be, from the management point of view. So how do you sustain quality of science?’

One of the members of the PSQM stakeholder group raised the possibility of having a different process for going for reaccreditation at gold level for a second time. This was based on feedback from teachers who had completed the PSQM. Currently the cost and process is the same even though the school may have maintained that outstanding practice for the last three years. This could

be a constraint holding schools back from resubmission at gold level – the cost, the amount of extra work and not knowing what else they could do when they are maintaining gold standard.

Hub leader quality

One aspect identified as a barrier to meeting the PSQM aims was the dependency on the quality of the hub leader:

‘I don’t think there is consistency across the process. I know there are people who are very happy and very well supported by their hub leaders, and then I know of other teachers who are not, who have had to look elsewhere for help and I think that’s a weakness’.

Capacity of the PSQM Programme for further growth

The following comments from one stakeholder illustrate how the PSQM may be constrained because of the lack of capacity for further growth:

‘... it [PSQM] is growing at a rate at which they could probably benefit from more staff...’

‘I’ve heard teachers say I’ve got in touch with them to say I want to sign up or I needed this, I needed that and didn’t get a reply - and that puts people off.’

This member of the stakeholder group felt that more hub leaders were needed, because face to face contact was so important. New hub leaders could be recruited from retired teachers, ex- local authority advisors for science. A suggestion was made that going forward the PSQM could focus on particular regions, with key people as hub leaders to organise that and to move it forward:

‘... because primary school teachers are extremely busy and have ten other subjects to deal with, and if they are going to do something significant in science, they need to be supported - and they need to be supported well by quality people.’

PSQM might have reached the point where further investment would enable it to run more efficiently and grow quicker.

5.6.2 PSQM hub leaders

Aspirations of a hub leader

One hub leader reported that:

‘For me the most valuable is more schools doing silver level (not necessarily progressing to it from bronze). It is good to have new subject leaders coming in at bronze but many subject leaders are able to start the process at silver. More schools at silver level means there are more schools with a whole school commitment to high quality science and a subject leader who is having impact on the science learning of all the pupils in the schools ... progression to gold is good but isn’t a realistic ambition for many schools and, as long as there are excellent schools doing outreach, every school only needs to be silver for science education in this country to be pretty amazing.’ (HL1)

Another hub leader pointed out that:

‘The guidance documents are useful but I don’t think they are as effective if they are used in isolation of each other. It is the whole package that makes PSQM so successful.’ (HL3)

How the framework criteria work

The framework was commonly felt to stimulate reflection on current practice in science teaching. One hub leader believed that:

‘... reflecting is hard for some ... I am getting people to begin reflections much earlier as this seems really powerful in bringing about change...’ (HL5)

One of the hub leaders stated that they liked the four main sections. One of the criteria was seen as particularly useful:

‘A5 (*The science leader knows about science teaching and learning across the school*) is especially useful for some science coordinators who haven't been involved in those sorts of activities before.’ (HL6)

A different hub leader suggested that:

‘Maybe some small tweaks needed but nothing major missing and nothing redundant. The overlap between A2 (*There is a clear vision for the teaching and learning of Science*) and A4 (*There is shared and demonstrated understanding of the importance and value of science to children's learning*) can be confusing.’ (HL1)

Another hub leader felt that it would be helpful to include the need to keep updated and to read research such as Dylan Wiliam on assessment, Wellcome Trust reports, Teacher Assessment in Primary Science (TAPS) project etc.’ – evidence based approaches – to ensure they are aware of the need for this as part of being a professional; not just following what other schools do. This could be supported by links to research on the PSQM site ...’ This participant also noted that:

‘There are many organisations that support science learning and therefore information is fragmented – a central point would be helpful.’ (HL2)

Other suggestions that would be helpful regarding the framework criteria and documentation were:

- A3 (*The current School Development Plan has appropriate and active targets for Science*) ‘is difficult for some science leaders to evidence but ... it is a very important one to show that science has some status. For bronze and silver schools where this is a problem, could some guidance be given for how they might address this?’
- C1 – bronze, silver and gold descriptions are very similar to make the differences clearer
- more emphasis on assessment for learning in C2 (*The purpose of science assessment is well understood and shared by members of the school community. Assessment approaches are designed to fit those purposes*)
- C3 (*Children enjoy their science experiences in school*) - maybe include compulsory pupil voice evidence
- in Section E the science leader could indicate the age group(s) they teach
- need to change subject management to subject leadership
- change the criteria into a set of questions for the science leader to reflect on
- make some of the differences clearer between the different levels
- ‘more clarity for the gold level indicating that not only must schools have influence beyond the school but that they must be secure in all the criteria across the school’
- minor changes in light of the new curriculum and assessment arrangements
- ‘more emphasis on child-led/initiated enquiry and what this means’
- ‘a template for the subject leader log – these vary in quality (and quantity) and often do not state the rationale behind the actions’
- ‘the action plan template can be difficult to use as sections ‘disappear’!’
- a requirement that the reflective paragraphs address all the points
- the criteria are clear, though there is a little overlap sometimes. Could it be slimmed down?

- ‘an element of longevity. For example a requirement to plan for something to still be ongoing the following year and the year after. Many schools do this but in some schools (especially if the Lead leaves or changes) the fantastic work comes to a halt’
- ‘a way for the portfolios to be shared with other schools so others can benefit’
- ‘a requirement to present the portfolio to an audience in school of governors, teachers, parents’

Other suggestions for supporting science leaders and hub leaders:

- a list of successful teaching and learning strategies from different schools
- ‘opportunity for links between schools e.g. science e-pals’
- the useful guidance on the website about writing reflections is often not applied – perhaps this is a hub leader training issue?
- the useful reviewing guidance on the website could be added to with examples of the difference between adequate and excellent reviewing. Also sharing some helpful phrases for when the submission just meets the criteria
- ‘free access to further training. Money for resources and experiences..... so many places I have worked in have NO science budget whatsoever’
- ‘a formal third day with our hubs would help’
- ‘FUNDING.... so many are put off by the cost’

A hub leader felt that their focus was the process rather than actual science teaching:

‘The training tends to be very focused on the process but the conversations between schools where you are looking at each other’s action plans and talk to each other about what you are doing it’s almost more peer to peer teaching ... There isn’t really time for the hub leader to do that as well because we are focusing on teaching about the criteria and how to do PSQM.’ (HL1)

This hub leader thought that it was important to find out:

‘... what is happening in the schools, picking up on areas where the quality is not as good as it should be and supporting / signposting help for improvement. If it is all left until the portfolio stage then the school may have done lots but not the most appropriate things ...’ (HL1)

They suggested that work should be brought to meetings early in the process to help monitor quality of what is going on in the school, because in a large scattered hub it is hard to know the schools well.

Regarding resubmission, one of the hub leaders felt it was important:

‘... even when the school’s reaccrrediting when it’s a new subject leader, for them to come to the training and get the face-to-face elements.’ (HL1)

Recruiting new schools

One of the hub leader highlighted difficulties in recruiting new schools:

‘... I have had a difficulty in recruiting schools in my area. I fully understand the costs involved in PSQM but from a school’s point of view, especially if it is not high priority for them it’s a lot of money to invest in a subject that they perhaps are not so pushed with. So when Ofsted goes in, for instance, and really supports PSQM that is really important. It is a wonderful process because of its reflective nature. It makes teachers think about what they have done and why they have done things and what’s been successful and what hasn’t. The whole process makes you go back to square one and really think why you have done something and what has been the benefit of it. Teachers often don’t do that unless they are made to because they are so busy. You know the things that work but you don’t really think

about why they do. It definitely has implications beyond just the award itself but I'm not sure that schools always understand that if they haven't done it. It's not quite like other awards, quality marks, because a lot of those involve tick boxes – have you done this, have you done that – it doesn't ask them to reflect on the process and what has really made the most impact.' (HL7)

'... I'm finding that [recruitment] really difficult in this area. Particularly as schools are becoming academies and aren't under the local authority remit anymore. I used to recruit through the local authority but a lot of local authorities don't have things like heads' breakfast briefings. Now they have clusters within Academy groups ... Some hub leaders are still working within a local authority or as a science advisor within a borough then they have a lot more access to head teachers, schools and those sort of introductions to start with. As an independent science consultant I find that a lot harder. It would be impossible to know who to approach really.' (HL7)

Recruitment strategies included:

- emailing 'subject leaders that I have met during the year information about PSQM when it is recruitment time'
- Leaflets and newsletters
- Offering 'the PSQM as part of other training programmes as a way of the school getting recognition for the money invested in science CPD'
- Getting 'subject leaders who have previously completed a PSQM to talk about the impact in their school in order to recruit new schools', at network meetings
- Enthusiasm as it is such an excellent programme
- 'Local authority science leader network meeting'
- Science Learning Centre courses
- 'Talking about it at head teacher meetings'
- 'Word of mouth (mainly head teachers)'
- Contacting schools that Gold schools support

5.6.3 Science leaders in schools engaging with the PSQM award through a focus group and submissions to the PSQM portal.

How the framework criteria work

The science leaders participating in the research felt the criteria were purposeful and worthwhile. The progression between award levels was clear. Points for further development that they raised included:

- more inclusion of pupil voice as it is 'important to hear what the children are saying about science.' (SL2)
- more on pupil impact rather than focussing on the science leader and the teachers
- less overlap and cross-referencing

The feedback sheet from the first award (silver) helped one of the science leaders to hone in mainly on the areas that needed developing to get gold. Two of the science leaders described how the school had benefitted from repeating the whole school INSET on developing the principles when they went for gold. For one school the new principles were more pupil-focussed. For the other school the staffing was very different:

'The first set of staff were very mature, they had been teaching for many years and were very confident teachers whereas our current staff are ... newly qualified or from abroad ... so they're not used to our systems; so the principles were slightly different and there was a different set of issues ... in terms of teaching science.' (SL2)

One of the science leaders commented:

'... the most useful thing for me was right at the beginning when you had to go through the self-assessment and looking at it and thinking well we don't do that, ah, we should be doing x, y and z, and if I do that ... and immediately it made you very quickly assess what we were doing or maybe half-doing and the things that were completely not in place, that straight away we need to work on and everyone needs to be on board otherwise it's not going to work.' (SL3)

Resubmissions

Since 2014 (round 8) schools that have previously taken part in the PSQM programme have been eligible to renew. In round 8 six schools (5% of the total) were renewals and in round 9 the number of renewal schools was 28 (11% of the total).

Of the five subject leaders who responded to questions about renewing the PSQM in their school, there were two who were continuing as science leaders since the first time the school attained a PSQM award. From the hub leaders responses it was clear that the science leaders develop as they undertake the PSQM which often means that they move on to other leadership roles.

One explained that they decided to go for renewal:

'To continue to promote good quality teaching and learning of science in a world where senior leadership team feel that Literacy and Maths are the only important subjects.' (SL5)

They went for gold level because they wanted 'to support other schools in raising the standards of teaching and learning of science.'

The science leaders who participated in the focus group were all from schools that were reaccrediting. They felt this had been a valuable experience:

'... I still think it is valuable even though I do know colleagues of mine who don't want to reaccredit because they think there should be a simplified version to reaccredit, but for various reasons I think you do need to go through it all again because school changes. The school moves on even after a year ... doing it the second time has been easier because I know what to look for and what to put in. The first time it did take a much longer time for me. The second time the writing wasn't so ... I knew what I was getting into...' (SL2)

When asked if their school will want to continue with keeping the PSQM award and to renew after three years, the science leaders responded:

'I would think so; my head's already talking about it.' (SL2)

'We have reaccredited and it's too soon to think about it again ... I think it's almost considered for us something that you have to renew every three years...' (SL3)

'I think we will ... my head is always keen to keep everything up to date and active so it stays with us as well and if I'm the leader then definitely.' (SL1)

6 Discussion of Key Findings

6.1 Contribution to raising the profile of science in primary schools

In the context of a declining profile of science in primary schools (Ofsted, 2013) the findings suggest that the PSQM has been playing an important role in **enhancing the teaching and learning of primary science**. There was an indication from the responses of PSQM stakeholders, hub leaders and science leaders that the PSQM programme was being chosen by schools to **address the perceived emphasis on literacy and numeracy** to the detriment of the other curriculum areas.

The way that the PSQM programme was seen as having this impact was through engendering a commitment to the **value of science at all levels**: the senior leadership team, the staff, the pupils, the parents and the governors. One hub included head teachers and senior leadership team members at the first meeting to ensure that they were aware of the requirements and were on board. This might be a model that other hubs could explore. Typically, the **profile of the science leader** was enhanced, giving them the recognition with which to lead change, and helping to develop their **professional identity** where they had newly taken on the role.

Through the PSQM year the science leaders reported that the **teachers grew in confidence** to teach science and there was an increase in **science-related talk amongst the staff**. The profile of science was being raised through **special science events**, visits and visitors that had been sparked by the PSQM process, as well as through displays of pupils' work increasing the visibility of science. Some of the changes had introduced an element of fun and excitement around engagement with science. The **attitudes of pupils and teachers** towards science teaching and learning were becoming increasingly positive. The PSQM may be playing a significant part in increasing the **science capital** of pupils through the **extended reach to parents** leading in some cases to engagement with science in the home (see Aspires Project Report 2013).

Evaluation of the submissions from schools that completed the PSQM programme reveal that the profile of science in these primary schools was raised through engaging in the PSQM programme at bronze, silver and gold levels. The characteristics of the award meant that the profile of science was raised according to the **level of the PSQM submission**. Silver and gold submissions had an impact beyond the science leaders' classroom to the whole school, and gold submissions had substantial impact beyond the school.

6.2 Contribution to providing schools with a framework and professional support for developing science leadership, teaching and learning

The PSQM was seen to have the advantage of being flexible enough to be context-specific because it is not focussed on particular content, but rather on **leadership development**. The PSQM was believed to turn coordinators into leaders who were more secure and confident in their role. The clear structure, contribution to developing understanding of the role and some of the key skills and creation of principles for a **whole school approach** were instrumental in this. The science leaders were better equipped for leading others because of **reflecting and evaluating practice** that was being provoked by engagement with the framework. The process helped the science leaders to understand the expectations of the role and how to promote and encourage science. They were developing skills of **modelling and team teaching** to disseminate good practice through the school. Their understanding of **progression in science teaching and learning** was enhanced.

The specialist leadership training was critical because most primary teachers are not science graduates and have limited training into the **scientific way of thinking**, challenging evidence and doing experiments. Science leaders were **better equipped for their own teaching** because they have

good access to professional development. The development of science subject knowledge and pedagogy was largely through networking, access to the knowledgeable hub leaders and signposting to appropriate CPD opportunities.

Schools were working from **key principles** for science teaching that had been developed as part of the PSQM programme through listening to the pupils. These provided a common understanding of what science in the school should look like and brought everyone together with a common agreed purpose and vision. The processes of **action planning and submission** provoked review and development of teaching and learning strategies. **The framework** deconstructed subject leadership into manageable steps. The PSQM provided a **legitimate space** for teachers to reflect on science in their school and the **resources, ideas and support** to help them to develop science learning in their school. It also provided a supportive sharing network across schools and a contact point for science leaders to ask where they are unsure. The close mentoring relationship between the science leader and the hub leader was empowering and provided support for action planning, reflecting on impact and advice on assessment.

There was a **wider range of learning opportunities** for children including learning outside, having science visitors and going on science-based trips in the schools as a result of participating in the PSQM programme. These strategies to engage pupils were being implemented in conjunction with a focus on **child-led** and **hands-on learning across the school**. Pupils were being given more opportunity to ask their own questions and to work scientifically to answer their own questions and lead their own investigations. Changing pedagogy was a challenge for many of the science leaders and teachers in their schools where this approach was new. Listening to **pupil voice** had a powerful impact on the science leaders.

The quality of science teaching and learning in primary schools was supported and enhanced by the PSQM through developing subject leadership and providing scaffolding and mentoring to support development of science provision across the school and beyond. Science teaching and learning was enriched, with more **consistency in the quality of teaching** primary science across the school.

The PSQM was having a wider impact on teaching and learning in primary science beyond their own schools partly through providing resources for the **Teacher Assessment in Primary Science (TAPS)** project and the **Exemplar** website.

The PSQM programme provided the underpinning for producing **sustainable school improvement in teaching and learning science** through subject leader development and an annual action plan which allows for new strategies to become embedded. This happened especially where schools have gone on to do the gold award after gaining the silver PSQM. The programme requires the commitment of the senior leadership team to giving the science leader time and support in developing science during the PSQM year. Sustainable improvement requires long term commitment, which is then the responsibility of the school. The sustained impact was largely dependent on the science leader. There were examples of where the impact had been sustained within the school and where relationships between schools which started in the PSQM year had continued, and one where the hub itself continued to meet with Science Learning Partnership funding as there were no local networks for the science leaders to join. There were also examples where the science leader changed, making the improvement harder to sustain. Some hubs carried on as a local network post-PSQM, but mostly hub leaders encouraged schools to maintain the network independently or via existing regional primary science networks. Where continued networking as a hub would sustain the development of primary science in the schools, it could be beneficial to explore how this could be facilitated financially. Sometimes there were geographical barriers to continuing as a hub. There were advantages in hubs containing science leaders from a wider geographical area and a variety of networks, as this brought a diversity of ideas to the group.

Where science leaders had become hub leaders, they had a **wider impact** as they worked with clusters of schools to raise the profile of science. Some science leaders built on their PSQM success in their own or another school. Some have become specialist leaders in education (SLEs). There was evidence that the science leaders themselves gained from the leadership development and that this impacted their career development, and provided skilled leaders to support further school improvement, though not always focussed on primary science.

Evaluation of the submissions revealed that there was especially high impact on the leadership of science and on the breadth of learning and teaching experiences within and beyond the classroom. There was also evidence of changes emerging that would ensure the impact of the PSQM would be sustained beyond the programme year. These included the approach to planning and wider links being developed by some schools.

6.3 Contribution to celebrating excellence in primary science

The **PSQM award ceremonies** and the **Exemplar Material project** provide two ways in which excellence in primary science is celebrated. These ways provide visible evidence of what the school has achieved. Some schools have celebrated through their own websites and a few schools have celebrated their achievements through publications, and one school has gone on to win a prestigious national award. In some schools, engagement in PSQM has led to science teaching and learning being highlighted as successful by Ofsted.

The unique award ceremonies provide a greatly anticipated celebration that publically recognises the hard work that has gone in to achieving the award and raising the profile of primary science with a wider audience.

Engaging science leaders in the Exemplar Material project has been challenging and part of the PSQM submission process could include schools choosing their best work, with their hub leader's help, for uploading to the Exemplar website. This would help to affirm for the science leader the comparative quality of their work. It would be good to showcase this work on their school website too. The Exemplar Material is useful for those doing the PSQM for the first time. People using the exemplar material could have a comment box to give their feedback.

Some science leaders go on to gain a Primary Science Teaching Trust PSTT award to recognise their individual contribution or win an ENTHUSE Celebration Award for their contribution to science education.

6.4 Contribution to using networks to provide local support for science for schools

The PSQM is the only award available to recognise **whole school achievement in primary science**. Other awards are available for individual teachers. It provides subject leadership development rather than CPD to develop the primary science content and pedagogical knowledge of teachers.

The PSQM Director has close links with a number of organisations that promote primary science, and these organisations network together in the **PSQM stakeholder group**, seeking opportunities to further their common aims of developing primary science. The PSQM Director is key in these relationships, enabling reciprocity between the organisations and the PSQM. This group has recognised expertise that gives it credibility in the world of science and education and was perceived as being very valuable to the members and their organisations. The PSQM stakeholder group has the potential to raise awareness at a governmental level and to bring about policy change, leading to science having recognition as a core subject. There were many aspects of the PSQM programme that were going well from the point of view of the different stakeholders.

A major benefit of this group for the PSQM is the **'critical friendship'** that it provides to the PSQM leadership. The interactions are mutually beneficial for the organisations in terms of up-to-date awareness of developments in the field, marketing opportunities, building membership, and providing a **rich interwoven network** to enhance science teaching and learning through primary science leaders. The PSQM promotes relevant activities and resources of all the stakeholder organisations to their science leaders, and The Ogden Trust, PSTT, National STEM Learning Centre, the Wellcome Trust and ASE include information about the PSQM on their websites. Some of this information would benefit from being reviewed and updated.

Recruitment to PSQM of new hubs may be through links with existing primary science networks or by new hub leaders being recruited by the PSQM Director from award winning schools and school improvement organisations. Schools are either recruited by hub leaders or come direct to PSQM having heard about the programme through word of mouth or publicity. Recruiting new schools can be challenging in the current climate of decreasing local authority networks. However, PSQM is largely school-led, which is a key strength that could be used more widely in publicity. The PSQM stakeholder meeting might benefit from input of current senior leadership from primary schools and systems.

There would be a benefit to these organisations to explore possibilities, within the constraints of current data protection legislation, to share regional data regarding the distribution of schools doing the PSQM and engaging with other organisations promoting primary science, to **identify areas to target primary science support**.

One of the reasons that schools choose to do the PSQM is to have the opportunity to learn together with colleagues from other schools and from hub leaders. The PSQM hubs network people with an interest in developing their primary science teaching skills so that teachers meet those at different stages of development and a great variety of practice and experience is shared. The gold PSQM award of teachers working with other schools is a good mechanism to promote inter-school collaborative work to raise the profile of primary science more widely. It could be recognised more widely as a tool for **school-to-school support** that is key in the current context of Teaching School Alliances.

6.5 Contribution to assembling a rich database of current practice in primary science and making it accessible to the wider science education community

There has been a scoping report demonstrating the richness of the data available in the submissions database and possible uses and the Director of the PSQM has made the stakeholders aware, however there was some confusion as to the nature of the database. There has only been limited use of the database for research or to inform to date. However, it is possible as the data is used more, for example, in this report and by other researchers including doctoral studentship holders focussing on this area, others might see the potential that is available to them. Currently the data is not easy to access, and it would need to be organised effectively for more extensive use.

6.6 Learning to support the further development and improvement of the programme

There may be some ways in which the PSQM could develop to become more effective. Some factors were raised that might be limiting the expansion of the PSQM including the **cost** of doing the PSQM to small schools especially outside of networks that have access to extra funding. Hub leaders were aware of schools with no funding for science or for science CPD. If these schools are identified, maybe a source of funding to support engagement with the PSQM and further CPD could be channelled in their direction.

The **commitment of the senior leadership team** was recognised, as the PSQM is quite labour-intensive, so the science leader has the protected time to mentor and coach colleagues, to do developmental work and to complete the process. The advantage of the PSQM is that once schools have committed they tend to complete,⁹ and the PSQM provides recognition of the work involved.

There was a question as to whether the **bronze award** was necessary. Many subject leaders are able to start the process at **silver** which means there is a whole school commitment to high quality science and a subject leader who is having impact on the science learning of all the pupils in the school. Progression to **gold** was seen as unrealistic for many schools and not essential for all schools as long as there are some excellent schools doing outreach. The focus of the PSQM is on achieving the award, but **beyond the award** there is no clear structure to monitor how the school is getting on, whether the science leader is still in place, and to offer **further support** if needed. **After the gold award** there were two views of what should happen **regarding resubmission**. Some felt that the cost and amount of extra work to resubmit at gold was a disincentive, and that the schools did not know what else they could do. Maybe there could be a cheaper 'gold light' involving collecting evidence to show sustained impact in and beyond the school over the intervening years. Others felt that it was important to go through the full process again for resubmission because it was often a different staff profile, including the subject leader, and the context could be different (change in national curriculum, school organisation) and the need to promote science was just as great. The process was seen to be of benefit, to ensure the quality of the work was sustained. A **platinum award** may be a future development for gold schools that would like to develop primary science further. This could include practitioner enquiry, for example, action research or lesson study, to develop science teaching and learning further within the school or beyond.

The PSQM is providing professional development opportunities for hub leaders, as they meet together and through participating in the processes. One aspect identified as a barrier to meeting the PSQM aims was the dependency on the quality of the **hub leader**. The need to monitor the quality of hub leaders and to support their on-going professional development will be vital going forward if the PSQM is to expand further, as more hub leaders will be needed. Identifying key hub leaders to move the work forward in areas which are identified as needing targeted support would lead to strategically planned growth of the PSQM into areas where the impact will be very significant. The introduction of senior regional hub leaders, who meet quarterly, could provide a structure for monitoring and developing the wider group of hub leaders.

The **sustainability of the impact** of the PSQM on a school may be reliant on the science leaders who led the school through the PSQM remaining in post. Where science leaders move on, this will mean that some of the rich experience and learning will go with them into a new setting. This is good for the school system as a whole, but might constrain the sustainability of the PSQM within the original school, unless there are opportunities for renewal, for upskilling the new science leader, or for a teacher to shadow the science leader to be able to transfer skills smoothly. A suggestion for going forward may be to have two science leaders, one mentoring the other, for succession. Where this has happened it helped to develop and empower the less experienced science leader. There is an indirect benefit of having science leaders entering senior leadership teams, if they continue in an ambassadorial role for primary science. This may increase impact beyond the original school.

The PSQM programme has grown; more than 1500 schools have been awarded Primary Science Quality Marks since the launch in 2010. **Further growth** could be constrained by the capacity of the core leadership team and a review of the working of the central team and communications may reveal a need for more investment in staff in the PSQM leadership and administrative centre.

⁹ Since round 1, 8% of schools taking part in the PSQM programme have failed to complete. In certain circumstances, schools may defer their submission for the award by one or two rounds. (Data: February 2016)

Recruiting new schools is challenging for some hub leaders because academisation has led to changing networks of schools which hub leaders do not necessarily have access to as they did through the local authority networks. The Teaching Schools Network and Multi-Academy Trusts may be the school networks that the PSQM leadership and hub leaders will need to engage with more going forward.

The framework was widely accepted as appropriate. A number of suggestions were shared by the hub leaders and the science leaders in the findings (Section 5.6.2 & 5.6.3) for developing the framework and documentation further. The science leaders felt that there should be more inclusion of pupil voice and pupil impact rather than focussing on the science leader and the teachers. It is also notable that there is nothing in the framework explicitly regarding pupil progress in science.

The PSQM stakeholder group might want to consider providing a shared **primary science website** as a starting point for all things to do with primary science as a resource for primary teachers and hub leaders who are finding the information fragmented.

Time in hub meetings was usually focussed on procedural aspects of the PSQM programme, a third day could provide more time to focus on primary science knowledge and pedagogy. Hub leaders are working without a first-hand knowledge of the schools that the science leaders are working in. They need enough time to monitor the quality through the documentation and discussions that the science leaders are bringing to the hub meetings, so that appropriate support is in place from the start of the PSQM year.

The PSQM programme may be a good model for other subject areas and could be used as a school improvement tool. Consideration could be made as to whether the framework and resources could be repackaged as a franchise for other subject areas for school improvement.

7 The Way Forward

7.1 Summary of possible ways forward for the PSQM team to explore

The new school landscape in England and beyond:

- Addition of the **voice of current primary senior school and system leaders** to the PSQM stakeholder meeting.
- Making links with the **Teaching School Alliances** through the **Teaching Schools Council** to promote the PSQM as a school improvement tool for **school-to-school** support.
- Developing links with the **Teaching Schools Network and Multi-Academy Trusts**
- Use of **school-led** improvement in primary science teaching and learning in publicity.
- Sharing of regional data regarding distribution of schools between stakeholders to **identify areas to target primary science support**, within the constraints of current data protection legislation.
- **Repackaging** the PSQM framework and resources to support subject leadership and school improvement beyond science.

Initial school engagement and sustaining impact:

- Financial support for schools to be able to engage in the PSQM and further science CPD as needed.
- Invitation to head teachers and senior leadership team members to the first hub meeting to ensure they are aware of the requirements and are committed.
- Financial support to continue a hub network beyond the PSQM year where other networks are not available.

- A process to monitor how schools are getting on after the award, whether the science leader has changed and whether further support is needed.
- Consideration of **gold light** for schools that are able to sustain their gold award quality of working and retain their science leader.
- Consideration of a **platinum award** for those who would like to develop primary science further through practitioner research, and have the potential to have national or international impact.
- **Promoting succession strategies** such as the use of two science leaders in large primary schools, or a less experienced teacher shadowing the science leader in advance of taking over the role, or a new science leader being mentored by an experienced science leader.

Maintaining and improving quality of PSQM support:

- Monitoring and supporting the professional development of **hub leaders** to ensure consistency and quality of support through the new hub leader structure.
- Review of communications and structure of **core PSQM team** to provide efficient leadership of growing programme.
- Further **development of the framework and documentation**, including consideration of more inclusion of pupil voice, and the impact on pupil progress in science.
- **More time** for hub leaders to meet with the schools in their hubs.

Internet presence:

- PSQM submission process could include choosing best work, with the hub leader's help, for uploading to the **Exemplar website**.
- Addition of a comment box for people using the **Exemplar Material** to give their feedback.
- Review and updating of information about the PSQM on the **stakeholders' websites**.
- A shared **primary science website** of all interested stakeholders, as a starting point for all things to do with primary science as a resource for primary teachers.

Further use of the PSQM submissions database:

- Organisation of the **submissions database** to enable easy access for researchers.

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