Supporting ongoing teacher development through Primary Science Quality Mark
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Introduction
The Primary Science Quality Mark (PSQM) is an award programme to develop and celebrate the quality of science teaching and learning in primary schools. The PSQM aims to:

- raise the profile of science in primary schools
- provide schools with a framework and professional support for developing science, teaching, learning and leadership
- celebrate excellence in primary science
- work with existing networks, and facilitate new networks, across the UK and elsewhere to provide local support for primary science
- assemble a rich database of current practice in primary science and make this accessible to the wider science education community.

The PSQM was piloted in 2008 and 2009 in response to the widely-reported downgrading of science in UK primary schools (Alexander, 2009; Royal Society, 2010), and rolled out across the UK in 2010. It has been widely supported by the science education community in the UK, with a range of organisations providing funding and in kind support.

Primary school science subject leaders apply to take part in the PSQM programme and are appointed to local PSQM hubs. Subject leaders either approach PSQM independently or are recommended to join the programme by local primary science consultants or national inspectors. Schools pay a fee to take part in the PSQM programme and the headteacher's support is required before an application is accepted. There are more than 80 active PSQM hubs across the UK and a growing number overseas. These are all led by PSQM hub leaders, local experts in primary science with experience of providing professional development. The science subject leaders meet as a group with their PSQM hub leader. There are four or more meetings during a year-long programme of professional development, school-based evaluation, action planning and implementation to develop all aspects of science teaching, learning and subject leadership. The science subject leaders also receive on-line feedback and support from their hub leader. In addition the collaborative group of science subject leaders can be used to share issues, test ideas and disseminate expertise.

The conclusion of this work is the PSQM submission, in which subject leaders reflect at a personal, professional and institutional level on the impact of taking part in the PSQM against each of the 13 PSQM criteria. Each school provides one submission, which contains 13 written reflections and supporting documentary evidence of the impact of interventions to improve the quality of science teaching and learning. The submissions are reviewed and moderated by other hub leaders before PSQM awards are made at gold, silver and bronze levels, according to the extent of the impact.

Oral and written comments show teachers value the support offered through PSQM. School inspectors recognise positive benefits of PSQM in terms of systematic evaluation of science provision (Ofsted, 2013). Although PSQM has been extensively evaluated (Ponchaud, 2011, White 2015), the specific role and impact of the tutor and the collaborative group have not been identified.

For many teachers, this process becomes a catalyst for wider reflection on professional practice. This is an intended outcome of the PSQM programme. As part of the training delivered by the

PSQM hub leaders, subject leaders are made aware of the work of Lawrence Stenhouse, specifically his argument that curriculum research and development should belong to the teacher, and that proposals from policy makers are not diktats, but ideas which the teacher should test out in his or her classroom (Stenhouse, 1975). This view of the classroom teacher as researcher is new to many of the primary science subject leaders taking part in the PSQM programme. It is introduced as part of impact-focused action planning, where teachers are encouraged to identify needs and envisage the outcomes of consequent interventions on pupils, colleagues, themselves and the culture of the school. A taxonomy of reflection based on analysis of previous submissions for PSQM is provided to guide teachers when evaluating evidence of the impact of their actions to improve science teaching and learning. This focus on systematically testing practice is evident in teachers' own reflections about their professional activity:

> *For myself new to the role as subject leader, it (PSQM) has helped me to focus on the strengths already in school and look towards ways of improving both the school and my role as leader. Each time an initiative has been thought of to develop science, PSQM has made me reflect: What am I doing? Why am I doing it? Then reflecting, what has the impact been? I have thorough enjoyed being involved with the success science has had across the school and I am looking forward to building on this next year.*
> (Silver PSQM submission, 2015)

PSQM may be illustrative of the shift over recent years to teacher development becoming more school-based (Taylor, 2015) and covering a range of possible mechanisms in addition to courses from an external provider, so that the boundaries between award-bearing and non-award-bearing professional development have become blurred. At the start of the PSQM programme, teachers typically have an instrumental view of the programme: by participating in the programme they get support for developing science teaching and learning in their school and a recognised award at the end of the process. In many cases there is clear shift in perspective, from an instrumental view to one where PSQM is viewed as a catalyst for professional growth which is valuable and worthwhile in itself, as these extracts from submissions exemplify.

> *Personally, the PSQM process has supported me in expanding and improving my own leadership skills. It has developed my confidence as a primary school teacher and has given me the opportunity to lead and support others in their own career. I now feel ready to further my career as a senior member of staff, if and when there is a post available.*
> (Bronze PSQM submission, 2013)

> *As science coordinator I feel that taking part in the PSQM process has focused my attention on what exactly leading a subject entails. I have become much more confident in understanding my role and now appreciate how best to drive improvement in my subject. The very nature of the PSQM process forces a school to critically reflect on their practice and then collectively work as a team to drive improvement and progression. A whole-school community approach, in which parents, governors, teachers, pupils, outside agencies (outreach) have all got involved in science teaching and learning, has served to raise its profile with our school curriculum and make science a fantastically exciting and engaging subject to teach and to learn.*
> (Silver PSQM submission, 2013)

Clarke and Hollingworth (2002) suggest that rapid professional growth is more likely where teachers value the outcomes of that process. In PSQM the outcomes of the programme are entirely defined by teachers. The only outcomes they work towards are outcomes that they have selected, on the basis of having value for the children and/or the school as an institution. Fraser et al (2007) recognise that personal ownership of professional development is more likely to lead to transformational professional learning. Rapid professional growth and transformational professional learning are certainly evident in a substantial number of PSQM teachers, and we believe that this validates the original decision to set up the PSQM programme as a self-directed and school-directed process of evaluation and development, rather than prescribing a set of activities and procedures for teachers to follow.

Simon and Campbell (2012) note that teachers' motivation to learn comes from within, and that reflection on professional practice can lead to a perceived need to change that practice. The fact that some teachers become interested in continuing the process of reflecting on professional practice after PSQM finishes is immensely encouraging. This goes beyond the outcomes originally envisaged when PSQM was first set up. However currently there is no mechanism to support these teachers. Sharp et al (2006) identified access to mentoring and to research expertise as fundamental to the success of school-based action research. We therefore recognise the need to build in some elements of ongoing support for the teachers who wish to continue this process of reflective practice.

This project was set up to explore the value of, and possible mechanism for, PSQM supporting teachers' school-based action research, either during or after the PSQM programme. Ideally this would lead to an accreditation route at Masters level at the University of Hertfordshire, where the project is based.

The specific research questions are:

- To what extent are teachers capable of carrying out school-based action research at the end of the PSQM programme?
- To what extent is face to face support from one or more tutors an essential factor leading to successful school-based research as part of PSQM?
- To what extent are PSQM hub leaders able to take on the role of guiding school-based research with the teachers?

Method

The project uses a participatory action research approach (McIntyre, 2008), in which reflecting on issues, action planning, implementing interventions and further reflection are part of an iterative process. This allows us to engage in systematic enquiry to enhance the PSQM programme, whilst working with the teachers and supporting them in their own school-based research. The project involves action research at two levels: the teachers' school-based research, using an action research framework, and the tutors' meta-level action research on supporting teachers' school-based research.

Three teachers (2:1 male:female) were selected for the case study. They were identified by their hub leader, based on the interest they showed in exploring professional practice during their PSQM programme. They are all relatively near the beginning of their careers (1-5 years teaching) and inexperienced in school-based research.

An initial meeting outlined the project and provided guidance on planning and implementing individual school-based action research. Over the next semester, three more meetings were held where tutors supported the teachers in their school-based research. Tutor support (McIntyre, 2008) emphasised identifying and refining suitable research questions and methodologies. No restrictions were placed on the types of research questions that would be suitable, though in practice the types of research questions teachers were interested in tended to be in the category of pedagogical content knowledge (Shulman, 1986). Both tutors attended each of the meetings with teachers, and both were available by telephone/email/skype to provide support at a distance.

Having two tutors present enabled us to provide maximum support to the teachers at the meetings. It also allowed us to make extensive field notes during meetings, compare notes and triangulate data. Data sources were field notes from meetings and tutor reflective diaries. In addition the teachers involved kept teacher diaries that they made available to tutors.

The framework used for data analysis was:

1. To what extent can teachers:
    a) identify potential research questions for their classrooms?
    b) refine these into focused and manageable research questions?
    c) identify methodologies that are suitable for investigating their research questions?
    d) interpret the data they collect and identify suitable action steps?

2. What kinds of tutor support seem effective in supporting the teachers' school-based research?

The small scale of the teacher case studies meant that the amount of data potentially was limited. For this reason the decision was made to extend the number of data sources and data collection mechanisms. This would enable a greater degree of triangulation and greater certainty in the validity and potential generalisability of the data.

A questionnaire was therefore used with regional hub leaders (N=16). Its purpose was to explore the potential role of regional hub leaders in supporting school-based research as part of a national framework. A more detailed semi-structured interview was carried out with one hub leader to explore views about the hub leaders' potential role in greater depth. The interview questions included the extent to which hub leaders might have the capacity to take on the role of research tutors, what training might be necessary and how this might best be provided, and what their involvement might be in the short and medium term.

Another data source was one of the external stakeholders. An education manager at the Royal Society of Chemistry was selected on the basis of his good understanding of primary professional practice, his extensive involvement in PSQM and his professional role in teacher development. A semi-structured interview was carried out to ascertain his views on the role of PSQM in teacher development and school development.

Results

Data from teachers

1.a&b) Tutor 1 had identified potential research questions in the teachers' PSQM submissions, in advance of meeting the teachers. At Meeting 1 none of the teachers had identified potential research questions for themselves, and none of them suggested suitable or manageable research questions. Potential research questions that arose in discussion appeared to be unfocused (e.g. What shall we do about assessment?) or unmanageable (e.g. can I set up a whole-school project on using different recording methods?). It seemed evident that this issue of how PSQM might support teachers in identifying suitable research questions is very important. If a teacher begins their school-based research by tackling an inappropriate or unmanageable question then they are much less likely to be successful.

Tutor-led discussion during Meeting 1 led to more appropriate and manageable research questions being identified. For example, the vague '*What shall we do about assessment*?' (Teacher G) became refined into the much more specific '*What is the impact of getting children to record learning rather than recording what they did*?'. Tutors left teachers with the task of refining their research questions before the next meeting.

At Meeting 2 our expectation was that suitable research questions would have been identified and the focus for the meeting would be on methodology. The teachers had a better idea of research questions than they did in Meeting 1, but it was apparent that there was still work to be done. Teachers certainly had more suitable questions in mind than at Meeting 1, but the questions seemed to be rather 'hypothetical' questions rather than questions that were really important to them. For example, Teacher G's starting focus was how children summarise their learning at the end of a lesson. His school has started to use Carol Dweck's work on mindset as the grounding for their pedagogy. This led to conversations about how children conceptualise success, how the teacher might influence this and how children can be involved in generating success criteria. The final focus was 'To what extent does how the teacher talks about success have an impact on children's perceptions of success?'.

By the end of Meeting 2 the teachers' final focus was very different from the initial discussions that we had in the earlier meeting. It was apparent that the earlier meeting had helped them to think more carefully about questions related to pedagogy and the development of science in their schools. However on their own their ability to identify a valuable and manageable research question appeared to be limited.

By meeting 4 (nearly 8 months after Meeting 1) the teachers were in agreement that deciding on a suitable research question is the hardest aspect of school-based research, along with refining it over a period of time to really make sure it works. 'Why' is not a good starting point for a research question. Getting together to talk through the research has been vital to them.

1.c) None of the teachers planned a suitable methodology without support. In Meeting 2 tutor discussion was necessary to refine their ideas about what might be manageable and effective ways to answer their research questions in their individual schools. For example Teacher G noted that '*Tutor 2 helped me to realise the scale of the task, as I was trying to include far too much*'. Through discussion they refined their ideas about what might be manageable and effective ways to answer their research questions.

1.d) By contrast, the teachers' were able to interpret data and identify suitable action steps much more successfully. By Meeting 3 Teacher K had answered her research question successfully, choosing suitable interventions and identifying their impact and deciding on suitable next steps. Teacher R had collected and analysed data appropriately, identified relevant action steps and developed a good understanding of the potential implications of his actions. Teacher G had identified three specific data collection methods and had a clear view of what further action steps were necessary. All the action steps and interventions seemed appropriate.

2. All of the teachers in the case study claimed that they have learnt a considerable amount through school-based research and that this has had visible impact on their classroom practice – and in some cases, on their colleagues as well. They noted that the process was initiated by PSQM, but the follow up school-based action research had taken this to a different level. Their horizons had been broadened beyond the 'tunnel-vision' that many teachers have and they were thinking about more general aspects of teaching and learning, such as how to help children to become learners, how to enthuse them to become scientific, and how to develop the curriculum across the school.

All of them claimed that face to face conversation has been critical in helping them define their focus and methodology and interpret data from a broader perspective. Teachers K and G stated that email/telephone contact with tutors and external agencies had been helpful, but not an adequate substitute for face-to-face meetings. Undergraduate guides to classroom-based research were also helpful.

The teachers suggested that a question bank of previous/useful research questions could provide a helpful start to the process. This could be accompanied by some kind of illustration of good/poor research questions, with an analysis of what makes them better or worse. They suggested that thinking about 'How do these data help to answer my research question?' would be a useful guide to writing the data analysis section.

<u>Data from hub leaders</u>
In the questionnaire to regional hub leaders, 100% of them also stated that face-to-face seminars are essential, though only 20% of them feel confident to lead these seminars. 69% of respondents agree that small-scale action research activity is a good 'next step' for PSQM participants and 47% that they would feel confident to identify suitable teachers. 'Often they have actually made a hypothesis, done something about it and then measured the impact.... small scale action research'.

The interview with a PSQM hub leader evinced similar data. She stated that she was keen to take on the role of action research tutor as it was a clear progression route for PSQM participants and also good professional development for her own career. There would be time and organisational implications, which could be addressed by some contact being on-line rather than face to face. This hub leader has no formal research training herself but significant experience of delivering CPD, working with teachers on long term curriculum development and PSQM hub leadership and submission review. She acknowledged that she would need initial training specifically in methodology, clear criteria for assessment, case study examples, library access and/or on line

materials and recommended reading lists. She also suggested 'buddying' experienced action research tutors with those with less experience, and an online support group for the tutors.

In other words, hub leaders are not yet in a position to take on the role of tutors leading and supporting follow up school-based action research. This remains a medium and long term aim, but does not appear to be realistic in the short term.

Data from external stakeholder

The external stakeholder referred to evaluation evidence (White 2015) when asserting that participation in PSQM leads to significant development of leadership skills for those science leaders involved, and that there is also wider impact, possibly at less depth, for other teachers teaching science through the support they get from their PSQM-linked science leader. He recognised that PSQM raises the profile of science and has a whole school impact on the place of science in a broad and balanced curriculum. He described the PSQM process as having a collegiate approach which values strong working relationships and personal support and interactions led by effective hub leaders.

These views of an informed external stakeholder appear to confirm the role PSQM plays in teacher professional development.

Discussion

All the teachers made progress with their school-based research. They identified development in practice and enhanced science education in their classrooms. This project supported school-based research in ways that these teachers value. For example, teacher K began by trying to get the children to take on challenges but found that they were often unwilling to do this. Her next intervention was to invite children to take on a challenge only when they feel ready, and to offer clues (in a Clues bag) for support. This time children were much more willing to take on the challenge – though some did ask her whether she felt they were ready to take it on. The teacher became aware that offering clues for additional support provides opportunities for self-selected differentiation by pupils. This links with pupils self-checking on 'how do you know that you have finished?'. Both of these complement the emphasis on growth mindsets in the school, and teacher K feels that Carol Dweck's work makes much more sense now that she is able to see some aspects of it in action.

It appears that teacher K's planned interventions have been successful. The initial focus has broadened to more generic strategies for teaching and learning. The children are now more independent, and colleagues comment on this on their learning walks. Teachers K says that she has changed her teaching as a result of this project, and she takes Dweck's work much more seriously now.

All of the teachers successfully interpreted data and planned relevant interventions. None of them selected a suitable research question or decided on a suitable methodology without support. Tutor interventions were necessary to identify potential research questions, refine these questions to make them focused and manageable, and plan suitable methodologies. Teachers' comments that deciding on a suitable research question is the hardest aspect of school-based research are consistent with what happened in practice. Doubtless some teachers will be able to identify and refine their research questions without tutor support, but not providing any tutor support for this process seems guaranteed to result in unfocused, misguided or unmanageable projects for many of the teachers.

The PSQM programme focuses on school improvement, yet many of the teachers self-report high levels of personal development too. This raises the question of how much overlap there is between the PSQM process and good CPD – in what ways are these similar? Do the factors that lead to effective school development also lead to effective teacher development? Adey et al (2004) claim that effective CPD has several elements, including a long time frame (ideally a year or more), support from senior management, clearly-articulated vision, collegiality and reflection. These have all informed the design of the PSQM programme: the head teacher's support and school

participation fee is mandatory; an initial compulsory activity for subject leaders is to compile a set of principles of 'good science teaching and learning' and communicate a shared vision for science in the school; PSQM hubs provide a collaborative network; and the submission is a set of 13 reflective statements supported by evidence.

Guskey (2000) identifies five levels of impact of effective CPD:
1. Participants' reaction
2. Participants' learning
3. Support & change in the organisation
4. Participants' use of new knowledge & skills
5. Student learning outcomes

Participants are encouraged to use this framework when planning for and evaluating impact of their actions. Many of the teachers structure the reflective statements in their submissions using a simplified version suggested by hub leaders: *What impact have I noticed and can evidence on behaviour, attitude and cognition in children, colleagues and (most importantly for this study), myself?*

Unsurprisingly therefore, PSQM submissions contain clear evidence of the impact of CPD at all 5 levels identified by Guskey. The examples of impact that are identified in submissions include:

- descriptions of subject leaders' personal enjoyment of the PSQM experience
- reflections on how their own understanding of how to teach and lead science has grown
- visible organisational, curriculum, resourcing and pedagogical improvements within their school
- significant changes to children's attitudes to science
- improvements in children's attainment in science.

This was summarised well by one 2015 participant:

> *The PSQM is an effective support tool for developing science in any school. Its framework ensures realistic self-evaluation and measured progress towards achievable targets. It necessitates whole school impact so development and success cannot remain with the senior leaders and as such improves scientific experiences and out-comes for all children – and teachers. Due to it having a significant monetary and time investment and a nationally respected accreditation at the end, value is placed on it within the school agenda so the senior leaders should be able to prioritise activities against other demands. Whilst the model requires that basic systems and processes are in place to ensure credibility and parity with others, it facilitates individual need and aspirations. As such, it is always going to be relevant to any school that wants to work hard to improve their science provision – but in a way that is meaningful for its unique situation.*
> (2015: PSQM Round 8 participant survey)

In their research the project teachers explored aspects of pedagogy. However the context for their pedagogy was teaching and learning in science. Shulman (1986) notes the significance of pedagogic content knowledge, not only for effective teaching but also for how teachers conceptualise their role in the classroom. Science is different in some significant ways from other subjects; science research is different from research in other subjects. To what extent then is research in aspects of science education different from research in other subject contexts? If the subject discipline makes a difference to a teacher and how the teacher's role is operationalised, is it unreasonable to suggest that it may also make a difference to a teacher as researcher and how they go about classroom-based research?

Perhaps the critical question here is whether and how a teacher's involvement in science enquiry, with a strong focus on the nature of scientific evidence, might influence how that teacher perceives classroom-based research and the nature and significance of research evidence. Although all the teachers view themselves as primary teachers rather than teachers of science, they also recognised that expectations and procedures that work well in other subjects do not necessarily translate easily into a science classroom. It may therefore be that they view evidence somewhat differently when they are researching the teaching of science compared to the teaching of other subjects.

There is an interesting parallel here in our research and the PSQM process. As noted above, teachers typically have an instrumental view of PSQM at the start of the programme, but many of them shift to a much more reflective view by the end. We began this project with a relatively instrumental view of how we might devise some kind of national framework to support school-based research. During the project it is clear that some significant questions have arisen through our reflective practice as researchers. Whilst there is insufficient data in this project to answer these questions, they do provide a valuable starting point for more generic research into teacher development, school development and the nature of science education research.

The limitations of this case study include the small number of teachers and the comparatively small amount of data collected. These teachers were selected by Tutor 1 for the pilot project, and a larger, self-selected group of teachers may not make such good progress in school-based research. The two tutors involved have significant expertise in supporting school-based research, but regional hub leaders do not typically share this level of expertise or feel confident to lead research discussions.

Although there are reservations about how this pilot project will scale up to a national framework, the data paint a positive picture and suggest that developing a national framework will be valuable. The main issue is how to organise face-to-face meetings with tutors. All the teachers were highly positive about the impact of tutor intervention through asking questions, offering alternative perspectives and raising possibilities for action. However replicating this on a national scale is expensive, so we need to look for ways to retain the benefits of tutor intervention but minimise the cost.

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