Research Article

Effective Assessment of Professional Development in Primary Science: A Case Study from the Open University, UK – Primary Teachers Learning Science

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The introduction of the national curriculum in science in England and Wales has resulted in a significant change in the emphasis and content of courses which promote professional development for teachers of primary aged children.

Work at the Centre for Science Education (CSE) at the Open University (OU) in England over the past six years has focused on developing courses in partnership with LEA advisory teams, mentored by academic staff at the CSE. These courses are based on distance learning materials which provide additional subject knowledge in science at the level of the teacher and explore ways in which links can be made between subject content and pedagogy.

Teachers for whom these courses are designed are generally experienced primary practitioners but they are likely to have low levels of subject knowledge and confidence in science.

In this paper, the impact on teaching and learning in primary schools of a new course providing professional development in primary science, 'Primary Teachers Learning Science', is considered via its assessment strategy. The assessment aims to reinforce the learning objectives of the course and help participants to acquire and apply appropriate concepts and skills.

What is to be assessed? An outline of the course.
Designing a course which is both accessible, challenging and appropriate to experienced primary teachers requires explicit links to be made between selected content and practice, so that the teachers' investment in time and effort in the course will be professionally relevant.

This was one of Harlen's main thrusts in her research into the development of science in the Primary School (Harlen 1992).

Six Workbooks are provided that focus on different areas of science and its teaching in school and these are linked with BBC broadcasts for teachers and children. The Workbooks are entitled Life: Diversity and Evolution; Materials: Chemical and Physical Changes; Forces and Energy; Electricity: Making Connections; The Planet Earth and Ecosystems. The Course Team advise Local Education Authority (LEA) groups on planning an appropriate in-service training (INSET) programme around the course materials. This programme will vary according to local needs and finances. All students have a tutor who provides support through face to face and distance contacts. Tutorial support is available to assist teachers' preparation and planning for assessment.

The 'Primary Teachers Learning Science' Workbooks take the reader through a learning process of exploring — planning — implementing — reviewing in a reflective learning cycle, based on the Mackinnon cycle (1987). Such a model for learning facilitates a move forward into new learning through the ability to process information gleaned during the course and insights gained with experience to move forward into new learning (Baird et al, 1991). The assessment woven into the course is a key element in establishing whether new learning has occurred and whether teachers have been able to use this new knowledge to make changes to established practice. Two strands of assessment are likely to be particularly revealing in establishing whether this has occurred: personal learning and the associated learning strategies and their impact on practice.

Effective guidance is required for the process of learning and its application to practice and to assist teachers in the production of assessed pieces of work. This is outlined in the opening section of each of the six workbooks and supported by tutors during the course.

Teachers are introduced to the concept of a learning journey which includes developing a model of reflective learning. In this way, teachers are encouraged to become actively involved in the learning process and to document and take responsibility for discovering changes which occur in themselves as they implement their learning.

There are explicit statements on general and subject specific outcomes expected after studying each workbook; performance criteria relevant to each specific outcome are given as is guidance in how to use them to map out an appropriate route through the workbook.

The Learning File

Teachers are asked to compile a learning file (in a ring binder which they receive as part of the course materials) to enable them to keep a record of their learning journey through notes, responses to activities, inclusion of pieces of children's work, results of reflection etc. Since most learning takes place when we are actively processing information (Wood, 1988) the activities and questions in the workbook are designed to assist teachers in achieving their chosen personal learning outcomes for a given area of science and absorbing these into their science teaching and 'practical' theory as described by Handel and Lauvas (1987).

Learning files can be considered as a record or evidence of their work in science. They might be used to contribute to course assignments for the OU's Certificate in Science for Primary Teachers, as the basis for a claim for a vocational qualification, in an application for promotion or a new job, or in staff development within their school.

Assessment strategy

Assessment aims to provide teachers with opportunities to demonstrate the processes involved in the development of science knowledge and skills in the 'real' teaching context. Teachers are required to evaluate their learning in science and apply their learning in their professional capacities.

As already implied, self assessment plays a leading role in evaluating learning. Within the workbooks are embedded activities designed to develop teachers' skills in interaction with concepts and ideas in science and science teaching introduced in the text. 'Core skills activities' develop skills that underpin all learning and are intended to assist evaluation of learning and professional performance using cyclical, reflective learning processes (Tresman and Edwards, 1993). Responses to 'Core skills activities' may contribute in the process of planning and structuring of tutor marked assignments.

Other activities are concerned with exploring specific concepts linked to the subject areas covered in the particular workbook. These are structured to develop knowledge and ideas, reinforce understanding and provide opportunities to practice and apply newly acquired concepts.

The Summative Assessment for the course comprises two assignments and one project. All are included in a Course and Assessment Guide provided to teachers and tutors at the outset of the course. All count towards the final assessment score. They have a dual focus: on personal learning; how the processes of learning science as an adult occur and on professional learning, i.e. how the subject knowledge is used within the context of primary teaching in science.

Tutors are briefed on the course and assessment strategy and are provided with detailed guidance notes for grading assignments. Feedback, through correspondence tuition, is provided to all students.

Assignment marking is monitored by a member of the Course Team or experienced Course Tutor as part of the quality assurance process to check that grading and type and amount of teaching comments are appropriate. Feedback and suggestions are given to tutors through the monitoring process to assist them in their support of students to critically reflect on their learning and its application to their classroom teaching.

The First Strand: personal learning in science

The first strand of the personal learning journey requires teachers to analyse the methods they use to learn science during the early stages of the course.

As part of the first assignment, they examine their progress in acquiring scientific knowledge in one area of science of their choice. They do this by constructing an audit of knowledge and skills after working on the particular section of the course in question. Estimations of progress in science have to be illustrated by evidence (derived from the course) in support of the statements contained in the audit, e.g. responses to related activities in the workbooks. A self-assessment of their competence in teaching this area of science and confidence in supporting colleagues in their learning and teaching of the same is an integral part of the audit.

In an analysis of responses to this first assignment, teachers clearly explained areas of uncertainty in their knowledge and skills at the start of the course. Many had difficulty realising precisely what they did not know until they began study, after confronting areas that were unfamiliar. Many demonstrated improvements in the first 3 months of the course, and there was a readiness to take knowledge beyond that needed in the primary classroom as personal development by some teachers.

Many teachers

- felt confident about knowledge in many science areas up to Key Stage 1 but not beyond
- felt that they lacked confidence in teaching/supporting colleagues and this was due to limited knowledge and understanding in science
- hoped that an increase in knowledge understanding would heighten their own awareness and stimulate interest in science which would
- enable them to feel more confident in supporting colleagues and identify more easily with children learning science.

At this stage, many students had difficulty in providing evidence in support of an evaluation of their current levels of knowledge. In some cases, tutors needed to give guidance on disentangling knowledge and skills when students considered their current levels and priorities for development. Priorities for future development were based on the teachers' science needs but also on the needs

of their schools and there were tensions when these two needs were not the same and where the latter needs were imposed by senior management teams/emphasis of school development plans. Support of the headteacher and colleagues was significant in fostering a positive approach to the course.

The personal learning strand is developed progressively in the second assignment. Students are required to give evidence (e.g. responses to Workbook activities) to show progression in understanding in a given area of science. This may build on priorities given in their previous audits. Teachers are guided to discuss strategies used to develop their ideas in a particular area of science and how they confronted difficult concepts, analysing why these ideas were problematic, and discuss strategies used to overcome them.

In the second assignment, the teachers described a number of ways in which they had worked to develop their knowledge in science and to confront difficult concepts. These included:

- reading and re-reading text,
- discussion with colleagues (found to be particularly useful by many teachers), family, friends and other students on the course,
- performing tasks in the course activities,
- making notes,
- drawing diagrams,
- participating in activities at tutorials,
- constructing concept maps,
- thinking of everyday/familiar i.e. real life examples helps to clarify ideas,
- making own glossary of terms — writing own definitions from memory — more effective than memorising or copying from text book
- 'reading round' — where time permits including visits to museums, lectures, TV and radio programmes as well as other books
- constructing learning timetable helped to provide focus as opposed to 'meandering through the workbooks'
- breaking text up into small chunks i.e. proceed in small steps (perhaps in conjunction with above)

Sometimes it was necessary to leave the task and return to it at a later time because of an initial lack of success. Allowing time to think and reflect on complex ideas was recognised as very important — time needs to be allowed to assimilate information. It was noted that this has interesting implications for the notion of primary aged children remaining 'on task' in order for learning to be effective.

A number of teachers commented that thinking about how they learned helped them to recognise that 'because I tell the children something does not mean that they will be able to accept it for themselves'. Some also commented that they recognised that their own role learning in the past had not led to sound understanding. The teachers became more aware of their own learning strategies, which in turn helped them to recognise the different strategies their pupils adopt. They could more readily identify with the situation of pupils confronted with new concepts. Some teachers also had a heightened awareness of the need to help children to understand how to select what is relevant in their ideas and observations and what to reject. They also highlighted the need to promote interaction between ideas and observations if learning in science is to be supported.

Teachers' evaluations of the learning and development achieved on the course, along with their expectations of the durability of the impact this will have on their practice are further developed in the project. The course takes each teacher on a personal learning journey where each finds their own level and makes progress on an individual basis.

The second strand: teaching science

Here the focus switches to an analysis of approaches to teaching science, requiring a critical evaluation of practice from a variety of perspectives. The balance of tasks and their timing is crucial here, so that they build sequentially, coherently and progressively across a period of a number of months.

The SPACE project constructivist approach (Russell and Watt, 1990) has been a major influence in bringing together ideas about the processes of learning and teaching of science concepts building on what children already know. The main focus of the teaching strand in the first assignment is to enable teachers to find out, and then use, the ideas which children hold about a given concept in science to plan learning objectives and select appropriate activities to help children realise them. In the second assignment these activities are taught and the learning experiences of the children and the contribution of the selected activities to that learning are analysed.

The children's learning is evaluated and appropriate evidence provided to support the analysis. The teaching is evaluated in terms of its appropriateness in terms of realising the original learning objectives identified in the first assignment.

Through 'bridging' questions, explicit links between acquisition of an enhanced personal knowledge in science and impact on practice are explored. A review of professional practice is sought, with supporting evidence, which demonstrates how practice has changed or modified as a result of studying the course.

In the first assignment some teachers experienced difficulty in focusing on a defined concept — the area of knowledge they selected and presented was too broad. This then led to difficulties in defining specific learning objectives for children and providing appropriate activities which were not too ambitious. Providing practical activities does not necessarily mean that learning will take place, and being able to spot when children have

difficulties or misconceptions has implications for the personal knowledge of teachers. Increased knowledge and understanding by the teachers appeared to enable them to intervene more effectively and support pupil learning. Tutor feedback on the assignment encouraged greater precision in stating concepts — breaking down complex ideas into a number of points.

Teachers used a variety of methods for finding out pupils' existing ideas in a science area.

Methods used to find out about children's ideas included:

- concept maps (useful tool for establishing misconceptions but does not give insight into extent or level of understanding)
- open questions (allows children to answer individually, to share ideas but depends on language/listening skills/confidence of children; particularly useful as it does not depend on reading/writing skills
- sorting (useful 'hands-on' method which does not depend on reading/writing skills) on-going diary (time consuming but valuable; children (or teaching on their behalf) recording their own ideas.

Many teachers used a combination of methods eg concept mapping coupled with questions to children individually or in small groups. Methods of recording ideas included:

- taped recording of open questions/dialogues occurring between children as they shared ideas. These proved invaluable for accurately establishing and subsequently analysing children's ideas in order to plan learning objectives. However, it was recognised that these strategies were more difficult to implement in whole class situations — and had significant resource implications.

Many teachers had difficulty selecting methods that were entirely effective in leading to detailed learning objectives for each child in their selected group. Many commented that they had tried concept mapping for the first time, found it worked very well, and would use this method again.

In their second assignment, teachers commented on their increasing confidence in planning and teaching areas of science where they previously had little confidence — or which they had avoided. Teachers acknowledged that they had avoided areas, particularly Forces, because of their lack of knowledge and understanding and correspondingly low levels of confidence in their ability to teach effectively. A wider knowledge of science concepts enabled them to provide a wider spectrum of appropriate activities in the classroom.

Many teachers recognised the beginning of changes in their practice. Notable was finding out children's existing ideas at the start of a topic and to plan the teaching to begin from 'where the pupils are at as opposed to where the teacher thinks they are at'.

The learning processes that the teachers were experiencing and their reflections on learning strategies were beginning to impact on the ways in which they approached science work in the classroom. The emphasis was moving away from 'telling' information and providing very structured activities towards more questioning and probing of children's ideas and this helped to make science more enjoyable!

Teachers noted that children also need time to reflect on what they have done and learned. Often they tried to cover too much in a given time. Increased knowledge in an area of science appears to give the teacher increased confidence to encourage children to articulate where they are still confused, so that the teacher can plan appropriate further work.

The second assignment demonstrated that working on the course had helped teachers broaden their knowledge of science and begin to reconsider their ideas on how to teach it more effectively in the classroom.

The project

The classroom based research project represents a shift in the level of demand to build on previous work and provides a challenge in the context of whole school science. In each case, teachers are required to demonstrate, through evidence, how they have translated their own science knowledge and understanding to inform their practice in the chosen area. Teachers are encouraged to include or make reference where appropriate to work from previous assignments.

A choice of three contexts is provided:

- to write a report of a project to develop a portfolio of assessed and moderated children's work in one area of science for use in school;
- to write a report of a project to plan science in the curriculum over a range of time scales;
- to write a report on the planning, running and evaluation of a science school-based in-service training session.

The evidence to show the range of contributions the project has made to assessing personal and professional development in primary science and the potential for primary teachers to work as researchers in their classrooms, will be considered in a later paper.

Conclusions

Evidence produced in an examination of responses by teachers to the assessment events punctuating the course indicates that this assessment strategy can contribute to a reinforcement of learning objectives by requesting teachers to analyse the extent and nature of their learning journey in science.

A measure of their acquisition of science concepts and skills is provided in the nature of students' responses to questions about personal learning. Some of the ways in which this learning has informed and impacted on practice have been revealed in answers to classroom-focused questions in both tutor marked assignments. There has been a move towards identifying child starting points and planning learning outcomes.

The personal assessment of professional development has revealed increasing confidence in understanding science and transferring the acquired knowledge and skills to the classroom situation through a constructivist approach in teachers' own learning and teaching.

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