Co-teaching as an Approach to Enhance Science Learning and Teaching in Primary Schools

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Abstract

In this article, we explore some of the experiences of student teachers, classroom teachers, science teacher educators, and children in co-teaching contexts in primary schools. The model of co-teaching adopted enabled student teachers (science specialist), classroom teachers, and university tutors to share expertise and work as equals, without mentoring, supervision, or assessment, to affect exciting learning opportunities for the children and for each other. Co-teachers planned, taught, and evaluated lessons together, and were encouraged to experiment with different learning and teaching approaches. The opportunities for all concerned were many. Students experienced an increase in their confidence to teach, and highly valued the more equal relationships they developed with the teachers and university tutors. The tutors also appreciated the improved relationships with students, the increased dialoguing with both students and classroom teachers about science, and the opportunity to reflect more on their own practice. Classroom teachers appreciated the opportunity to reflect in diaries that they kept, and greatly valued their own increased confidence in teaching investigative science. A survey of children carried out 6 months after the student placements evidenced their improved attitudes to school science, and fewer gender differences, compared with non-project children. Co-teaching constraints included the individual concerns of some students and teachers about their respective roles. The opportunities offered by co-teaching arose from processes such as the sharing of expertise, individuals working together with the same objective of enhancing children's science learning, the participation of science teacher educators, and the science workshops that took place in the university. (This paper is a summary, and update, of Murphy, Beggs, Carlisle, & Greenwood, 2004)

Introduction

A few years ago, the principal of a local primary school invited us (the two authors) to come and discuss ways in which the school could improve science learning and teaching. We asked her what she thought she most needed. "I need your science student teachers, who could work alongside our teachers in class, I need some of the college resources, and I need you guys to provide practical workshops for our teachers in science areas they find difficult."

So began our first venture into co-teaching. We set about putting together a proposal for funding to see whether implementing the principal's request would work in a group of 20 schools. Could co-teaching by science student teachers and more experienced classroom teachers result in an enhanced science learning and teaching experience for children, student teachers, classroom teachers, and science teacher educators?

In our case, co-teaching involves 2 or more teachers who plan and teach lessons, and who subsequently evaluate their teaching together. The aim is to provide the most effective and enjoyable learning experiences for the children, whilst at the same time, to learn from each other and improve their own practice. When teachers begin working together, and share the full responsibility for planning, teaching, and reflecting on lessons, there is "automatically a greater range of action possibilities" and collective activity enables each individual to develop since "any individual can now enact teaching practices not available in individual teaching" (Roth and Tobin, 2005, p. x).

Some of the main challenges in primary science teaching include the low levels of confidence of many primary teachers to teach aspects of the science curriculum, teaching inquiry-based science, maintaining pupil interest in school science, and the difficulty of some science content.

The Context: Challenges for Teaching Primary Science

There is much evidence from research and government reports worldwide that highlights the problem of primary school teachers' lack of confidence in science and technology teaching. Many elementary teachers lose their confidence during their first year in the classroom (Soodak & Podell, 1997), and many primary teachers also lack confidence in their ability to teach science and technology (Harlen, Holroyd, & Byrne, 1995). A third of the teachers in the latter study identified their own lack of background knowledge as a source of their problems.

The main problems in preparing teachers for science in primary schools arise from the situation that the majority of student teachers are not science specialists. There is an urgent need for such individuals to become confident and effective science teachers. Many have an inordinate level of fear for dealing with difficult science questions from children, such as "how does the sun stay hot?" or "what is electricity?" New teachers are also anxious about conducting science investigations with children due to time and resource management, as well as explaining anomalous results. Reports from the United States (Fulp, 2002; Weiss, Pasley, Smith, Baniflower, & Heck, 2003) and the United Kingdom (Department of Education for Northern Ireland, 2002) have highlighted inadequacies in the preparation of teachers of science for primary schools. Some of our own work showed that even third-level student teachers, including those who experienced compulsory school science during the ages of 11 to 16 years and some with post-16 science qualifications, could not correctly answer questions on some primary science tests that had been written for 11-year-olds (Murphy, Beggs, Hickey, O'Meara, & Sweeney, 2001). These problems, when taken together with the emphasis of national tests on content knowledge, may have contributed to science frequently being taught as facts, or as a body of knowledge, in the final 2 years of primary school. Teachers feel the need to prepare children for the tests by ensuring that they can recall the required content knowledge. Attention to constructivist theories of learning science and to scientific enquiry has diminished by this stage. The UK Office for Standards in Education (OFSTED) reported that some teachers' understanding of particular areas of science, especially the physical sciences, "is not sufficiently well developed and this gives rise to unevenness of standards, particularly in Years 5 and 6 [9- to 11-year-olds]" (OFSTED, 1995, pp. 6-7). The Office further reported that in the upper years of Key Stage 2 (which represents 9- to 11-year-old children), "shortcomings in teachers' understanding of science are evident in the incorrect use of scientific terminology and an overemphasis on the acquisition of knowledge at the expense of conceptual development" (p. 10).

Maintaining pupils' interest in school science as they get older is another challenge for primary teachers. Most researchers agree that the erosion in pupils' interest in school science occurs between the ages of 9 and 14 years (e.g., Hadden & Johnstone, 1983; Schibeci, 1984), even though they retain positive attitudes towards science generally and acknowledge its importance in everyday life. The problem of declining interest in school science is international and many reasons have been put forward to explain it, including the transition between primary and post-primary schooling, the content-driven nature of the science curriculum, the perceived difficulty of school science, and ineffective science teaching, as well as home-related and social-related factors. We carried out an extensive survey of primary children's attitudes to science and found that most of the older pupils (10- to 11-year-olds) had significantly less positive attitudes than younger ones (8- to 9-year-olds) towards science enjoyment, even though the older pupils were

more confident about their ability to do science. The effect of age on pupils' attitudes was far more significant than that of gender. Girls, however, were more positive about their enjoyment of science and were a lot more enthusiastic about how their science lessons impacted upon their environmental awareness and how they kept healthy. There were also a few significant differences in the topics liked by girls and boys. Girls generally favored topics in the life sciences and boys preferred some of the physical science topics (Murphy & Beggs, 2003).

A third challenge for primary science teachers is the curriculum. The contemporary science curricula in the US were considered "overstuffed and undernourished" (Nelson, 1998, p. 4). A prescriptive set of specific learning goals (benchmarks) from K–12 was recommended in *Benchmarks for Science Literacy* (American Association for the Advancement of Science [AAAS], 1993), which suggested reasonable progress towards the adult literacy goals laid out in a sister report *Science for All Americans* (AAAS, 1990). In the UK, it has also been recognized that there is still an over-emphasis on content in the school science curriculum. Much of this content is isolated from the contexts that could provide relevance and meaning. Further problems include the lack of an agreed model for the development of pupils' scientific capability from the age of 5 years upwards and the fact that assessment in science is geared towards success in formal examinations (Reiss, Millar, & Osborne, 1999). A 2-year study, *Beyond 2000* (Nuffield Foundation, 1998), has made 10 recommendations regarding the implementation of the Science National Curriculum in England and Wales. Essentially, it suggests that the curriculum should be redesigned to enhance general scientific literacy as opposed to the current curriculum that is geared towards the small proportion of pupils who will become scientists.

Co-teaching Science in Northern Ireland Primary Schools

The work we discuss in this paper was carried out in the full range of primary schools in Northern Ireland, many of which are very small rural schools (less than 100 pupils) whilst others are large urban schools with up to 1200 children enrolled. The student teachers involved in the co-teaching are preparing to become primary school teachers via completion of the Bachelor of Education (BEd) degree. All BEd student teachers study a specialist subject to degree level, in addition to Education Studies and Curriculum Studies. Co-teaching is an element of preparing science specialist student teachers for teaching. The science teacher educators and research associate worked closely with student teachers and schools to enhance the opportunities afforded by co-teaching science. The co-teaching was undertaken by third- and fourth-year science BEd students for one half a day each week, for a 10-week period, in the first semester (part of the science methods course) and during their school placements in the second semester. Co-teaching took place in primary classes 1 to 7, involving children between the ages of 4 and 11.

To enable co-teaching to work most effectively, we devised a model that would promote equal roles for student teachers and teachers and more effective learning and teaching of science for all participants. Equal roles were promoted by means of shared responsibility for, as opposed to sharing of, all tasks. However, student teachers and teachers planned, taught, and evaluated all lessons together. More effective science learning by pupils was addressed by freeing student teachers from mentoring, supervision, or assessment of their work and encouraging them to concentrate on experimenting with a wide variety of teaching approaches as they concentrated the co-teaching on science investigations. Student teachers' and teachers' own learning was brought about via the sharing of science and classroom expertise, and by the completion of reflective diaries during the co-teaching placements.

Co-teaching in Practice

This section outlines some of the lessons, showing what co-teaching looks and feels like. We illustrate, using transcripts of classroom discourse, the different roles between student teachers and the more experienced classroom teachers. (Names of schools, teachers, student teachers, and children have been changed.)

The following extract from the observation notes of the research fellow, Karen, reveals the complexity of the co-teaching context. As with all teaching situations, there is a host of factors external to learning and teaching that are going to have a huge impact on what goes on in the classroom. In this case, we are looking at a student teacher's first co-teaching session, but the regular classroom teacher is absent for the lesson and there is a substitute teacher in her place. At the moment when the field notes begin, the class is very boisterous and the room is cramped. This primary school is situated in South Belfast. It is average in size (just over 400 children on the roll) with two Primary 5 (P5) classes (pupils aged 8 & 9 years) participating in the project.

> We are in a P5 class taught by Susan (substitute teacher) and Emma (student teacher). The science lesson had just started and Emma was giving an introduction to the senses and the sense of taste. The children were sitting at their desks and the teacher, who was substituting (class teacher was off sick), was sitting at the front of the class. The children seemed quite restless and had to be subdued by the student teacher/teacher/classroom assistant throughout the lesson. I later found out that this class was known to be a "difficult" one.
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> The student teacher put up a picture of a mouth with the tongue sticking out (home-made--very good and colourful) and began describing the sense of taste and taste buds. The children were able to remember scientific terms that their teacher had used in previous weeks. Emma talked about different tastes and how different parts of the tongue can taste sweet, salty, sour and bitter. She asked one child from the class to put 'taste buds' on the tongue to show the different parts of the tongue that taste sweet, etc.
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> After the introduction, Emma began explaining the investigation. The children would be given a plate of food and they had to taste the food and decide whether it was salty, sweet, sour, or bitter. They also had to try and identify the food. Before beginning the investigation they were encouraged to predict what each food would taste like. The children were very boisterous and the instructions had to be repeated a number of times to make sure the children understood what they were to do. The children worked in groups (each table of 4-5 was a group) and 1 person from each group was responsible for collecting the materials for the investigation. The teacher, student teacher, and classroom assistant were all working together, making sure the children knew what they were doing and didn't misbehave. The children seemed to enjoy tasting the food and trying to guess what it was.
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> The teacher was very interested in the project. She supported the student teacher in discipline matters and helped out during questioning and throughout the investigation. She admitted that she was coping very well with the class considering how difficult they were.
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> Emma was very nervous, as it was her first day and she did have problems with discipline, however she did have the support of the other adults in the room, which

made things a little easier. She was very well organized and had good visual aids, the plates for the taste investigation were all set up, and she also provided worksheets for the children to record their findings. The children mostly were attentive, although there were a few who had to be repeatedly asked to keep quiet (by all adults).

The classroom is very cramped, over 25 children in the small classroom. I think Emma has her work cut out for her. Generally, the class responds well to her, but there are a few who may cause problems. There was no one person who was dominant when Emma was introducing the lesson. The teacher was observing and making comments where necessary.

On my second visit to this school, I brought my camera to take some stills of the lessons. The school secretary has a child in one of the P5 classes taking part and informed me that every Tuesday her child comes home raving on about science and how much they are enjoying the investigations (very encouraging!!).

On my first visit to this class the teacher was off sick. However, today she was there, along with the classroom assistant and Julian (science teacher educator). The student teacher was explaining the investigation at the front of the class, the classroom assistant was sitting with the children (who were at their desks), and the teacher was walking around the room, preparing for the investigation. The children were much better behaved this time. The teacher had informed them they would have some visitors today, so I think that had something to do with it!

Emma began the lesson with an introduction to the investigation, which she had written on the board as a mission: "Keep u Dry is a leading umbrella manufacturer in Northern Ireland, and due to recent weather conditions they are having to make hundreds more umbrellas. They have asked you to decide what material they should make these umbrellas from! Remember, they must keep the customers dry and be long-lasting!"

The children were then given out a number of plastic cups and different materials to test: plastic, kitchen towel, cotton, cloth, and newspaper. Each group had to pour some water on the materials that were placed over the top of the plastic cup and secured using an elastic band. They then had to decide how quickly the water passed through the material. Before starting the investigation, they had to make a prediction on which material they thought would be most waterproof.

As the children worked, the teacher and student teacher walked around the groups, helping and answering any questions they had. Julian also helped out. The children, through the investigation and prompting by the teacher and student teacher, were able to determine which material was the most waterproof. The student teacher finished up the lesson by asking the children to report on their findings and decide which material would be the most suitable for making umbrellas.

The teacher was pleased with her student teacher and felt that, although she had a very rowdy class, she was doing well and getting the children interested in science. She commented that she couldn't really approach some of the investigations on her own and appreciated that she had been able to try different things. Throughout the lesson, she worked with small groups of children and took on some of the discipline. She let the student teacher lead the lesson.

> The student teacher was more at ease today, and I felt her confidence with the children had grown from the first week. She knew all their names and was more assertive when they got boisterous. She took a good lesson, very simple idea but effective.

In this next extract from Karen's field notes, also describing a student teacher in her first co-teaching session, we see an entirely different scenario. The school is well-resourced for science teaching. There is even a dedicated science room. The teacher is a more experienced science co-teacher, having worked with a different student teacher the previous year.

> We are in P6 (ages 9 & 10 years) class. Sinead is the teacher and Ciara is the student teacher. The science lesson is taking place in a specially-designated science room; this room is only used for science and has been laid out specifically for investigations. There are a lot of displays on the walls, most of the equipment and furniture is new, and it is a very bright, welcoming room. The children are sitting in groups at their desks. The student teacher and the teacher are sharing the lead in the lesson, the student teacher gives a brief introduction and the teacher fills out what she has said. The class is very noisy but the chat is mostly about the investigation.
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> The topic of the investigation is Materials, and whether they are transparent, opaque, or translucent. The student teacher and teacher describe the words and refer to previous work they have done to ensure they understand the terms. The children are given a number of materials, a piece of card, and a torch, and with minimal instructions they have to find out whether the materials are transparent, translucent, or opaque. The children work in groups at their desks; the teacher and student teacher work with the groups. The children are very engaged in the investigation and this is reflected in the noise level!! The teacher tells the class to quieten down a number of times; the student teacher doesn't deal with any discipline issues. After the investigation, individual children come to the front of the class to report their findings to the rest of the class. During this, the teacher and student teacher ask them questions about the investigation to check their understanding.
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> The teacher had taken part in the project last year, and I have noticed how much more confident she is. She is participating more, using more scientific language, and in some cases more able than the student teacher to explore the children's ideas regarding the investigation. The teacher is fairly at ease with the student teacher and they have had some opportunity to plan the lessons. This year, there is a more equal partnership between the teacher and her student teacher.
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> The student teacher, whilst having a fair amount of scientific knowledge, lacks confidence when trying to control the class. This is almost entirely left to the teacher. She leads the introduction, but allows the teacher to follow through any areas that she hasn't covered. It works well, as both have a different viewpoint. Throughout the group work, the student teacher walks around the groups, talking ideas through with the children.
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> Overall, this team works well, the teacher is more dominant, mainly because of her increased confidence, although when I pointed this out to her, she said she wasn't aware of it. The children are very keen; this may be due to the culture in the school and the promotion of science. The teacher pointed out that in the practice transfer test, the children (even the weaker ones) scored well in science.

As the student teachers and teachers progressed with co-teaching, we noticed that they effortlessly seemed to work together in many different ways.

Children's Enjoyment and Learning

We carried out a survey of children's enjoyment of science about 6 months after the placement. We were interested to see if the co-teaching had a long-term effect, and if the teachers' reported increase in confidence in investigative science teaching translated into a more enjoyable experience of science for the children. We compared children who had been co-taught science investigations with those who had been taught science more traditionally.

We found that the children who had been co-taught were significantly more positive than other children about their science lessons. The chart of Figure 1 represents the percentage of children in each group who agreed with the statements (a) science lessons are fun, (b) solving science problems is enjoyable, and (c) I look forward to science lessons.

The fact that the survey was carried out 6 months after the placement indicates that the student teacher involvement appears to have positively influenced the science experience of the children in the longer-term. Many children commented in the free response section of the questionnaire on their enjoyment of science lessons when the student teachers were in the schools; for example, "I liked it when we were doing dissolving" and "it was good fun making circuits."

Comments from the teacher journals also reflected children's enjoyment of the experience. One said, for instance: "I feel that the children really enjoyed the practical experimenting and testing. I think they have learned from their experiences and I enjoyed watching them progress."

Student teachers also highlighted children's enjoyment of the experience in their journals. When reflecting on children's enjoyment of their learning, most student teachers linked this with their progress. As one student teacher said: "They loved the practicals, it added to their enjoyment . . . they listen more and take more in. We tested them through questioning at the end--they all seemed to take it in a lot better than previous classes I have taught who haven't had as much practical work."

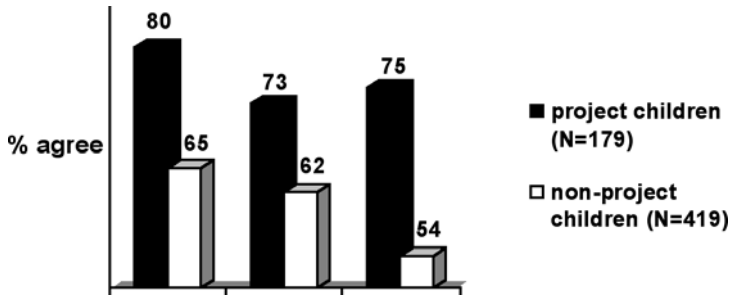

Figure 1. Prevalence of children agreeing with the statements (from left to right): (a) science lessons are fun; (b) solving science problems is enjoyable, and (c) I look forward to science lessons.

There were also fewer differences between girls' and boys' preferences for different science topics in the classes that had been involved in the co-teaching project. Project children also showed much less of a decline in enjoyment of science in the more senior primary classes (9- to

11-year-olds) than those who had not been involved (Murphy, Beggs, Carlisle, & Greenwood, 2004). This was exemplified by a teacher's comments during his interview:

> In P6 [9- and 10-year-olds], the investigation side takes a back seat because of the transfer [a high-stakes test which is taken by those pupils who wish to attend grammar schools in Northern Ireland, and which is being abolished in 2008]. I would not have done as much investigations without being part of this project, so it was great that way. When [the pupils] did the experiments and saw with their own eyes what happened--that was great!

In their journals and interviews, teachers commented about the children's learning: "They learned about the skill of predicting, and that predictions don't always have to be correct" and "when I tested the kids I couldn't believe how much they'd picked up from her, even the weakest of the children knew what she'd been doing."

We asked student teachers and teachers to prioritise another aspect of children's learning--that of encouraging children to talk science. The following extract is from a 9-year-old girl, Sarah, who is talking about the water cycle to the whole class, prompted by the student teacher, Aisling. Sarah has a large diagram of the water cycle on a flip chart and her "talk" is aided by constant reference to the picture.

Sarah:	The sun heats up the river.
Aisling:	Good girl!
Sarah:	And it goes up. [Sarah moves her hand from the river up towards the clouds.]
Aisling:	What goes up?
Sarah:	The steam.
Aisling:	Or the _?
Sarah:	Water vapour. Water vapour goes up into the sky and it gets colder and colder and forms clouds.
Aisling:	Why? What happens to the water vapour? Why does it form clouds?
Sarah:	Because the sky is cold.
Aisling:	Yes, so what happens when it gets colder? What does the water vapour do? It goes into.
Sarah:	The clouds.
Aisling:	And then they join together, don't they?
Sarah:	Yes, and the clouds grow bigger and bigger and when it gets too heavy it goes down and forms rain and then it goes back down into the oceans and rivers and it goes again and again. [As she says the last phrase, Sarah draws an imaginary circle from the river to the sky, clouds, rain, and back to the sky several times to demonstrate the cycling of the water.]
Aisling:	That's brilliant! I think we should give Sarah a clap. Excellent!

Sarah's description of the water cycle commences with short answers to the student teacher's questions. After plenty of encouragement, she launches into her description of clouds forming rain, the rain moving back down to sea level, and its evaporation from rivers and oceans to start the process again. The attention of the rest of the children was intense; they were hearing the water cycle described by one of their peers in words and phrases with which they were familiar. Their clapping at the end of Sarah's short presentation was really enthusiastic!

These findings imply that the work carried out by children in science lessons which involved a science student teacher co-teaching with the classroom teacher--with both clearly focusing on investigative science--was more enjoyable for pupils and enhanced their science knowledge and skills.

Conclusion

In this short paper, we have described some of our work on co-teaching science in primary schools. For further details, please see Murphy and Beggs (2005). The potential benefits for all participants are immense, and we have been able to provide substantial evidence of this. We feel strongly that, whilst we have been discussing and analyzing the co-teaching of science in primary schools, that co-teaching provides the way forward for pre-service education in all subject areas, both primary and secondary. Last year, we extended our work to include a virtual learning environment that could be used by all teachers and student teachers on the project. The virtual learning environment enabled participants to communicate "live," or asynchronously, despite being in schools that were, in some cases, over 160 km apart. We moderated the student teacher conversations on the virtual learning environment and advised them, if they wished for privacy in any of their conversations, to use e-mail. A snippet between two student teachers, which we picked up recently, reinforced our belief of the potential of co-teaching beyond science in primary schools:

> I'm doing Sound for my tutor's visit for science--gonna split the class in half, half make an instrument and the others investigate vibrations with tuning fork, drums, rice, etc. The height of originality! Any other ideas?
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> Can't help on the ideas really, but that sounds grand. Sure it's all in the way you teach it--which will be class. We are taking the co-teaching to the extreme and doing everything together, it's good, it works well. That's all, hope you all get on well.

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