



Getting Practical

# Getting Practical: Improving Practical Work in Science

A report on the achievements of the programme 2009–2011



## Discover...

## Inspire...



## Explore...



## FOREWORD



**Practical work is an essential feature of good science teaching.** The aim of science is to find explanations that are supported by evidence for the events and phenomena of the natural world. So teaching science involves 'showing' students things, or putting them into situations where they can see things for themselves. Simply 'telling' them is unlikely to work. Practical work also gives students a sense of what is distinctive about science as a 'way of knowing' about the world.

There is, however, much evidence from research that practical work often does not lead to effective learning—and is also less than motivating for many students. We need to improve the effectiveness of practical activities. This is what the *Getting Practical: Improving Practical Work in Science (Getting Practical)* programme has been all about. It has not set out to develop a collection of new 'effective practicals' that come with success guaranteed. These do not exist. Instead it has encouraged teachers to reflect on the learning objectives of the practical activities they currently use or are thinking of using—to analyse the kinds of thinking these require of students, and think about how the activity is designed, and how they will 'stage' it within a lesson sequence. A key aim has been to try to make practicals 'minds on' as well as 'hands on'—so that students understand why they are carrying out the practical activity, and are thinking about what they are doing and finding out as they do it.

One short professional development programme cannot transform practice in a matter of months. However the evaluation of the Getting Practical programme has shown how systematic reflection on practice, focusing on aspects of the design of practical activities that research suggests are critical to effectiveness, can stimulate significant changes in practice. The challenge now is to build on this, by supporting more teachers in systematic reflection on their current practice, and building up a professional community of science teachers who reflect critically on their practices and evaluate the impact of changes and new developments. We need to ensure that improvements are not local and short lived, but widespread and sustained. Getting Practical has provided a model on which to build.

A handwritten signature in blue ink that reads "Robin Millar". The signature is written in a cursive style and is positioned above a horizontal blue line.

*Robin Millar*  
*Salters' Professor of Science Education*  
*University of York*

## INTRODUCTION

### GETTING PRACTICAL: IMPROVING PRACTICAL WORK IN SCIENCE

Following the SCORE report in 2008 titled 'Practical Work in Science', the Department for Children, Schools and Families (DCSF) funded a 2-year programme of professional development for teachers of science to improve the way in which practical work in science was being taught in schools.

A consortium of partners, led by the Association for Science Education (ASE) created a package of continuing professional development (CPD) materials for this purpose. The development of this package was informed by the mapping exercise carried out by the Centre for Science Education (CSE) and was put together by experts from the National Science Learning Centre, regional Science Learning Centres (SLCs), CLEAPSS, the University of York, the National Strategies, ASE and CSE.

The course materials were designed to help teachers reflect on and improve the:

- Clarity of the learning outcomes associated with practical work
- Effectiveness and impact of the practical work
- Sustainability of this approach within their schools, allowing for ongoing improvements
- Quality rather than quantity of practical work used.

The Getting Practical programme aimed to train 2000 teachers from both primary and secondary phases working with a

team of 200 Getting Practical trainers over two years. A cascade model was used to deliver the training with the 200 trainers attending Train the Trainer events at their regional SLCs during the autumn terms of 2009 and 2010. These Getting Practical trainers then ran professional development courses in their local area.

The six-hour course could be delivered through three models; a whole day course, two half day courses or three twilight sessions with trainers choosing the model or models to best suit the teachers in their area.

Teachers at all stages of their careers engaged with the programme, with entire departments attending some courses. Technicians and teaching assistants were also encouraged to attend in order to improve the support they can offer teachers in delivering practical work. The CPD has also been adapted for use with trainee teachers.

The feedback from those that have attended the courses has been positive with many teachers appreciating the opportunity to reflect upon their own teaching and look for ways to improve it for the benefit of the young people they teach.

#### Quotes from feedback:

- 'I feel more confident in delivering practical work'
- 'I am leaving this course with a clearer purpose when it comes to the role of practicals in focusing students' learning'
- 'Very good CPD and I can see quite a few 'light-bulb' moments by teachers in the outreach sessions'
- 'I really enjoyed the hands on approach as I was able to see the students' point of view...it has made me evaluate my use of practicals'

By March 31st 2011, 900 secondary teachers and 700 primary teachers had taken part in the training offered by the programme. In addition to this, over 600 teachers have engaged with the programme through taster sessions, workshops and teacher training courses. By the end of July 2011, we will have exceeded our target of training 2000 teachers.

There is no doubt that the key messages of the programme are essential for any teacher of practical work in science to understand and grasp. In recognition of this, many of the Getting Practical consortium partners are embedding parts of the training course into their own CPD courses to ensure the legacy of the programme continues.

## Getting Practical partners

### Coordinating partners



### Contributing partners



### Supported by



Independent  
evaluators





## GETTING PRACTICAL: IMPROVING PRACTICAL WORK IN SCIENCE

### Management team

Director – Marianne Cutler, Association for Science Education (ASE)

Deputy Director and Strand Manager for Communications – Phil Bunyan, CLEAPSS

Strand Manager for Professional Development – Miranda Stephenson, National Science Learning Centre (NSLC)

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Programme Manager: Communications – Georgina Chapman

Programme Administrator (from March 2010) – Helen Smith

Programme Administrator (until March 2010) – Jane Legate

### Advisory Group

Derek Bell – The Wellcome Trust

Phil Bunyan – CLEAPSS

Marianne Cutler – ASE

Justin Dillon – King's College, London

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Julian Huppert – MP (from May 2010)

Steve Jones – University College London

Amanda Middleton – Royal Society of Chemistry (RSC)

Fiona Miller – Science Community Representing Education (SCORE)

Richard Needham – NSLC / ASE

Ian Richardson – Her Majesty's Inspectors of Schools (HMI)

Annette Smith – ASE

Phil Willis – MP (until May 2010)

# Independent Evaluation Report

## Getting Practical: Improving Practical Work in Science

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## EXECUTIVE SUMMARY

The main findings to have emerged from this evaluation are that:

- 1 The Getting Practical: Improving Practical Work in Science programme (Getting Practical) can, and did, bring about substantial change in both the use and effectiveness of practical work.
- 2 The extent of this change and improved effectiveness was seen to depend on who undertook the training, e.g. whether they were a head of department or an NQT, and the extent to which the school's senior management team was supportive and keen to implement the ideas.
- 3 The impact of the Getting Practical programme amongst primary teachers was, compared to their secondary colleagues, less noticeable. This was *not* because of any failure on the part of primary teachers to engage with the Getting Practical programme but because, in almost every case that was observed, much of their pre-training practice already embodied many of the good characteristics that the Getting Practical programme was designed to inculcate.

The principal implications of these findings are that:

- 1 A relatively short six hour training programme is sufficient to raise teachers' awareness of the Getting Practical 'message'.
- 2 If the Getting Practical training programme is to be more effective in bringing about a lasting change of teaching practice then those undertaking the initial training should be senior members of a science department and they should have the active support of the school's senior management team.

## ABSTRACT

This report, based on a study of thirty English schools, provides a summative evaluation of the Getting Practical: Improving Practical Work in Science (Getting Practical) programme. The findings of this study suggest that the programme can, and in some cases did, bring about notable improvements in the effectiveness of practical work. However, it also found that the extent to which this was achieved depended, to a large extent, on the departmental seniority of the person who received the training and the extent to which the training, the cascade of information within the school and its implementation within the department and/or by other teachers in the school were actively supported by senior members of the school management team. What also emerged was a noticeable difference between the way in which primary and secondary school teachers structure and use practical work. As a result, the Getting Practical programme had a much less noticeable effect on the way primary teachers taught science since much of what Getting Practical set out to achieve was already taking place in primary science lessons.



**Students themselves claim to find practical work a useful and enjoyable way to learn about science when compared with other forms of teaching.**

## INTRODUCTION

The frequent and widespread use of practical work—activities in which the students manipulate and observe real objects and materials—in many countries (Bennett, 2003; Millar, 2004) is one of the features of science education that sets it apart from almost all other school subjects. In countries such as England, where there is a tradition of practical work in school science, it is often seen by teachers and others as being a central part of the appeal and effectiveness of science education. Indeed, The House of Commons Science and Technology Committee (2002) suggested that:

... practical work, including fieldwork, is a vital part of science education. It helps students to develop their understanding of science, appreciate that science is based on evidence and acquire hands-on skills that are essential if students are to progress in science. (para. 40)

Likewise, in their major review of learning and teaching in the science laboratory, Lunetta *et al.* (2007) concluded that:

Much more must be done to assist teachers in engaging their students in school science laboratory experiences in ways that optimize the potential of laboratory activities as a unique and crucial medium that promotes the learning of science concepts and procedures, the nature of science, and other important goals in science education (p. 433).

One conclusion from our research is that, perhaps surprisingly, it was the primary teachers of science who did a better job of helping learners to learn science concepts, simply because of the way they facilitated learners' discussion and thinking about what they were doing in their practical activities.

Importantly, students themselves claim to find practical work a useful and enjoyable

way to learn about science when compared with other forms of teaching and learning about the subject (Cerini, Murray & Reiss, 2003). Yet, despite the views of students, and the common perception amongst teachers that the use of practical work can motivate students (Wellington, 2005), questions have been raised by some science educators about its effectiveness. Wellington (1998), for example, suggests that it is "time for a reappraisal" (p. 3) of the role of practical work in the teaching and learning of science whilst Osborne (1993) suggests a range of possible alternatives to practical work. In what is now an oft-cited quote Hodson (1991) goes so far as to claim that:

As practised in many schools it [practical work] is ill-conceived, confused and unproductive. For many children, what goes on in the laboratory contributes little to their learning of science. (p. 176)

This study sought to evaluate the impact of Getting Practical on the way in which practical work is taught as a means of enhancing knowledge and understanding, either of the material world or of the processes and practices of scientific enquiry. The term 'practical work', rather than 'laboratory work' or 'experiments', is used to describe the kind of lesson activity we were interested in because, although many practical lessons take place in purpose-built laboratories (White, 1988), the type of activity on which we focused related primarily to the things learners did and not where they did them. Similarly, an 'experiment' is often seen as an intervention in the material world designed specifically to test a prediction derived from either a theory or hypothesis which, in our experience, is not the way many school science practical tasks are structured.



## A FRAMEWORK FOR CONSIDERING THE EFFECTIVENESS OF PRACTICAL WORK

Practical work encompasses a broad range of activities that can have widely differing aims and objectives (Lunetta & Tamir, 1979). As such, the effectiveness of *specific* practical tasks, rather than the effectiveness of practical work in general, is what needs to be considered. The analytical framework used here is based upon a model of the processes involved in designing and evaluating a practical task (Figure 1) proposed by Millar *et al.* (1999).

Given that this model aims to consider the effectiveness of a specific task *relative* to the aims and intentions of the teacher, the starting point (Box A) is an evaluation of

the teacher's learning objectives in terms of what it is they want the students to learn. Having decided what it is that they want the learners to learn the next step (Box B) is for the teacher to design or choose a specific practical task that they believe has the potential to enable the learners to achieve the desired learning objectives. However, because the learners might not do exactly as was intended by the teacher when they designed the task the next step (Box C) considers what it is that the learners actually do as they undertake the task. There are various reasons as to why and to what extent what the learners actually do might differ from what was intended by the teacher. For example, the learners might not understand the instructions or, even when they do and adhere to them meticulously, faulty apparatus could prevent them from doing what was intended by the teacher. Alternatively, even if the task is carried out as

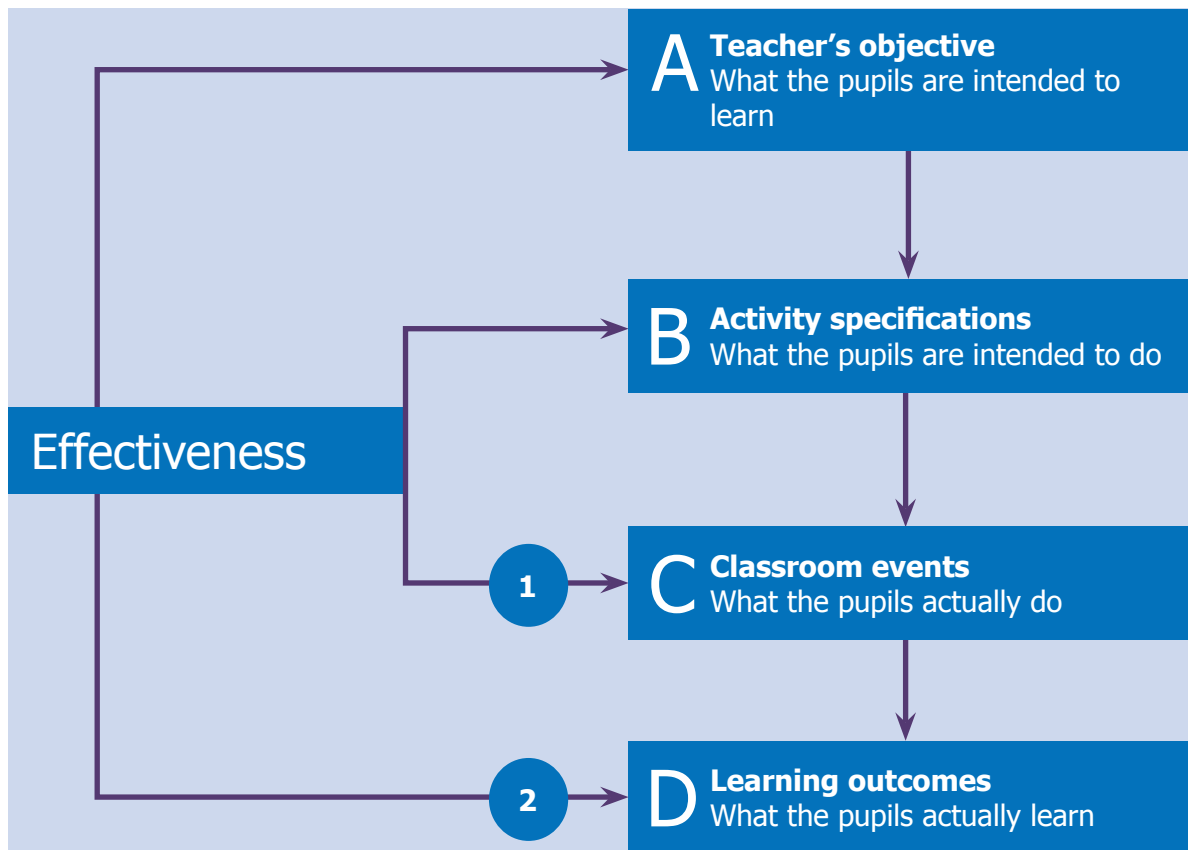


Figure 1. Model of the process of design and evaluation of a practical task

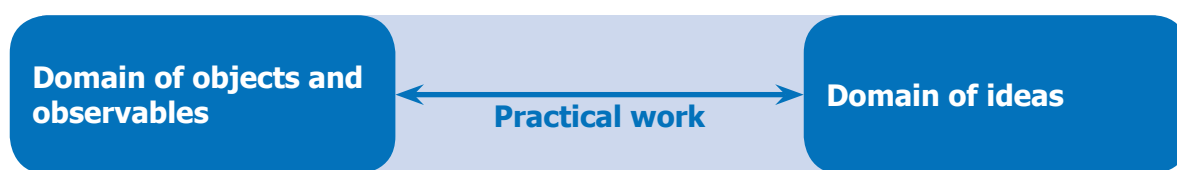


Figure 2. Practical work: linking two domains (from Tiberghien, 2000)

the teacher intends and all of the apparatus functions as intended, the learners still might not engage mentally with the task using the ideas that the teacher had intended them to use. The final stage of the model (Box D) is thus concerned with what the learners learn as a consequence of undertaking the task. This model therefore distinguishes two senses of 'effectiveness'. We can consider the match between what the teacher *intended* learners to *do* and what they *actually do* (the effectiveness of the task at Level 1), and the match between what the teacher *intended* the learners to *learn* and what they *actually learn* (the effectiveness of the task at Level 2). 'Level 1 effectiveness' is therefore concerned with the relationship between Boxes B and C in Figure 1, while 'Level 2 effectiveness' is concerned with the relationship between Boxes A and D.

In the discussion above we have alluded to a further dimension—the kind of action (physical or mental)—and hence learning, involved. Yet learning about scientific ideas, as Millar (2004) suggests:

... is not discovery or construction of something new and unknown; rather it is making what others already know your own. (p. 6)

From this perspective the role of practical work is to help learners develop a link (Figure 2) between what Tiberghien (2000) refers to as two 'domains' of knowledge: the domain of observables and the domain of ideas.

Yet although practical work in the laboratory offers important opportunities to link science concepts and theories with

observations of phenomena (Hofstein & Lunetta, 2004) for this to be successful it is necessary for learners to have access to *both* and, in order for this to occur, learners must be helped not only to observe what the teacher wants them to observe but, equally importantly, to think about their observations in a particular way (Gunstone, 1991). In such tasks learners are likely to require assistance to use or develop the ideas that make sense of the activity and lead to learning. Tasks that are more effective will, we suggest, have this kind of 'scaffolding' built into their design.

Whilst some school science practical tasks deal only, or mainly, with the domain of observables, others involve both domains. Combining the two-level model of effectiveness with this two-domain model of knowledge leads to the analytical framework presented in Table 1 for considering the effectiveness of a given practical task. This framework can apply equally to practical tasks in which the focus is on learners' learning of substantive scientific knowledge or on learning about some aspect of scientific enquiry procedures.

The four cells of Table 1 are not independent as it seems that within each of the two domains effectiveness at Level 2 requires

**We can consider the match between what the teacher intended learners to do and what they actually do, and the match between what the teacher intended the learners to learn and what they actually learn.**

Intended outcomes	in the domain of observables (Domain o)	in the domain of ideas (Domain i)
at level 1 (what learners do)	Set up the equipment and operate it in such a manner as to undertake what the teacher intended.	Think about the task using the ideas intended by the teacher.
at level 2 (what learners learn)	To set up and operate similar equipment. Discover patterns within their observations/data.	To understand their observations/data by being able to link them, using the ideas intended by the teacher, with the correct scientific theory.

Table 1. A 2x2 effectiveness matrix for practical work

effectiveness at Level 1. It also appears unlikely that a task could be effective at Level 2:i unless it was also effective at Level 1:i, and, most likely, also at Level 1:o. Likewise, effectiveness at Level 2:o is of more value to the teacher if the task is effective at Level 1:o and, as such, the observations that the learners recall are the ones that the teacher wanted them to make. These interdependencies withstanding, this framework provides a useful means of analysing examples of practical work in school science.

It should be pointed out that in *all* the lessons we observed there was almost no discussion of specific points about scientific enquiry in general, nor almost any examples of use by the teacher of learners' data to draw out general points about the collection, analysis, and interpretation of empirical data despite there being, in some of those lessons, clear opportunities to do so. In the discussion below the focus is therefore essentially on the use of practical work to develop learners' understanding of substantive science ideas—not because the framework used in this evaluation excluded other aspects of learning, but because this reflects what we actually observed.



## RESEARCH STRATEGY AND METHODS

Whilst there have been previous large-scale questionnaire-based studies of practical work in English and Welsh secondary schools (Kerr, 1964; Thompson, 1975; Beatty & Woolnough, 1982; Abrahams & Saglam, 2010) these focused not on teachers' actual practice but on their views and opinions. In contrast, this study sought to explore the reality of practical work in the school laboratory and, as such, used a strategy that brought the researchers into closer contact with teachers and learners as they undertook practical work by collecting data in the teaching laboratory and by focusing on observation of actual practices augmented by interviews conducted in the context of these observations. It was felt that if an interviewee was aware that the interviewer had observed the practice being discussed, their responses would be more likely to be anchored to the reality of what happened in that observed lesson, and less likely to be 'rhetorical' or 'aspirational' in nature.

Permission was asked of ten primary teachers (Key Stages 1 and 2) and twenty secondary teachers (Key Stage 3, 4 and 5) to observe two of their practical lessons, one before the teacher undertook the Getting Practical training and another after the training was completed, and to talk to them, as well as some of the learners, about the lesson. Written permission for all school visits was obtained from headteachers. The geographical location of the schools are presented in Table 2 from which it can be seen that the sample consisted of primary and secondary schools in both rural and urban settings.

Broadly speaking, these schools were typical of primary and secondary schools in England. In identifying practical tasks to observe we were conscious that we were only able to visit each school to observe a single lesson on each of the two occasions.

Type of School	Primary	Secondary
Rural	3	8
Urban	7	12

Table 2. Geographical school type

Whilst we had no control over the subject matter or age of the learners (beyond their being in primary or secondary schools) in the lessons observed, a reasonably balanced coverage of subject material and age ranges was achieved.—see Table 3.

It should be noted that whilst practical work in primary school was generally referred to by the teacher as 'science practical' we have classified the lesson content in terms of biology, chemistry or physics so as to present an overview of the range of subject areas observed across all age ranges.

Although the sample was not unduly large it was felt, given that later observations, in both pre and post-training visits, raised the same issues as earlier ones, that adequate data saturation had been achieved and, as such, nothing special would have been likely to have been gained from increasing the sample size further. The observation of data saturation in the second round of observations was important given that eight of the secondary teachers and two of the primary teachers who had agreed to take part in the programme subsequently declined to be observed a second time and/or moved from the school, leaving no contact information and/or failed to complete the training by the end of February 2011. This suggests that the findings that emerged are indeed representative of the sample as a whole.

Digitally audio-recorded interviews were carried out with the teacher before and after each lesson. In addition to digitally



audio-recording all teacher-whole class discussion and instructions, conversations between groups of learners, and between learners and the researcher, were also digitally audio-recorded. These conversations, in addition to field notes that were made, provided insights into the learners’

thinking not only about the task(s) that they were observed undertaking but also with regards to their recollections of certain previous practical tasks that they had undertaken.

School type	Learner age range	Biology	Chemistry	Physics	Other (Earth Science)
Primary	5–7	2 (0)	1 (0)	5 (2)	0 (0)
	7–11	0 (2)	1 (1)	1 (3)	0 (0)
Secondary	11–14	4 (3)	3 (3)	6 (2)	1 (0)
	14–16	1 (0)	2 (1)	0 (0)	0 (0)
	16–18	1 (1)	1 (1)	1 (0)	0 (0)

Table 3. Lesson observations by learner age range and subject (Brackets indicate second round observations)



# FINDINGS

## Introduction

The analytical framework presented in Table 1 was used in analysing the data, and will also be used here to structure the discussion. Throughout this article each teacher is referred to by a code that indicates their gender (we simply use Mr or Ms) followed by the first two letters of the school's name whilst the third letter a 'p' or an 's' indicates whether the school was primary or secondary. So, for example, Ms WAp refers to a female primary teacher at a school identified as WA. In extracts from interviews with learners, each is identified by a code consisting of the teacher's three letter identification (without their title) followed by a further number. This coding enables the reader not only to distinguish between primary and secondary teachers but to distinguish between different learners in the same lesson and to follow the flow of their conversation. For example, WEs1, WEs2, and WEs3 would refer to three learners in a lesson at the secondary school WE.

We start by considering the pre-training observations and the effectiveness of tasks at Level 1, that is in getting learners to do what the teacher wanted them to do with, on the one hand, objects and materials and, on the other hand, ideas. We then go on to consider effectiveness at Level 2 which relates to the effectiveness of the practical task in getting the learners to learn what the teacher wanted them to learn about in the domain of observables and the domain of ideas. We then move on to consider the nature of any changes observed in the post-training lessons in order to evaluate the impact of Getting Practical on the way practical work is used in both primary and secondary schools. Following this we consider the effectiveness of the training itself, using Guskey's (2002) five hierarchical levels of CPD, and then, in the final section, we draw conclusions and suggest what the possible

implications of these might be in terms of the impact and possible legacy of the Getting Practical programme.

## Pre-training observations

### *Doing with Objects, Materials and Ideas*

Practical work in both primary and secondary schools was, in most cases, highly effective in enabling almost all of the learners to successfully 'produce the phenomenon' (Hacking, 1983) and/or data that their teacher wanted them to, using the objects and materials provided. The most noticeable factor contributing to this appeared to be the widespread use of 'recipe style' tasks (Clackson & Wright, 1992; Kirschner, 1992). Some teachers reported that their decision to use 'recipe style' tasks was, as the following examples illustrate, based on the need to ensure that within a typical practical lesson most of their learners would successfully be able to set up the apparatus, produce a particular phenomenon, and record and analyse the results.

Mr ARs: ... we've got a 50 minute lesson, right, say we're going to do this practical, we need to do this, this, this, get on with it.

Ms WAp pointed out that she saw the use of highly structured tasks [recipe style] as being of particular value in helping the academically weaker learners in her class complete the task in the lesson and so avoid her having to overrun into the next period's lesson.  
(Field notes)

The overall impression to emerge was that both primary and secondary teachers saw the production of the intended phenomenon, and/or collection of the intended data, by the majority of learners in their class as being central to the success of the lesson. Given that the effectiveness of a practical task in all the other cells of Table 1 arguably depends on its being effective at Level 1:0 this emphasis, on the part of the teachers, might be neither unexpected

nor unwarranted. However, that said, if the effective production of a phenomenon and collection of data becomes the sole aim of a practical lesson then the potential teaching and learning value of practical work is substantially diminished. In many cases, as the following example illustrates, learners appeared primarily to be focused on following the 'recipe' provided in order to complete the task and had little understanding as to the reason why they were doing it:

CAs17: Yeah, so I'm just following the method that we've been given [indicates worksheet] and hopefully... And we've got like the results table [points to pre-printed table on the worksheet] so we'll just get them [their results] down.

Indeed, Edmondson and Novak (1993) concluded that a focus on completing the task within the lesson could overwhelm any serious opportunity for conceptual learning to occur.

However, whilst 'doing' with objects and materials is self-explanatory, 'doing with ideas' is less self-evident; it refers to the process of thinking and talking about objects and materials, using scientific terminology, in terms of theoretical entities or constructs that are not themselves directly observable. Not all thinking is synonymous with 'doing with ideas' since, for example, a learner may think about the readings on an ammeter entirely in terms of observables—the position of a pointer on a scale—rather than as measures of the flow of charge.

Getting learners to think about objects and materials within a particular framework of ideas and to do so using specific scientific terminology can be difficult as these ideas do not present themselves directly to their senses and often the scientific words are either strange, and possibly previously unheard, e.g. inertia, kinetic and plasma, or, whilst familiar, have alternative, well established, non-scientific meanings, e.g. force, work and moment. Almost all of the 30 practical lessons we observed provided

learners with the opportunity to think about objects and phenomena using scientific ideas, although the extent to which this might have had a significant impact on their actions or on the possible learning outcomes, particularly in primary schools where some of the scientific ideas were often very basic, varied from task to task. Whilst the overwhelming majority of practical tasks, in both primary and secondary schools, were effective in enabling learners to do what their teacher wanted them to do with objects and materials and to learn about what they had done and/or seen, they were noticeably less effective in getting learners to do with, and learn about, ideas.

Whilst primary teachers were, compared to their secondary colleagues, more effective in getting their learners to 'do with ideas' this was essentially as a result of their devoting whole class time to learning the meaning of the new scientific words rather than in their being more effective in getting learners to talk about objects and materials in terms of theoretical entities or constructs that are not themselves directly observable.

The following example illustrates a particular example of the effective 'doing with ideas' in a primary school lesson in so far as it relates to getting learners to understand the meaning of new scientific words:

In what is to be an hour long lesson Ms SO has devoted the first 16 minutes of the lesson to strengthening the students' understanding of ten new scientific words: constellation, crescent, waxing, waning, rotate, orbit, satellite, sphere, planet and phase. The students are being encouraged to practise pronouncing these words, discuss their meaning within small groups, and then share tips with the rest of the class about how they might successfully remember what they meant – this was particularly useful with the words 'waxing' and 'waning' which many of the class confused one with the other.

(Field notes)





**Most (primary teachers) appeared better able to empathise with the problems that their learners faced when learning about new ideas in science and the meaning of new scientific terms.**

Unlike primary teachers, who often spent whole class practical lesson time ensuring learners understood the meaning of new scientific words, secondary teachers frequently assumed that their learners understood all of the scientific words being used. Yet what emerged from talking to secondary school learners was that many of them appeared unfamiliar with, or perhaps to have forgotten, some of the ideas and/or scientific terminology that their teachers intended them to use:

Researcher: And what's this Benedict's?

CAs11: It tells you whether it's reducing or non-reducing isn't it?

Researcher: Is it? What's a reducing or non-reducing?

CAs11: Not that I know to be fair.

Researcher: What's a reducing sugar?

CAs15: I'm not sure.

Researcher: What does the word optimum up there [points to the white-board] mean?

UPs2: Um, I actually don't know.

UPs3: I haven't a clue [laughing].

One possible reason for the differences between how learners 'did things with

ideas' in primary and secondary school appears to be that of the ten primary lessons nine were taught by teachers who were *not* science subject specialists in the sense that their secondary colleagues were. Indeed, not only were most of the primary teachers not science specialists but some of them spoke to us about their own difficulties in understanding scientific ideas and the meaning of certain scientific terms as well as, in some cases, a lack of confidence in teaching science (cf. Appleton, 1995; Harlen & Holroyd, 1997). Yet, as a consequence of their own difficulty with some aspects of science, most appeared better able to empathise with the problems that their learners faced when learning about new ideas in science and the meaning of new scientific terms than were many secondary subject specialists. For example, in the example of primary school SO, discussed above, the teacher mentioned that she too often confused the meaning of 'waxing' and 'waning' and that was why she knew that many of her learners would also find those words confusing.

Whilst primary teachers also used 'cook-book' or 'recipe following' (Clackson & Wright, 1992) practical tasks as a means of ensuring that all of their learners were able to see the desired phenomenon and/or collected the required data in the time available, their tasks tended to be shorter than those used by secondary teachers. By using shorter practical tasks, embedded within a lesson rather than taking up the entire lesson as was a more common feature of practical work in secondary schools, primary teachers had more time, which they often referred to as 'carpet time', in which to introduce learners to the meaning of new scientific terms and, when necessary, *scaffold* (Wood, Bruner & Ross, 1976, p. 90) new scientific ideas, both of which, as Abrahams and Millar (2008) have suggested, are necessary if teaching is to be effective in developing conceptual understanding.





### *What learners learned*

The analytical framework presented in Table 1 distinguishes between two levels of effectiveness of a practical task. Level 1 is concerned whether learners *did* the things the teacher wanted, and Level 2 is concerned with whether or not they *learned* the things the teacher intended them to learn. We will now consider the effectiveness of the lessons observed at Level 2. The difference between Level 1 and Level 2 is fairly clear within the domain of observables, in so far as effectiveness at Level 1 relates to what learners do whilst Level 2 relates to what they learned about the things they have done with the objects and materials involved, and the phenomena they observed. The distinction between effectiveness at Levels 1 and 2 in the domain of ideas is more subtle. The distinction here is between being able to 'do things with ideas' during the lesson at Level 1, which entails being able to use and engage with scientific terminology, and being able to use and show an understanding of the scientific ideas that explain or interrogate observations and/or data, either during or subsequent to the lesson, at Level 2. Observations of only single practical lessons mean that judgements about effectiveness at Level 2 are based on two main kinds of evidence: evidence of short-term learning within the lessons observed and comments made by learners during the lesson when questioned about previous practical work they had undertaken.

### *What learners learned about observables*

In discussions with learners during the lesson observation what emerged was that both primary and secondary learners were able to recollect details of a number of practical tasks that they had either undertaken themselves or had observed their teacher demonstrating, albeit that the number of tasks that they were able, unprompted, to recollect was relatively small. The following example illustrates both the fact that a group of learners (aged 13–14) was apparently only able, after two full years at secondary school, to recollect a single (particularly memorable) practical task from their first year at secondary school (aged 11–12) and that what they were able to recollect was limited to a brief description of what they had seen. Furthermore, in findings similar to those reported by Hart *et al.* (2000), it illustrates that they had little, if any, understanding as to *why* they undertook the task, that is its purpose, or what they had learned about the underlying scientific ideas:

Researcher: Can you remember any practicals you've done since you've been at school?

ALs21: Yeah [talking to AS62] do you remember in Year 7 [learners aged 11–12], that collapsing can?

Researcher: Collapsing can?

ALs22: Oh yeah, they put it in something.

ALs21: And put it in cold water.

ALs22: Yeah.

Researcher: What did you learn from that?

ALs21: I don't know, I didn't learn anything, it was just quite funny.

ALs22: When I did it, it didn't work for some strange reason.

A similar inability to recollect what was learned from a particular task emerged, as can be seen in the following example, from discussions with primary learners:

Researcher: Can you remember any other experiments you've done?

BRp12: We did that one with balloons.

BRp11: Yeah, we did one with a balloon where ... I can't remember, but we tried to make something and the balloon blew up and, like it burst.

Researcher: Right, and what did you learn from that [addressing BRp11 and BRp12]?

BRp11: [Laughs, shrugs and shakes head to indicate they do not remember]

BRp12: [Shakes head to indicate they do not remember]

The learners' inability to recollect more than vague details of what they did, and more specifically what they did recollect related only to the more memorable aspects of the task, appears, and similar results have been reported by Abrahams and Millar (2008), to reflect the emphasis that many of the teachers placed on ensuring that their learners were successfully able to produce a particular phenomenon by *doing* what they wanted them to do with objects and materials. Whilst a learner's ability to recollect only a partial description of a practical task does not in itself necessarily imply that they have not learned any more than that, it does illustrate all that the learner is able to recollect of having learned from undertaking that task. In this respect, and in contrast to the claim that practical tasks anchor associated scientific ideas (White, 1979), this study found that what practical tasks appeared to anchor, for both primary and secondary

learners, was, in most cases, limited to a partial *descriptive* account of what they did and saw.

#### *What learners learned about ideas*

Data collected during practical tasks did not provide strong evidence of learners' learning about the ideas the task was designed to help them understand. Because a practical activity can be a part of a sequence of activities designed to develop learners' understanding of a particular point or topic it might be the case that teachers used other parts of the teaching sequence to develop the links between observations and ideas rather than doing so within the observed practical lesson. That said, no teacher explicitly said that they planned to develop the ideas associated with the practical task in subsequent lessons and, indeed, many of the intended learning objectives, as stated by the teachers to their learners at the starts of the practical lessons observed, specifically included the learning of scientific concepts. Admittedly, even when a teacher had designed a practical task to develop conceptual understanding it might be overly optimistic to expect lasting conceptual understanding to be attributable to any single exposure to an idea, however clear or memorable the practical task might be. Indeed, what emerged from the comments made by both primary and secondary learners, as the following example illustrates, was that there was little evidence of any enduring conceptual understanding that could be clearly attributed to a specific practical task:

Researcher: What other fun activity do you remember doing?

COp29: Oh, we had, like, all this equipment on our tables.

COp30: Like we had lots of equipment on our table, and what else did we do?

COp29: Oh yeah, we did this sand one, didn't we?

Researcher: Sand? What did you do with that?

COp30: We had sand and we had, like, seashells and we had rubber bands and stuff and ah ...

COp27: ... and we had like milk straws that were full.

Researcher: What did you have to do?

COp29: We had to see what it was in there.

Researcher: That sounds exciting.

What did you learn from that?

COp29: Everything.

Researcher: Everything? Wow.

COp30: And once we had these pots with different things in, 'caus there was this pot and it had one of them in it and we had to find out which one it was.

**Pre-training observations found that secondary school teachers tended to focus on getting learners to produce and observe phenomena rather than on the development of their conceptual understanding and the meaning of scientific terminology. In contrast, primary teachers empathised to a greater extent with the problems learners faced when learning about new scientific ideas and terms.**

Certainly whilst some learners were able to recollect what they did there was no evidence of their having understood the task using the ideas that we must presume the teacher intended them to use. Yet it is important to point out that learning about ideas can often be an intellectually more demanding task in secondary school science than it is in primary school science, if for no other reason than the concepts involved are more complex. Indeed, 'learning about ideas' in primary school science was often observed to be very similar to 'doing with ideas' in the sense that the former often placed little additional cognitive demand on the learner. For example, studying 'force' would involve primary

learners 'doing with ideas' in the sense that they would use the scientific word 'force' to describe pushes and pulls. Yet, in terms of their understanding of 'force', there is nothing further, in terms of 'learning about ideas', than the idea that a force is a push or a pull that they need to know. In this respect effectiveness at Level 1:i becomes all but indistinguishable from effectiveness at Level 2:i and the achievement of the former virtually entails the achievement of the latter. In contrast, in secondary school the ability to use the word 'force', when describing a push or a pull, does not necessarily imply an understanding of the more complex, Newtonian, concept of a force.

Leach and Scott (1995, 2002) have developed the idea of learning demand to discuss teaching and learning in science more generally. They use it to capture the sense that some activities, and the learning steps they are designed to help learners take, make significantly greater cognitive demands than others. In the context of practical work, there is a substantial difference in learning demand between tasks in which the primary aim is that learners should simply see an event or phenomenon, or become able to manipulate a piece of equipment, and tasks where the aim requires learners to *both* do with objects and materials and develop an understanding of certain scientific ideas or models that might account for what is observed. As the following example, from a chemistry lesson (ages 17–18), illustrates learners can experience difficulties when tasks places high demands on them both in terms of 'doing' *and* 'learning':

Ms AR: I'm going to strain your brains today, I did warn two of you yesterday. On the board are two possible equations for the thermal decomposition of copper carbonate. They are both possible but what you're going to do this morning is to plan and carry out a practical which is going to give us some info. which will help us to deter-



mine which of these equations is the correct one.

However, as the field notes below show, the task itself also made high demands on the learners in terms of 'doing with objects and materials' and as a result many of the students were unable to obtain the data necessary to allow them to effectively engage with the learning objectives.

Many of the students appear to have weak skills in chemistry practical work and numerous pieces of equipment are getting broken—the windows are being opened as there is smoke from burning rubber clamps on the retort stands which have unintentionally been set on fire. What appears to be a non-Pyrex tube has just melted, spilling hot copper carbonate onto the desk. The delivery tube of another pair of students has likewise just 'sucked back' cold water into a boiling tube which has cracked. The students said that they have been taught chemistry by a biology teacher for the last two years and have done almost no practical work. None of the learners has collected gas over water before [these claims were later confirmed by their teacher Ms AR].

(Field notes)

In the above example the learners were unable to focus their full attention on the intended learning (Level 2:i) due to the competing demands that were being made of them in terms of 'doing' with objects and materials (Level 1:o). An unintentional outcome of this lesson was evidence of learning at Level 2:o as the students clearly learned something about setting up and handling the equipment necessary for collecting a sample of gas evolved during the thermal decomposition of a material.

In conclusion, our pre-training observations found that secondary school teachers tended to focus on getting learners to produce and observe specific phenomena rather than on the development of their conceptual understanding and the

meaning of new scientific terminology. Whilst the practical work was generally effective in enabling students to do and see what the teacher wanted, it was much less effective in getting them to talk and think about the associated scientific ideas and concepts. In contrast, primary teachers, most of whom were not science subject specialists in the sense that the term 'science subject specialists' is understood by secondary science teachers, empathised to a greater extent with the problems learners faced when learning about new scientific ideas and the meaning of new scientific terms. As a consequence, primary teachers sought, in addition to enabling their learners to successfully produce and observe phenomena, to devote more time in a practical lesson to learning about scientific terminology and ideas. Indeed, there was seen to be a strong emphasis placed on the meaning of words and ideas to ensure that students were able to think about what they were *doing* with objects and materials employing scientific terms and ideas. Certainly, much of the primary science observed before the Getting Practical training was already effective in so far as the primary teachers were already using practical lessons as an opportunity for both 'hands-on' and 'minds-on' teaching and learning with the practical activity itself being an embedded component within the science lesson rather than occupying the entire, or at least a substantial part of, the science lesson. Indeed, the average time for actually doing practical work in primary science lessons was approximately 19 minutes compared to almost 30 minutes in secondary schools.

We now move on to consider the observations made after the teachers had completed the Getting Practical training. It should be noted, and this will be discussed later, that whilst most of the teachers undertook their training at external centres, two teachers, one primary and one secondary, received bespoke training within their own school.



## Post-training observations

### *Doing with Objects, Materials and Ideas*

The overall impression to emerge was that both primary and secondary teachers continued to see the production of the intended phenomenon, and/or collection of the intended data, by the majority of learners in their class, as being central to the success of the lesson. In this respect, as before, the continued widespread use of 'recipe style' tasks meant that in both primary and secondary schools practical work remained highly effective in enabling most of the learners to successfully produce the phenomenon that their teachers wanted them to, using the objects and materials provided.

Whilst it was found that Getting Practical did, for some secondary teachers, bring about improvements in the effectiveness of practical work, the extent to which this was seen to occur was largely dependent upon who undertook the training and the extent to which there was support for the programme from the members of the school's senior management team. Furthermore, it also emerged that the Getting Practical programme had a much less noticeable impact on the way primary teachers used practical work since much of what Getting Practical set out to achieve was already taking place in primary science lessons prior to the training.

## Primary School Impact

The most notable finding to emerge from the post-training observations of primary school teachers was the extent to which there was a feeling that the Getting Practical 'message' was not anything new to them and that they had been doing the same sort of things as were being advocated in the Getting Practical training, for, in some cases, many years. As one teacher explained:

I don't think that the message that was coming across from what the ASE told us has got any measurable benefits over and above what we're doing anyway, because a lot of what we were doing, what we do as a school, we were actually ahead of the game anyway, we were already doing better, more often ... (Ms WAp).

Certainly, the observations of the primary teachers' pre-training lessons, that have been discussed above, would support such claims and, as a consequence, there was far less opportunity for primary teachers who were, generally speaking, already using practical work effectively, to exhibit improvements in the way they used it in the post-training lessons.

It was, however, evident in the post-training observations that the Getting Practical training had caused many of the



primary teachers to think more carefully about their aims for using practical work. In particular, many of them reported, when asked to reflect on what they thought the central message of the Getting Practical training had been, that there was, as the following examples illustrate, a need to ensure that their practical lessons contained fewer learning objectives:

Having a clear, like one clear, one or two clear focuses. (Ms HEp)

It made me focus more on specific objectives. I think before [the Getting Practical training] I would try to do too much in the whole lesson. (Ms OSp)

Yet, despite an evident and widely shared understanding of this issue there was no clear evidence from the second round of observations that this awareness had been translated into actual practice.

Primary teachers were clearly focusing their lessons on one or two specific learning objectives and explicitly concentrating on key vocabulary associated with the short but clear practical task. It therefore appears that what the Getting Practical training provided primary teachers with was an opportunity to reinforce and recognise the strengths of an approach to the use of practical work that was already being widely implemented in their schools. As one teacher succinctly put it:

It was good to have a refresher of the approaches to take (Ms COp)

Overall, the impression was that whilst the Getting Practical training had been effective in getting primary teachers to *think* about some of the issues relating to the effectiveness of practical work it made, given the existing strengths of primary science teachers use of practical work, little impact on their actual practice.

### Secondary School Impact

The impact of the Getting Practical training on secondary teachers was found to vary

**Getting Practical training provided primary teachers with an opportunity to reinforce and recognise the strengths of an approach to the use of practical work that was already being widely implemented in their schools.**

considerably more than was the case with primary teachers and the extent of the impact was very much dependent upon *who* undertook the training and the degree to which the programme had support from the school's senior management team.

The results at Uplands Community College (the head teacher agreed to the removal of anonymity to benefit the training providers) clearly show what can be achieved in 'ideal' conditions. In this case it was the head of department who undertook the training, saw tremendous value in the material being delivered, and returned to the school keen and determined to implement the Getting Practical programme ideas across the department as a whole. The senior management team within the school was fully committed to supporting the full-scale implementation of the required changes in the science department's schemes of work so as to bring these more into line with the ideas, suggested by the Getting Practical training, regarding the use of practical work. Likewise, the senior management team fully supported the head of science in requiring all members of the department to attend a detailed cascade of the Getting Practical training material—an event to which primary teachers of science from the local feeder primary schools were also invited and many of whom were reported to have attended. A very noticeable change in practice was evident, compared to the pre-training observation, when the second (post-training) lesson was observed. In the latter the focus was on a few, clearly identified, learning objectives, and the lesson

was clearly both 'hands-on' and 'minds-on'. Indeed, rather than taking up the entire lesson the practical component was, in the post-training lesson, only started after the learners had engaged with the ideas that would enable them to understand their observations. As the following examples demonstrate, the learners were able to explain the scientific ideas and use vocabulary appropriately prior to commencing the embedded practical component to the lesson:

Researcher: Do you know what this ... What is an enzyme?

UPs2: It's a type of thing that's in your saliva and it just helps break down all the larger molecules into smaller molecules so when they go down into the intestine all the villi absorb all the goodness and take it into your blood.

UPs6: So if that goes into there the product of it at the end is just these little bits, starch molecules and it's called maltose.

Researcher: Maltose?

UPs6: Yep.

Researcher: Where did you learn all these words, here?

UPs6: Yep here, in the lessons.

Other members of this department stated that they too, as a result of the cascade event, were familiar with the ideas of the Getting Practical programme. Not only did they talk positively about changes to the way that they now used practical work but the head of department, again with the support of the senior management team, had introduced a programme of regular peer observations of each other's use of practical work that were designed to help reinforce the Getting Practical message within the department.

One point that the head of department did make was that there wasn't, in her opinion, enough of the research background to the programme on the training and this was something she felt would have been very useful to have:

The one thing I would have really liked was more of the research background, so there was a little bit of stuff from Robin [Professor Robin Millar] and yourself, I would have preferred more of that. There wasn't enough, and I did kind of trawl a little bit but it's not so easy to get academic journals when you've not got access to an academic library and so on. (Ms Ups)

Whilst Uplands shows the potential for change that the Getting Practical programme has the potential to achieve, the impact in the other secondary schools within the sample was noticeably less effective. Whilst there was no single reason why this was the case, there did appear to be a number of factors, including the seniority of the teacher within the department who had received the Getting Practical programme training, explicit support from the senior management team, follow up in-school support and the trainee's perception of the training programme, the lack of which either separately and/or together has the potential to impact negatively on the effectiveness of the programme.

Generally speaking, it was found that the seniority of the member of staff undertaking the training was influential in determining the extent to which the ideas were fed back and implemented by other members of the department. We observed, for example, that when an NQT undertook the training there was no subsequent cascade of ideas within the department, no evidence that other members of staff were even aware of the Getting Practical programme and no evidence of any change in the way that the NQT used practical work. Likewise, when a biology teacher undertook the training prior to moving to a part-time position in a new school where she had no additional departmental responsibility there had been no attempt to cascade or discuss the Getting Practical training at the new school. Indeed, two other members of the department in that school who were questioned by the researcher knew nothing about the



programme and whilst a third, the head of department, recollected being told about the programme when the teacher was being interviewed for the post, they claimed not to have heard any more about the programme over the intervening months.

In another school (CA), although the head of department invited all members of the science department to attend the in-school Getting Practical training, attendance was limited, in many cases by disinterest but also by teaching commitments, to about half of the department. This was an example of a situation in a number of schools in which the head of department, whilst keen to introduce the ideas associated with the Getting Practical programme, received no support from the senior management team to help ensure that the programme was given the same sort of training status within the department as had been the case at Uplands. Whilst Ms CAs undertook the training and spoke highly of it there was no evidence of any change in her practice:

I enjoyed it actually, I thought it was very good. I thought that it did a good job of making you think about how to plan practical to meet different objectives (Ms CAs)

Indeed, despite her claims to be aware of the need for practical lessons to combine a 'hands-on' and 'minds-on' approach, her post-training lesson was, as in the first observation, still focused solely on 'doing' with many of the learners unclear about why they were doing the practical work and what it was meant to show them as well as the meaning of some of the scientific words that were used. As the following example illustrates, learners often appeared unsure of what they were doing and were, essentially, just following a recipe:

Researcher: Right. Why do we have to heat it? I'm not a biologist so I plead ignorance.

CAs17: I'm not too sure really to be honest.

Researcher: Right. So basically you're doing everything it tells you and hopefully that'll mean you'll get the result that you need?

CAs17: Yeah, so I'm just following the method that we've been give and hopefully ... and we've got like the results table so we'll just get them down and ...

However, two of the five teachers who attended the training in the department claimed that there had been organisational changes in that the reasons for using practical work were far more frequently discussed although these discussions were limited to those who had attended the training. It should be emphasised that, unlike at Uplands, there was no regular departmental follow-up support to reinforce the initial training. Yet without such regular and sustained reinforcement there appears little reason to expect teachers who attend a 'one-off' training event to have the opportunity to further develop and engage with any new ideas and to begin to integrate them over a more extended period into their own teaching practice.

In another school, in which there was no observed change from what was essentially only a 'hands-on' approach observed in the pre-training lesson, the highly experienced head of biology felt, despite the evidence to the contrary from their practice, that many of the ideas entailed in the Getting Practical programme were:

...already a strength of the department. (Ms ILs)

In this case the teacher remained committed to the view:

...the reason why we do it [practical work] is it's fun, it's got nothing to do with the curriculum. (Ms ILs)

When asked to reflect on what she had found most interesting in the training Ms ILs claimed (and this appeared to be in all sincerity), and despite the fact that she



was able to discuss the ideas associated with the Getting Practical training, that this was the fact that:

Primary children did know how to draw graphs (Ms ILs)

Ms ILs reported having learned this from primary teachers attending the same training session. Indeed, this was the sole message that she claimed to have passed on to her colleagues in the science department:

Ms ILs: ... So that was what I found was interesting [during the training] and what I brought back to share with everybody. It was essentially that, yeah, we need to crack the whips on these kids a little bit really, because if you let them not to do stuff they won't do it will they? But it's amazing how many ... because, as I say, we're like four or five weeks in, I can't draw a graph, I can't do this, and I [now] know they can. So, yeah, whereas before we'd have a lesson on graph drawing, I'm a little bit more ...  
 Researcher: Now you say, oh, you remember and ...  
 Ms ILs: Yes ...



We now move on to consider the effectiveness of the training using Guskey's (2002) five levels of CPD.

### Effectiveness of the Getting Practical Training

**To evaluate the effectiveness of the training we will use Guskey's (2002) five levels of CPD, namely:**

- 1. Participants' reflection**
- 2. Participants' learning**
- 3. Organisational change**
- 4. Participants' use of new learning**
- 5. Impact on students.**

Guskey's five levels provide a useful and well established means of evaluating the effectiveness of a training programme and help distil our lesson observations and interviews into a common framework.

#### *Level 1*

All of the teachers in the sample achieved level 1 in so far as it was very evident that every one of them had reflected on the Getting Practical training and that the overwhelming majority of teachers' reflections were positive:

It was good ... The best thing I liked about it was the fact that it just makes you focus on one thing. (Ms SCs)

I found it very useful ... It was well delivered and it was structured nicely and I took quite a lot from it I think, yeah, it was worth it I think. (Mr SWs)

I think it's been helpful ... (Ms BRp)

The few critical reflections tended, as the following example illustrates, to relate to the duration of the training:

It was a good day, it did make me look again at how I teach practical

science. The only thing I would say is they seemed to be expecting miracles, a reinvention of science teaching from one day's teaching [training]. (Ms OSp)

The message here was that the training, unless reinforced within the school as in Uplands Community College, was too short to bring about lasting changes—which in many cases was what emerged in the evaluation. The above quote was particularly interesting given that the teacher who made it was already using practical work in a very effective way and it was difficult to see what else she could have done in light of the Getting Practical training that she was not already doing.

### Level 2

Similarly, from discussions with each of the teachers it emerged that they had all learned about, and were able to critically discuss, the ideas associated with the Getting Practical programme as a direct result of undertaking the training. Whilst the extent and nature of their learning varied from teacher to teacher, there was a widely shared understanding that to make their practical work more effective necessitated using fewer learning objectives and moving away from a solely 'hands-on' approach towards one that was a *both* 'hands-on' *and* 'minds-on' activity. Indeed, one teacher summing up the Getting Practical training suggested that:

... it would be the slogan actually, hands on, minds on, I think. (Ms OSp)

### Level 3

Organisational change was not evident in most of the schools. There were two main reasons for this. In the first case, as already discussed, much of what Getting Practical was presenting was already being done in primary schools and so with little 'new' there was no basis for introducing any organisational change. One head teacher, when asked if the teacher

who had attended the training had instigated any changes in the way science was taught in the school as a whole, stated that:

Not really because she did not see anything new that would benefit their [other teachers of science] current practice. (Head Teacher COp)

In secondary schools, other than at Uplands Community College, the opportunity for organisational change was limited by the fact that many of those teachers who had attended the training then failed to cascade the information down to colleagues within the department. In one school (CA) two teachers spoke of what they perceived to be organisational changes that had resulted from the training but since these consisted solely of reports that some teachers were talking more about practical work than they had previously done this could not be independently verified by us. In another school (TO) whilst there was clear evidence that the training had achieved Guskey's levels 1 and 2 the teacher's head of department reported that there had been no cascading of ideas and two other members of the department who were questioned had no knowledge of the programme. In terms of Guskey's level 4—participants' use of new learning—whilst the teacher claimed that she now understood the value of embedding a smaller amount of practical work into a lesson rather than allowing it to occupy the entire lesson and was now 'more aware of practical work as a means to an end' rather than simply doing practical work for its own sake, there was no evidence of any change in practice during the Year 7 lesson that was observed.

Overall, the picture to emerge was that lasting and measureable organisational change only occurred when there was a sustained input from a senior member of the department and the active support of the school's senior management team.

*Level 4*

Whilst primary teachers demonstrated effective use of practical work they did so both before and after the training and, as such, there was no change of practice that could be directly attributed to the Getting Practical training. Despite the expectation that secondary teachers would demonstrate more effective use of practical work in the post-training observations on the basis of having achieved level 2, this was only evident in five schools. It appears, as with level 3, that without sustained input from a senior member of the department and possibly the active support of the school's senior management team in order to provide time and resources for in-school training, that it is arguably unrealistic to expect a single six hour training session to bring about lasting changes in established teaching practice. The continuing professional development literature attests to the need for coaching and on-going support if substantial changes are permanently to be made to practice (Joyce & Showers, 2002; Loucks-Horsley *et al.*, 2003).

*Level 5*

Impact on students was extremely difficult to ascertain and even more difficult to attribute with any degree of certainty to the Getting Practical training. What did emerge, from the comments made by teachers and learners, was that there appeared to be no discernable difference in learners' attitudes to practical work as a consequence of their teachers having undertaken the training. The following comments highlight teachers' responses to the question on the impact the training may have on their students:

Ms BRp: I think it is quite hard to determine whether it has had an impact on the child apart from the fact you can see them enjoying it and you know that they've learned something from the beginning of the lesson to the end of the lesson. I think the only ... the formal way of knowing if

there's any impact is the increased test results, which have stopped now they've stopped SATs, so it is more teacher evaluation and things.

Ms WIp: Well hopefully the lessons are better, hopefully. Well they should be. If I focus on fewer objectives, the lesson is more focussed then they should be better taught.

In terms of impact on conceptual development, we would tentatively suggest that students in the post-training lesson at Uplands did appear, when questioned about the practical work that they were undertaking, to understand the science and the reasons for undertaking the task substantially better than they did in the pre-training lesson observation. It must, however, be emphasised that this might have been due to other factors such as, for example, the topic being different and/or the practical lesson in the second observation coming at a later point in the teaching sequence. We did not observe any noticeable impact on primary students that could be directly and unambiguously attributed to the Getting Practical training undertaken by their teachers.

In summary, whilst it was clear that primary and secondary teachers were able to reflect upon their training and, as a result, had started to think more critically about the value and role of practical work, there was no evidence, in most cases, of any noticeable change in their actual practice. Indeed, and despite having achieved level 2, most secondary teachers remained, in terms of their observable practice, focused on the production of phenomena. In the primary school it was not possible to attribute the observation of characteristics associated with levels 4 and 5 to the Getting Practical training since the same characteristics had been observed in the majority of pre-training lessons.



## CONCLUSIONS AND IMPLICATIONS

The aim of this study was to evaluate the intended outcomes of the Getting Practical programme which, as laid out in the tender, were to bring about:

- 1 Observable changes in the emphasis given to practical science in schools and colleges.
- 2 Observable improvements in young people's perception of, and positive attitudes towards, science.
- 3 Observable changes in the confidence and attitudes of science teachers and other staff in using practical science as part of the teaching and learning process.

To these we added:

- 4 Observable improvements in the learning of science concepts.

Two main findings have emerged from this evaluation. First, and foremost, is the fact that the Getting Practical programme can, and did, bring about substantial change in both the use and effectiveness of practical work. However, the extent of this change and improved effectiveness was seen to depend to a very large extent on who undertook the training, e.g. whether they were a head of department or an NQT, and the extent to which the school's senior management team was supportive and keen to implement the ideas either within the science department (secondary) or amongst other teachers of science within the school (primary). Secondly, the impact of the Getting Practical programme amongst primary teachers was, compared to their secondary colleagues, less noticeable. This was *not* because of any failure on their part to engage with the Getting Practical programme but because, in almost every case that was observed, much of their pre-training practice already embodied many of the good characteristics

that the Getting Practical programme was designed to inculcate.

The principal implications of these findings are that simply being aware of the Getting Practical 'message' whilst important is, of itself, insufficient and it is essential that task design should more clearly reflect an understanding that 'doing' things with objects, materials, and phenomena will not necessarily lead to the learners 'learning' (or even 'doing' with) scientific ideas and concepts unless they are provided with what Wood *et al.* (1976, p. 90) term a 'scaffold'. Here, scaffolding is the initial means by which learners are guided towards 'seeing' the phenomena in the same 'scientific way' that their teacher 'sees' it (Ogborn, Kress, Martins & McGillicuddy, 1996). As Lunetta (1998) has argued:

...laboratory inquiry alone is not sufficient to enable students to construct the complex conceptual understandings of the contemporary scientific community. If students' understandings are to be changed towards those of accepted science, then intervention and negotiation with an authority, usually a teacher, is essential. (p. 252)

Whilst the Getting Practical training programme has the potential to enhance the overall effectiveness of practical work, its primary impact to date has been in getting teachers to think about, and question, the value and role of practical work in science education. If this greater awareness is to stand a better chance of manifesting itself into an enduring change of teaching practice then it would seem advisable to ensure that those undertaking the initial training are senior members of a science department and that they have the active support of the school's senior management team.

**Getting Practical can, and did, bring about substantial change in both the use and effectiveness of practical work.**



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