What is practical work?

Practical work is viewed by the vast majority of science teachers, as an essential and integral part of science education. In fact, many regard it as an indispensable aspect of being a ‘ science teacher’ (Donnolly 1998 from review Practical work effectiveness in primary/sec schools Abraham). Practical work can encompass many different components, which can be divided into two main groups as described in Woodley E, (2009), as follows:

1) Core activities: These include ‘ hands-on’ activities such as different investigations, laboratory techniques and procedures, as well as fieldwork. These types of activities can help enhance the development of students’ practical laboratory skills, as well as helping them to understand key scientific concepts and phenomena.

2) Directly related activities: These are closely connected to the above core activities, and include practical demonstrations performed by the teacher, planning and designing scientific investigations and analysis of data.

In addition, some argue that other activities such as use of computer simulations, modelling, use of surveys, presentations, group discussion and role plays can also constitute what is meant by the term practical activity (SCORE, 2008). However, others would disagree, and believe these activities would not come under the practical activity ‘ umbrella’, and rather that they should be used complementarily alongside other practical activities, rather than be a substitute for them (Woodley, E).

Millar described a practical activity as ‘ Any science teaching and learning activity which at some point involves the students, working individually or in small groups, in observing or manipulating objects to develop

understanding’. (Millar (2009)). It is described in The National Strategies as: ‘ Any activity that enables pupils to have direct, often hands-on, experience of the phenomena they are studying’ . (The National Strategies (2008)).

In fact the following quotation from SCORE underpins what many believe about the importance of practical work in science: ‘ Science without practical is like swimming without water’ . (SCORE, 2008).

Therefore, regardless of how practical work is defined, or what activities are thought to constitute it, it can be seen as a central part of how science should be taught in schools

What is the Purpose of Practical Work?

The main purposes of practical work are to engage students, aiding them to develop many important skills. In fact, practical work can support learning in a multitude of ways ranging from ‘ Personal learning and thinking skills’ to ‘ How science works’ (E Woodley) -See Figure 1. The overriding principle, however is ‘ to make links between the concrete and abstract worlds’. (Reflecting on practical work). From reading the literature, it is clear that the different reasons and rationales for carrying out practical work in science can be classified into three main areas (see below), as discussed in (Practical Work in School Science: Which Way Now? Jerry Wellington):

Arguments for and against the use of practical work in science:

1). Cognitive arguments: It is thought that practical activities can relate to knowledge and understanding (the cognitive domain) by helping to strengthen students’ conceptual understanding of science by enabling them

to visualise and make sense of different scientific laws and theories, often supporting learnt theory work.

2). Affective domains: This relates to the enjoyment and motivational aspects of practical work. Practical work is often used to generate interest and enthusiasm amongst students, and is thought to aid students in remembering things; ‘ making things stick’. In fact, reports show that in terms of how students rate the enjoyability of school science activities, the three top rated were: ‘ going on a science trip (85%), looking at videos (75%) and doing a science experiment (71%), supporting the view that practical work is indeed highly motivational (Dillion J).

3). Skills argument: The last of the three main rationales for practical work is that it can help develop many transferable skills, as illustrated in Figure 1 above.

However, characterising the real value and purpose of practical work is a very difficult task and divides opinion across the science education profession. In fact there are many arguments and counter arguments for and against practical work in science.

Counter responses to the cognitive argument include the idea that practical work can often confuse rather than improve students’ understanding (especially if the practical does not go to plan). In addition Scott and Leach propose that practical work is not a good approach to teach theory, suggesting that theories comprise abstract ideas which cannot be demonstrated physically: ‘ In the context of the school laboratory it is clear that students cannot develop an understanding through their own

observations, as the theoretical entities of science are not there to be seen'. (Taken from Wellington book- Leach and Scott 1995: 48)

Arguments against the affective argument include the notion that many students are simply turned off at the idea and prospect of doing practicals. There is also evidence indicating that boys enjoy practical work more so than girls, and hence girls can often be less enthusiastic and motivated compared to boys doing the same practical task. (Wellington).

Counter arguments to the proposal that practical work can develop many transferable skills also exist. These include the argument that group work within practical science often does not improve key skills such as communication and interaction, as widely believed, but when studied more closely, often results in more forceful students' dominating the task, resulting in lack of enjoyment and engagement for some and the demotion of some students to simple medial tasks, such as drawing out tables or recording results without any real participation in the practical activity themselves.(Wellington).

Many other science education professionals make claims of the ' overselling' of the science education in terms of concept that science practical work can develop many transferable skills. The idea that these skills can add value to students and aid them on their chosen career paths have been discredited by some. In fact, Ausubel in the 1960's argued that any practical task that can give rise to the application of skills required for many disciplines, is simply not specific enough to address the particular scientific investigation being addressed: ' Grand strategies of discovery do not seem to be

transferable across disciplines.. it hardly seems plausible that a strategy of inquiry, which must necessarily be broad enough to be applicable to a wide range of disciplines and problems, can ever have sufficient particular relevance to be helpful in the solution of the specific problem at hand'. (wellington, Ausubel 1964: 298).

Hence, there is much debate regarding the use of practical work within the teaching and learning of science in schools. The key question here really is to do with cognition and how we acquire knowledge. i. e. : How do we understand the world and make sense of it in our heads? (Miller R, 2004). One significant answer to this came from Jean Piaget, who is credited as the pioneer of the constructivist theory of knowing. He argued that we construct ever more complicated and sophisticated representations of the world. This is through modifying our existing understandings (or schemas; a structured cluster of concepts) through our actions on the world around us. If Piaget is correct, then the use of practical work in observing and intervening in the world must be vital for our understanding of science (R Miller 2004).

The effectiveness of practical work in science

As discussed above, many science teachers and other science education professionals believe that practical work in the education of science in schools is vital for helping students learn and remember things more clearly. However, as also noted there are arguments suggesting that practical work is actually not all that effective at achieving these aims. A prominent quotation from Osborne (1998) questions the effectiveness of practical work in the learning of science, saying that practical work: ' has only a limited role

to play in learning science and that much of it is of little educational value' (p. 156. from Miller 2004 review).

Much of the conclusions of research into the effectiveness of practical work remain somewhat ambiguous. Research carried out in the 1980's by Hewson and Hewson (1983), in which

In addition, others have argued that the way in which practical work is practised is often the cause of its ineffectiveness, and perhaps, therefore the type of practical work used, and the way it is used should be analysed, rather than simply saying that all practical work is ineffective. Hence if we are interested in looking at the effectiveness of practical work in science, the specific practical work used, or planning to be used need to be very carefully planned and thought out. A key consideration here is actually what is meant by the term ' effectiveness'.

A framework for judging the effectiveness of practical work

Theobald in the 1960's argued that scientific theory must always be taught first and is required in order to visualise: ' Experience does not give concepts meaning, if anything concepts give experience meaning' (J Wellington).