

This item was submitted to [Loughborough's Research Repository](#) by the author.
Items in Figshare are protected by copyright, with all rights reserved, unless otherwise indicated.

Classroom and chatroom - why school science pupils should discuss practical science work online

PLEASE CITE THE PUBLISHED VERSION

PUBLISHER

© Loughborough University

LICENCE

CC BY-NC-ND 4.0

REPOSITORY RECORD

Fullick, Patrick. 2019. "Classroom and Chatroom - Why School Science Pupils Should Discuss Practical Science Work Online". figshare. <https://hdl.handle.net/2134/2496>.

Classroom and chatroom – why school science pupils should discuss practical science work online

Patrick Fullick

School of Education, University of Southampton

In this paper I want to argue that there are compelling reasons for school science pupils to engage in discussing their practical work online. These reasons stem from two sources: first, a general agreement among science educators that the discussion of practical work may, if suitably managed, lead to increased understanding among pupils of the nature of science; and second, the observation that the rapidly increasing use of networked computers (in learning settings outside formal schooling and by school pupils in their personal lives, also outside formal schooling) provides a natural way of doing this. When referring to the use of networked computers as a tool for online collaborative learning, the term CSCL (Computer Supported Collaborative Learning) is used throughout this paper.

Science education and practical work

In the last 15 years, many books have been published concerning the variety of challenges to be met by secondary science education (for example Woolnough, 1991; Wellington, 1994; Levinson, 1994; Levinson & Thomas, 1997; Ratcliffe, 1998; Monk & Osborne, 2000; Sears & Sorensen, 2000; Wellington, 2000). In all of these, science practical work (its nature, purposes and conduct) and the nature of science (in the context of developing young people's understanding of how scientists work and the powers and limitations of scientific knowledge) are explored in considerable depth. Often, the exploration of these two themes is closely related: Millar argues for the need to teach "practical techniques" of scientific enquiry and "inquiry tactics" as a way of developing students' understanding of the way in which scientific knowledge is acquired (Millar, 1991: 51); Monk & Dillon are concerned that pupils should understand the rôle of theory in guiding the collection of experimental data (Monk & Dillon, 2000: 79); and Wellington raises issues relating to the images of science that are presented to pupils through their experiences of practical work (Wellington, 2000:226-248).

The lack of clarity of purpose of much science practical work carried out in schools is likened by Woolnough to an extract from *The House at Pooh Corner* where Winnie the Pooh first meets Tigger (Milne, 1928:21):

... and with one loud Worraworraworraworraworra he jumped at the end of the tablecloth, pulled it to the ground, wrapped himself up in it three times, rolled to the other end of the room, and, after a terrible struggle, got his head into daylight again, and said cheerfully: 'Have I won?'

(Woolnough, 1991:3)

One reason for this lack of clarity is that teachers state a wide variety of reasons for carrying out practical work, which include motivating pupils, encouraging accurate observation and aiding understanding (Kerr, 1963; Woolnough & Allsop, 1985); these reasons have remained remarkably consistent over the last 35 years (Swain, Monk and Johnson, 2000). Yet the purposes of practical work in science lessons as evidenced in documents that currently inform and guide science teaching on a working, day-by-day level are quite unambiguous:

During Key Stage 3 pupils ... use scientific ideas and models to explain phenomena and events ... do more quantitative work, carrying out investigations on their own and with others. They evaluate their work, in particular the strength of the evidence they and others have collected ... They communicate clearly what they did and its significance ... learn how scientists work together ... and about the importance of experimental evidence in supporting scientific ideas.

(DfEE, 1999:28)

The function of practical work in such a context is clear, and divides into two different areas:

- a) providing pupils with evidence for a particular theory; and
- b) providing a way of helping students to develop some understanding of the methods used by scientists as they develop scientific theories.

These are considered below.

Providing students with evidence

In many cases, practical work is seen as a “warrant for belief” (Brickhouse et al, 2000), providing students with opportunities to make observations that support the theories that they are learning; for example, the increase in mass recorded when magnesium is heated in air is commonly used as a way of “showing” students that chemical combination produces an increase in mass.

As Hodson points out, there are problems – both philosophical and pedagogical – with the use of practical work in this manner. Philosophically, the use of a school practical to “test” a scientific theory is seriously flawed, since the outcome is certain by the very nature of the theory being tested. Otherwise it would be impossible to explain the continued existence of Newton’s second and third laws of motion when there is daily proof from school science laboratories that momentum is *not* conserved in collisions:

... children are seriously misled by teachers who pretend that they are testing a theory when, in reality, they are illustrating it. The so-called rigorous testing of hypotheses by experimental methods that is given pride of place in the Nuffield courses is something of a sham, because success is guaranteed and is under-written by the assumptions of the very theory that is supposed to be under test.

(Hodson, 1988:27)

Lakin and Wellington (1994) write about the strong link that exists between teachers’ classroom practice and their views on the nature of science. They describe the results of a small study in which these views were explored, noting that the teachers were insecure about their ideas, and had had little opportunity for reflection on them as part of their initial training or their teaching experience. An extensive review of the literature related to teachers’ conceptions of the nature of science (Abd-El-Khalik and Lederman, 2000) supports these conclusions, and notes that “it should be emphasized that possessing adequate understandings of NOS [the nature of science] is not sufficient to enable teachers to enhance pupils’ conceptions of the scientific enterprise.” (Abd-El-Khalik and Lederman, 2000:696). The implication of Hodson’s concern when coupled with these conclusions suggests that a poor understanding of the nature of science among science teachers is highly likely to lead to potentially confusing messages being sent to pupils through poor pedagogy. More positively, Bartholomew et al argue that teachers’ knowledge and understanding of the nature of science is only part of the picture, and that there are reasons to think that teachers may be equipped to provide pupils with insights into the nature of science even if they express a lack of confidence in their ability to do so (Bartholomew, Osborne, & Ratcliffe, 2004).

To many teachers, engaged in a pragmatic search for meaningful experiences for pupils as part of their science education such concerns may seem irrelevant or even trite. But pedagogical issues relating to the use of the outcomes of practical work as a rhetorical

device to convince pupils of the correctness of a particular interpretation of the world also raise concerns.

Most science teachers are familiar with situations in which pupils undertaking practical work obtain conflicting results. Such a situation may arise due to inconsistencies *within* data collected during a single investigation, or due to inconsistencies *between* datasets collected during several instances of a particular investigation. The collection of oxygen (demonstrated through the rekindling of a glowing splint) from pondweed illuminated by bright light is an example of this (Nott and Smith, 1995:403).

Personal observation of this lesson taught by many trainee science teachers over the years has found this piece of practical work to be extremely problematic, in the sense that there is always one or more members of the class who obtain results that clearly show that the gas collected extinguishes a glowing splint and is therefore not oxygen. In every case the role of the practical work as a warrant for belief was very clear to the teacher, who wanted to be able to say (effectively) to the pupils – “you’ve seen this happen for yourselves!”. For this reason, the need to find a convincing way to “explain away” the anomalous results is very strong, and the experienced teacher has many such explanations. (There is also evidence to suggest that experienced teachers may resort to dubious practices (“fiddling” and “conjuring”) in anticipation of such problems (Nott and Smith, 1995).) Pupils are generally quite well-aware of their own shortcomings and of the shortcomings of the school’s apparatus when it comes to practical work, and will normally defer to such explanations.

Despite their apparently willing acceptance by pupils, the messages, both overt and covert, that teachers convey when they provide plausible explanations for the outcomes of practical work that has “gone wrong” (Nott and Smith, 1995:399) can be very undesirable. For example, Driver points out that when teacher and textbook appear as a kind of “revealing authority”, their message carrying weight by virtue of its status, the outcome may well be a kind of dual-belief system:

... learners [may] accept what they are presented with through books, teacher talk and guided experimental work because of its authoritative status. This can and does get in the way of students making sense of the ideas for themselves ... [so] that students may have one belief system which operates in the classroom, and a quite separate set of beliefs which operate elsewhere – hardly a recipe for scientific

literacy.

(Driver, 1989:103)

This tension between the "pupils' science" and "scientists' science" is there to be resolved within any kind of activity involving science investigations. Not only does the teacher in search of a warrant need to explain why the results obtained by pupil A differ from those obtained by pupil B; it is also very frequently necessary to explain why the outcomes of scientists' science differ from those of pupils' science. Concerning this, Millar writes :

*... students in science classes construct their own meanings for events and phenomena ... The science teacher (and the textbook) have access to one preferred set of meanings which have been constructed by scientists and [which] ... necessarily carry greater weight than students' personal meanings ... But this does not negate the need to **discuss** and **negotiate** the meaning of observation and experiment in the science classroom.*

(Millar, 1989a:56 [original's emphasis])

The need for discussion and negotiation of meaning relates closely to the second function of practical work in school science, which concerns the desire for pupils to develop some understanding of the methods used by scientists as they develop scientific theories.

Helping pupils understand the methods of science

The role of practical work in science as a vehicle for gaining an understanding of the methods used by scientists first came to prominence in curriculum developments in the 1960s and 70s, with the Nuffield vision of the "pupil as scientist" (Millar, 1998:17). The Nuffield projects presented pupils with a model in which scientific thought develops through the engagement of scientists with experiments concerned with manipulation and observation of the natural world. Through the involvement of pupils with the natural world in a similar way, the projects aimed to provide them with a better understanding of scientific theories, this deriving from having "discovered" or "proved" such theories themselves to their own satisfaction:

Even at school it is not too early for young people to think about scientific things in the way that practising scientists do. Thus the objective ... is to encourage children to think freely and courageously about science. ... the best way to awaken original thinking in children studying science is to engage them in experimental and practical enquiry.

(Nuffield Foundation, 1964:5-6)

The philosophical shortcomings of this approach have already been touched upon earlier in this chapter. There is also evidence to suggest that pupils have considerable difficulty in making links between their practical work and theories of scientific knowledge (Solomon, 1991). Citing work carried out in the UK and Canada, Solomon observes that:

*Neither project gives much hope that a student diet of laboratory work would automatically yield understanding of **the nature of science**.*

(Solomon, 1991:97 [original's emphasis])

The Nuffield courses with their emphasis on practical work were succeeded by the "process science" movement of the 1980s (Nuffield Foundation, 1999:6). This movement saw science as having a set of processes such as observing, classifying, hypothesising etc which are entirely distinct from processes concerned with everyday life. Two well-known examples of schemes teaching materials produced using such a philosophy were *Warwick Process Science* (Screen, 1986) and *Science in Process* (Wray, 1987). The presentation in these teaching schemes is one in which science consists of a unique, hierarchical set of processes in which observation precedes theory. This is based on a model of science that has as its chief characteristic *naïve inductivism* (Chalmers, 1982), an epistemological position widely regarded by philosophers of science as unsound (see, for example, Chalmers, 1982:2-11 and O'Hear, 1989:12-34). The idea therefore that any reasonable picture of the methods used by scientists could arise from such schemes is quite unrealistic, embodying as they do a picture of science that is rejected both by philosophers and by science studiers (the term used by Yearley (1994) "to embrace historians and the whole variety of social analysts of science"), and from within the science education community itself (Millar, 1989b; Selley, 1989).

At the end of the 1980s, the Education Reform Act of 1988 brought the introduction of a National Curriculum for science to all state maintained schools in England and Wales. Introduced in 1989, the statutory orders setting out what was to be taught consisted of 17 "Attainment Targets", one of which ("Attainment Target 1" or "AT1") was concerned with pupils' practical work. Influenced at least in part by the process science movement that had come before it, AT1 required pupils to undertake science investigations which were assessed. The model of science behind the investigations required by AT1 lay very much in the sphere of naïve induction, with variables to be controlled, varied and measured in

pursuit of testing a hypothesis. While pupils were required to assess the extent to which the data collected in a particular investigation could be regarded as “reliable” and thus to evaluate the strength of their conclusions drawn from it, there was no suggestion in AT1 that scientists’ science involves a process of evaluating knowledge claims within a social arena. Yet elsewhere in the orders (in AT17 – “Exploration of Science”) pupils were required to *be able to demonstrate that different interpretations of experimental evidence are possible*.

The introduction of this model of practical work, overlaid by a complex system of assessment, did not go smoothly, and revisions to the curriculum followed, the most radical being in 1991 (table 1.1). This introduced requirements relating to pupils considering different interpretations of experimental evidence as part of investigations which were to be based on accepted scientific knowledge. These two requirements brought about a conflict that even today, after two further revisions, teachers find hard to reconcile – if pupils’ investigative work is to be based on accepted scientific knowledge and is also to be assessed, what exactly is being investigated? As Donnelly observed:

What [do investigations] test: the scientific idea or the pupil’s experimental procedures? If, as must surely be the case, the latter, why make the linkage to the former at all? And if, as seems likely to have been the case, the established outcome was clear, in what sense was the investigation open?

(Donnelly et al., 1996:47)

1991	1995	1999
<p>Number of Attainment Targets reduced to four. AT1 and AT17 combined to produce “Sc1”. Students required to carry out investigations involving the relationship between variables, and to consider different interpretations of experimental evidence. Investigations must be based upon accepted scientific knowledge. Sc1 is based on three “strands” – <i>asking questions, hypothesising and predicting; carrying out investigations; and interpreting results and evaluating scientific evidence.</i></p>	<p>Preamble to the Programme of Study for each Key Stage is added. This sets a context within which the study of science is to take place:</p> <ul style="list-style-type: none"> • <i>science</i> • <i>scientific ideas</i> • This part of the science curriculum is dubbed “Sc0” by science teachers. It is not assessed directly, and therefore its impact on classroom practice is limited. <p>The three “strands” of Sc1 become four – <i>Planning experimental procedures; Obtaining evidence; Analysing evidence and drawing conclusions; and Evaluating evidence.</i></p>	<p>Principles of “Sc0” in 1995 revision combined with Sc1, requiring teachers to incorporate ideas about the nature of science into investigations and other teaching.</p> <p>Use of ICT in science curriculum compulsory. National Curriculum document includes <i>non-statutory guidance</i> highlighting “ICT opportunities” – examples of the use of ICT in teaching specific aspects of the science curriculum.</p>

Table 1.1 – revisions to the National Curriculum for Science

Science investigations are problematic due to the confusion in rôles demanded by teachers, reinforced by the statutory curriculum. At the same time as acting to provide a vehicle for the pupil gathering data to test a hypothesis or to understand the relationship between several variables, the practical work is also required to provide a warrant for belief, meaning that pupils’ science must not only get an answer which does not challenge scientists’ science, but must also do so using a plausible method.

Networked computers and CSCL

If recent publications dealing with the challenges to be met by science education in secondary schools have been consistently concerned with the rôle of practical work and

pupils' understanding of the nature of science, the literature relating to the use of computers in schools over the same period has been much less static. Largely this is due to the technological changes that have happened in this period; but also of importance is a developing understanding of the *affordances* (Mynatt et al, 1998; Conole and Dyke, 2004; Boyle and Cook, 2004) of computers in the context of the school science classroom.

CSCL in non-school settings

The birth of networked computing in 1969 (Zakon, 2004) provided technologists and educators with a new medium to explore for the purposes of bringing learners together. While the very earliest computer resources involved little more than knowledge representation and transmission (eg the MacMan medical simulations used in Canada in the early 1970s (Darby, 2002:17)), by the 1980s the opportunities offered by computer networks as a means of communication were becoming apparent. During this decade the distribution of videoconferencing data over computer networks became possible (Bretz, 1983:244), and by 1987 the introduction of the *Minitel* service in France had produced the world's largest email community, leading also to the establishment of social bulletin boards or *messengeries*, the first public, online communities (Lemos, 1996). Already this new medium had begun to be exploited for educational purposes, with a pedagogy unique to this setting beginning to emerge (Feenberg, 1987). It was, however, the introduction of the hypertext transfer protocol which brought about CSCL as a reality (Darby, 2002:17); the first Web server was established in the USA in 1991 (Gromov, 2003).

The following year, the fourth international research conference on computer supported cooperative work (CSCW) was held in Toronto; as implied by the title, the conference was concerned with the use of networked computers in workplace settings and their rôle in the "shift from an industrial to a post-industrial age" (Kumon, 1992). A similar optimism for the transformative rôle of computers pervades some writing about the potential for networked computers in learning from around this period, for example: "... this medium can be more effective than either the traditional classroom or one-way distance education delivery" (Hiltz, 1992:206); "... distance education systems should place more emphasis on active and cooperative learning strategies ... CSCL might well play a major role in this process" (Kaye, 1995:142). Whether this optimism was well-placed or not, the employment of CSCL in university courses at the start of the 1990s was certainly not limited to a few isolated courses (Hiltz, 1992:188).

During the following decade the rapid development of new technologies (both software and hardware) opened up the possibilities for CSCL. Reviewing the technologies for CSCL, McConnell describes four factors leading to wider use of CSCL, based on: accessibility of computer technologies at home and at work; the increasing sophistication and ease of use of software; increasing availability of access to networked computers; and the incorporation of the Web and the Internet into people's everyday lives (McConnell, 2000:67-68). This situation has given rise to the widespread adoption of CSCL in higher education, where course tutors and leaders are " ... in an enviable position of having a variety of media to choose from in the organization of teaching and learning" (McAteer et al, 2002). It is also the case in organisations outside education, for example, in industry:

Video-conferencing technologies are used in corporations to enable distributed groups to work together regularly without the need for frequent travel. On-line computer conferences and chat rooms provide ... additional ways to post materials and interact with students in large lecture classes.

(Ruhleder, 2002)

CSCL in schools

Despite the widespread adoption of CSCL in settings outside schools the implications of this new technology for school science teaching in the early 1990s was yet to be considered. At this time science educators working on the use of computers in teaching and learning science were concerned to develop software and techniques for data-logging, for simulating laboratory practical work and for small-scale databases (Kahn, 1985; Rogers, 1990; Lunetta & Hofstein, 1991). The absence of any significant interest in the use of networked computers at this stage to support science education is reflected in the ImpactT Report (King's College, 1993). Describing the outcomes of a two-year longitudinal study carried out in London schools between 1989 and 1991, this makes no mention of the use of networked computers in schools.

With the growth of the Web, the use of networked computers in schools for educational purposes appeared to grow during the 1990s and into the early part of the 21st century, according to official figures (table 1.2). Comparison between the figures over this period is difficult since the basis on which data were collected changed with a new administration in 1997; the emphasis in later years lay in measuring the growth of Internet connections with greater bandwidth, in connection with the government target of connecting all schools to the Internet via a broadband connection of 2Mbit/s or greater by 2006 (DfES, 2003:3). Nevertheless, the two surveys cited in table 1.2 clearly show the growth of computer

networks in schools over this period, although the more recent report provides no information concerning the nature of pupils' use of this equipment.

Although a high proportion of computers used for teaching and learning in secondary schools are connected to the Internet, the ImpaCT2 Report (Harrison et al., 2003) shows that these machines may not receive extensive use. Based on a survey of 60 schools in England carried out between 1999 and 2002, 31 % of pupils in Key Stage 3 reported "using ICT at least some weeks in lessons in 2001", while "30% reported using computers at home in some weeks" (Harrison et al., 2003:6); figures for Key Stage 4 were very similar. Much of this employment of computers in science appears to be "Internet use" (Harrison et al., 2003:33), but the report provides no further insight into the nature of this use other than to speculate as to the nature of the "research activities" to which this use may relate.

1996	2002-03		
<p>"In the secondary sector, the most commonly used service was electronic mail, used by 58 per cent of schools." (DfEE, 1997:18)</p> <p>"Pupils used WorldwideWeb [sic] and text only Internet services in 30 per cent and 20 per cent of schools respectively." (DfEE, 1997:18)</p>		2002	2003
	Secondary schools with Internet connection	>99%	>99%
	Connection by modem	1%	1%
	Connection by ISDN2	28%	9%
	Connection >128kbit/s <2Mbit/s	3%	5%
	Connection >2Mbit/s	68%	86%
	Proportion of computers connected to the Internet in schools:	2002	2003
	Teaching and learning	82.9%	86.5%
	Management	80.8%	87.3%
	(DfES, 2003:17)		

Table 1.2 – Government statistics for the use of computers in schools in the UK

Two sources provide further insights into the way in which computers are currently used in secondary science teaching. The first of these is a special edition of the Association for

Science Education's *School Science Review* (SSR) devoted to ICT in science education (Wellington, 2003b), and the second is a report of by the Office for Standards in Education (Ofsted) examining the effect of government ICT initiatives on the teaching of science in secondary schools in England and Wales (Ofsted, 2002). These two sources and their findings are described below.

The SSR special edition contains ten articles by teachers and researchers designed to argue the case that "ICT has made and can make a difference to science education, when used thoughtfully and reflectively" (Wellington, 2003a:39). Whilst there is no claim in this editorial piece that the articles are intended to comprise a complete review of all possible uses of ICT in science teaching, it is reasonable to assume that the intention of this collection is to cover the major areas of ICT likely to be of interest to science teachers and educators involved in working with pupils in secondary schools.

A survey of the articles in the SSR special edition produced the list of ICT applications shown in table 1.3, in which those relating to networked computers are marked with an asterisk (5 out of 13). The division of these uses of networked computers falls into two classes: searching for information and sharing/communicating information (table 1.4). This division has been noted by Fullick, in the context of motivating pupils to use the Internet for school science work where sharing/communicating information engages pupils more actively in making sense of scientific ideas than simply searching for information (Fullick, 1997).

<ul style="list-style-type: none"> • "Office" applications for worksheets and presentations • • • resources together with an online pupil portfolio * • • 	<ul style="list-style-type: none"> • • • • • • modelling and simulations
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------

Table 1.3 – uses of ICT in SSR no 309 on ICT in science teaching

Classification	Use
retrieving information	<ul style="list-style-type: none"> • • • resources
communicating/sharing information	<ul style="list-style-type: none"> • • •

Table 1.4 – classes of networked computer use in SSR no 309

The Ofsted report on the effect of government ICT initiatives on science teaching in secondary schools is based on school inspection evidence collected between May and December 2001 (Ofsted, 2002:4). It identifies three “principal approaches” to the use of ICT in science classrooms:

- ... *computer-linked instrumentation to support pupils’ practical work*
- *single computers and data-projectors or whiteboards*
- *computer suites for ... interactive software or information retrieval*

(Ofsted, 2002:5)

Only the third of these approaches employs networked computers, and simply in the sense of information retrieval, not information sharing. Nowhere in the Ofsted report is there any evidence to suggest that networked computers are used in secondary school science in the UK to encourage pupils to share their ideas with other pupils in a dynamic way – employing them to foster co-operative learning (McConnell, 2000). Surveys two years later also contain no mention of the use of networked computers in science lessons (Ofsted, 2004b) or in any other areas of the school curriculum (Ofsted, 2004a), all descriptions of computer networks relating solely to their employment in distributing access to hardware and software resources. The absence or near-absence of the educational use of networked computers in schools is a situation also found outside the UK (Lakkala, Rahikainen, & Hakkarainen, 2001:24).

Networked computers and science learning

The importance of the personal and social construction of knowledge in science classrooms was raised earlier in this paper, in the context of pupils making sense of the outcomes of science practical work.

In view of the influence of constructivism in science education (Driver, 1994; Leach & Scott, 2000; Scaife, 2000), the lack of any mention of CSCL in the literature relating to priorities for the development of school science education is surprising, since CSCL has a strong tradition of constructivism (Bannon, 1995:273). It is also some cause for concern, for two reasons.

First, as described in the earlier part of this paper, CSCL has been used to extend traditional learning communities in Higher Education and Continuing Education for some time. In addition to the straightforward provision of resources via the Web, online learning in these settings commonly makes use of tools that allows learners to communicate with one another in order to foster discussion and so encourage the social construction of knowledge – for example, the open source learning environment *Moodle* (Dougiamas & Taylor, 2003). The use of online learning environments in universities has been the subject of considerable research which could potentially be used to inform the development of computer networks as a tool for learning in schools (Lakkala, Rahikainen, & Hakkarainen, 2001).

Second, despite the fact that they do not commonly encounter computer networks as a means of actively communicating and sharing knowledge in school, children are making increasing use of them outside school. There is an emerging literature relating to children's out of school use of networked computers that shows that they make use of them to establish, maintain and develop relationships with other pupils, both known and unknown to them at school (Livingstone, 2002; Holloway & Valentine, 2003; Facer et al., 2003). Research conducted in 2001 suggested that at that time 20% of young people in the UK between the ages of 7 and 16 used chatrooms, and 12.5% used instant messaging programs (Cyberspace Research Unit, 2002); it therefore seems likely that a small but significant proportion of school pupils make use of networked computers as a communication tool, much as previous generations made use of the telephone; in fact, many young people see the primary purpose of their Internet use as keeping in contact with friends:

Children's motivations for going online centre on new opportunities for communication and identity play. While the conversational content is often mundane, being readily in touch with their friends is important to them.
(Livingstone & Bober, 2003:2)

(The proportion of school pupils using the Internet in this way has almost certainly grown since these results were published.) One study found that "... young people find some

forms of on-line communication more private and more intimate than off-line communication – they use MSN/IM [instant messaging software] to discuss personal problems, ask for advice from peers, etc.” (Media Awareness Network, 2004:12). This literature suggests that the lives of children in the UK today are intertwined inextricably with technology, a relationship that has been described as a “powerful association” in which children and technology are “natural bedfellows” (Facer et al., 2003:4).

In conclusion

The first part of this paper shows that an important current issue for science education research is the use of investigations and practical work as means of developing school pupils’ understanding of the nature of science. A particularly promising approach appears to be by means of discussion, engaging pupils in the active construction of meaning through language, creating knowledge that is new to the learners both in a sense that is both personal and collective (Sutton, 1996).

The second part of the paper provides a picture of the widespread adoption of CSCL outside formal school education, both in the social life of young people (as yet poorly-understood) and in formal and work-based education (where there is an extensive research literature). The extensive and growing body of research into the use of CSCL therefore provides an opportunity to inform enquiry into how it might be used as part of the school curriculum, to encourage pupils to participate in the joint construction of scientific meanings, extending discussions about practical work beyond the classroom using a medium in which many pupils already feel comfortable.

References

- Abd-El-Khalik, F. & Lederman, N. G. (2000) Improving science teachers' conceptions of nature of science: a critical review of the literature, *International Journal of Science Education*, **22**, 7, pp. 665-701.
- Bartholomew, H., Osborne, J., & Ratcliffe, M. Teaching Students "Ideas-About-Science": five dimensions of effective practice. *Science Education*. **88**, 5, pp. 655-682.
- Boyle, T. & Cook, J. (2004) Understanding and Using Technological Affordances: A Commentary on Conole and Dyke, *ALT-J, Research in Learning Technology*, **12**, 2, p. 122-nnn.
- Bretz, R. (1983) *Media for Interactive Communication*. London: Sage.
- Brickhouse, N. W., Dagher, Z. R., Shipman, H. L., & Letts, W. J. I. (2000) Why things fall: evidence and warrants for belief in a college astronomy course, in R. H. Millar, J. Leach & J. Osborne (eds.) *Improving Science Education: the contribution of research*, Buckingham: Open University Press, pp. 11-26.
- Chalmers, A. F. (1982) *What is this thing called Science? An assessment of the nature and status of science and its methods*. (Second edition.) Milton Keynes: Open University Press.
- Conole, G. C. & Dyke, M. (2004) What are the affordances of information and communication technologies?, *ALT-J, Research in Learning Technology*, **12**, 2, pp. 111-122.
- Cyberspace Research Unit (2002) *Young People's Use of Chatrooms: implications for policy strategies and programs of education*. Preston: University of Central Lancashire.
- Darby, J. (2002) Networked Learning in Higher Education: the mule in the barn, in C. Steeples & C. Jones (eds.) *Networked Learning: perspectives and issues*, London: Springer, pp. 17-26.
- DfEE (1997) *Statistical Bulletin Issue No 3/97 Survey of Information Technology in Schools 1996*. London: HMSO.
- DfEE (1999) *Science: The National Curriculum for England*. London: DfEE.
- DfES (2003) *Survey of Information and Communications Technology in Schools 2003*. London: DfES.
- Donnelly, J., Buchan, A., Jenkins, E., Laws, P., and Welford, G. (1996) *Investigations by Order: Policy, curriculum and science teachers' work under the Education Reform Act*. Nafferton: Studies in Education.
- Dougiamas, M. & Taylor, P. C. (2003) Moodle: using Learning Communities to Create an Open Source Course Management System (refereed paper presented at ED-MEDIA Conference, Hawaii 2003). Available from: <http://dougiamas.com/writing/edmedia2003/> [Accessed 14 May 2004].

- Driver, R. (1989) The Construction of Scientific Knowledge in School Classrooms, in R. H. Millar (ed.) *Doing Science: Images of Science in Science Education.*, Lewes: Falmer Press, pp. 83-106.
- Driver, R. (1994) The fallacy of induction in science teaching, in R. Levinson (ed.) *Teaching Science*, London: Routledge, pp. 41-48.
- Facer, K., Furlong, J., Furlong, R., and Sutherland, R. (2003) *ScreenPlay: children and computing in the home*. London: RoutledgeFalmer.
- Feenberg, A. (1987) Computer conferencing and the humanities, *Instructional Sciences* 16, pp. 169-186.
- Fullick, P. L. (1997) Using an online journal to teach students about science, in Z. Burge & M. Collins (eds.) *Volume 4: Writing, Reading and Language Acquisition*, Cresskill, NJ: Hampton Press,
- Gromov, G. R. (2003) Roads and Crossroads of Internet History: Part 4. Birth of the Web. Available from: <http://www.netvalley.com/intvalweb.html> [Accessed 10 May 2004].
- Harrison, C., Comber, C., Fisher, T., Haw, K., Lewin, C., Lunzer, E., McFarlane, A., Mavers, D., Scrimshaw, P., Somekh, B., and Watling, R. (2003) *ImpaCT2: The Impact of Information and Communication Technologies on Pupil Learning and Attainment*. London: DfES.
- Hiltz, S. R. (1992) Constructing a Virtual Classroom, in M. Lea (ed.) *Contexts of Computer-Mediated Communication*, Hemel Hempstead: Harvester Wheatsheaf, pp. 188-208.
- Hodson, D. (1988) Toward a Philosophically More Valid Science Curriculum, *Science Education*, **72**, 1, pp. 19-40.
- Holloway, S. L. and Valentine, G. (2003) *Cyberkids: Children in the Information Age*. London: RoutledgeFalmer.
- Kahn, B. (1985) *Computers in Science*. Cambridge: Cambridge University Press.
- Kaye, A. R. (1995) Computer Supported Collaborative Learning in Distance Education, in C. O'Malley (ed.) *Computer Supported Collaborative Learning*, Berlin: Springer Verlag, pp. 125-143.
- Kerr, J. F. (1963) *Practical Work in School Science: an enquiry into the nature and purpose of practical work in school science teaching in England and Wales*. Leicester: Leicester University Press.
- King's College (1993) *The Impact Summary*. London: Department for Education and King's College.
- Kumon, S. (1992), From Wealth to Wisdom: a change in the social paradigm, ACM 1992 Conference on Computer-Supported Cooperative Work: sharing perspectives, New York.
- Lakin, S. & Wellington, J. (1994) Who will teach the 'nature of science'? teachers' views of science and their implications for science education, *International Journal of Science Education*, **16**, 2, pp. 175-190.

- Lakkala, M., Rahikainen, M., and Hakkarainen, K. (2001) *ITCOLE Project: perspectives of CSCL in Europe - a review*. Helsinki: University of Art & Design.
- Leach, J. & Scott, P. (2000) Children's thinking, learning, teaching and constructivism, in M. Monk & J. Osborne (eds.) *Good Practice in Science Teaching: what research has to say*, Buckingham: Open University Press, pp. 41-56.
- Lemos, A. (1996) The Labyrinth of Minitel, in R. Shields (ed.) *Cultures of Internet: virtual spaces, real histories, living bodies*, London: Sage, pp. 32-48.
- Levinson, R. (ed.) (1994) *Teaching Science*. London: Routledge.
- Levinson, R. and Thomas, J. (eds.) (1997) *Science Today: problem or crisis?* London: Routledge.
- Livingstone, S. (2002) *Children's Use of the Internet: a review of the research literature*. London: National Children's Bureau.
- Livingstone, S. and Bober, M. (2003) *UK Children Go Online: listening to young people's experiences*. London: London School of Economics and Political Science.
- Lunetta, V. & Hofstein, A. (1991) Simulation and laboratory practical activity, in B. E. Woolnough (ed.) *Practical Science*, Milton Keynes: Open University Press, pp. 125-137.
- McAteer, E., Tolmie, A., Crook, C., Macleod, H., & Musselbrook, K. (2002) Learning Networks and the Issue of Communication Skills, in C. Steeples & C. Jones (eds.) *Networked Learning: perspectives and issues*, London: Springer, pp. 309-322.
- McConnell, D. (2000) *Implementing Computer Supported Cooperative Learning*. (Second edition) London: Kogan Page.
- Media Awareness Network (2004) *Young Canadians in a Wired World - Phase II*. Ottawa: Media Awareness Network.
- Millar, R. H. (1989a) Bending the Evidence: The Relationship Between Theory and Experiment in Science Education, in R. H. Millar (ed.) *Doing Science: Images of Science in Science Education*, Lewes: Falmer Press, pp. 38-61.
- Millar, R. H. (1989b) What is 'scientific method' and can it be taught?, in J. Wellington (ed.) *Skills and Processes in Science Education*, London: Routledge, pp. 47-62.
- Millar, R. H. (1991) A means to an end: the role of processes in science education, in B. E. Woolnough (ed.) *Practical Science*, Milton Keynes: Open University Press, pp. 43-52.
- Millar, R. H. (1998) Rhetoric and reality, in J. Wellington (ed.) *Practical Work in School Science: which way now?*, London: Routledge, pp. 16-31.
- Milne, A. A. (1928) *The House at Pooh Corner*. (Methuen Children's Books edition) London: Methuen.
- Monk, M. & Dillon, J. (2000) The Nature of Scientific Knowledge, in M. Monk & J. Osborne (eds.) *Good Practice in Science Teaching: What research has to say*, Buckingham: Open University Press, pp. 72-87.

- Monk, M. and Osborne, J. (eds.) (2000) *Good Practice in Science Teaching: what research has to say*. Buckingham: Open University Press.
- Mynatt, E. D., Day, V. L., Adler, A., & Ito, M. (1998) Network Communities: Something Old, Something New, Something Borrowed ..., *Computer Supported Cooperative Work (CSCW)*, **7**, 1-2, pp. 123-156.
- Nott, M. & Smith, R. (1995) 'Talking your way out of it', 'rigging' and 'conjuring': what science teachers do when practicals go wrong., *International Journal of Science Education*, **17**, 3, pp. 399-410.
- Nuffield Foundation (1964) *The Nuffield Foundation Science Teaching Project October 1964: progress report*. London: Longmans/Penguin Books.
- Nuffield Foundation (1999) *Beyond 2000: Science Education for the Future*. London: King's College.
- O'Hear, A. (1989) *An Introduction to the Philosophy of Science*. Oxford: Clarendon Press.
- Ofsted (2002) *ICT in Schools: effect of government initiatives - secondary science*. London: Office for Standards in Education.
- Ofsted (2004a) *ICT in Schools: the impact of government initiatives five years on*. London: Office for Standards in Education.
- Ofsted (2004b) *ICT in schools: the impact of government initiatives – secondary science*. London: Office for Standards in Education.
- Ratcliffe, M. (ed.) (1998) *ASE Guide to Secondary Science Education*. Hatfield: Association for Science Education.
- Rogers, L. (1990) IT in science in the National Curriculum, *Journal of Computer Assisted Learning* **6**, pp. 246-254.
- Ruhleder, K. (2002) Understanding on-line community: the affordances of virtual space. *Information Research* **7**[3].
- Scaife, J. (2000) Learning in Science, in J. Wellington (ed.) *Teaching and LEarning Secondary Science: contemporary issues and practical approaches*, London: Routledge, pp. 61-108.
- Screen, P. (ed.) (1986) *Warwick Process Science*. Southampton: Ashford Press.
- Sears, J. and Sorensen, P. (eds.) (2000) *Issues in Science Teaching*. London: RoutledgeFalmer.
- Selley, N. J. (1989) Philosophies of science and their relation to scientific processes and the science curriculum, in J. Wellington (ed.) *Skills and Processes in Science Education: a critical analysis*, London: Routledge, pp. 5-20.
- Solomon, J. (1991) Teaching about the nature of science in the British National Curriculum, *Science Education*, **75**, 1, pp. 95-103.
- Sutton, C. (1996) Beliefs about science and beliefs about language, *International Journal of Science Education*, **18**, 1, pp. 1-18.

- Swain, J., Monk, M., & Johnson, S. (2000) Developments in Science Teachers' Attitudes to Aims for Practical Work: continuity and change, *Teacher Development*, **4**, 2, pp. 281-292.
- Wellington, J. (1994) *Secondary Science: contemporary issues and practical approaches*. London: Routledge.
- Wellington, J. (2000) *Teaching and Learning Secondary Science: contemporary issues and practical approaches*. London: Routledge.
- Wellington, J. (2003a) Has ICT in science teaching come of age?, *School Science Review*, **84**, 309, p. 39.
- Wellington, J. (ed.) (2003b) *School Science Review: ICT in science education*. (84)
- Woolnough, B. E. (ed.) (1991) *Practical Science*. Milton Keynes: Open University Press.
- Woolnough, B. E. and Allsop, T. (1985) *Practical Work in Science*. Cambridge: Cambridge University Press.
- Wray, J. (ed.) (1987) *Science in Process*. London: Heinemann.
- Yearley, S. (1994) Understanding science from the perspective of the sociology of scientific knowledge: an overview., *Public Understanding of Science*, **3**, pp. 245-258.
- Zakon, R. H. (2004) Hobbes' Internet Timeline - the definitive ARPAnet and Internet history. Available from: <http://www.zakon.org/robert/internet/timeline/> [Accessed May 21 2004].