Evidence-based Practice in Science Education (EPSE) Research Network

Science Education Practitioners' Views of Research and its Influence on their Practice

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EPSE RESEARCH REPORT

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Executive Summary

This report presents the findings of an interview and focus group study which explored perceptions of educational research and its use amongst teachers of science and others engaged in science education. The rationale for the study arose from the significant and ongoing international debate about the claim that evidence should play a more significant role in the professional practice of teachers and in shaping educational policy and practice.

The aims of the study were to:

- obtain a better understanding of the extent to which science teachers, and others professionally engaged in science education, recognise and make use of educational research in the course of their normal practice;
- explore the factors which promote and inhibit the impact on practice of research on science teaching and learning;
- investigate some possible models for the involvement of teachers in shaping research agendas and identifying research priorities.

These aims were realised by conducting:

- a set of 62 interviews with primary and secondary science teachers (including 21 with experience of research) and 'others engaged in science education' (policy makers, pre-service and in-service teacher trainers, textbook authors and examiners). These sought to elicit interviewees' views on the nature of research in science education, the influence of research on their current practice, and the potential contribution of research to improving and evaluating practice.
- a set of 6 focus group discussions (three with primary teachers, and three with secondary teachers). These explored the extent to which teachers saw findings from science education research as convincing and persuasive of the need to change practice, and to clarify the issues which teachers thought might be addressed by research.

Four centres were involved in data collection and analysis — the Universities of York, Leeds and Southampton, and King's College London. Transcripts were analysed using a grounded-theory approach, to identify the major themes emerging themes. These concerned:

- Influences of educational research;
- Perceptions of educational research;
- Sources of research knowledge;
- Development and evaluation of professional practice.

Influences of educational research

Participants saw educational research as beneficial and influential on practice, though only a few felt it was a relatively major influence. Many saw research as a 'background' influence on practice — possibly quite substantial, but 'built in' to materials and routine practices and so implicit at the point of use.

The influence of research on practice fell into four categories:

1. specific (where knowledge of a research finding influences a specific piece of teaching);
2. general (where research is believed to lend support to some aspect of general teaching style or approach);
3. mediated (through using teaching materials produced by a research project);
4. indirect (through using teaching materials, or curriculum specifications and schemes of work that are considered to be informed by research).

Most of the examples given of the influence of research on practice were in categories 2 and 3.

Perceptions of educational research

From the interviews, there appeared no single, or even dominant, view of the criteria which made an activity 'research' in science education. Rather, different activities were seen as research by different interviewees, often on different grounds. About a third of interviewees saw both a clear purpose and a systematic approach as the defining characteristics of research, but the majority of interviewees focused on just one criterion. In general, teachers without research experience had quite limited notions of what constitutes educational research despite their wide-ranging comments on its purpose and methods.

In the focus groups, research was seen as convincing if it appeared generalisable to different contexts and came from studies with clear methods. Teachers' comments strongly suggested that a research finding would only stimulate a change in practice if it also resonated with teachers' experience.

Sources of research knowledge

Reading was seen as one primary source of knowledge of research, along with in-service training and interactions with colleagues. The activities of the Association for Science Education (ASE) appeared to play a key role in developing awareness of research and in disseminating research findings. A lack of time to read accounts of research, and the inaccessibility of many research reports in both location and style, were seen as barriers to impact of research. A few interviewees suggested that short research digests might help address these problems. Responses of focus group participants to short accounts of research studies, however, suggested that these raised doubts and further questions about the findings, and were rarely (if ever) seen as persuasive or wholly convincing of the need to make a change in practice.

Development of professional practice

In terms of research design, the emphasis of our interviewees and focus group participants on empirical enquiry and large sample size suggests that many use a 'natural science' model of research when assessing the quality of educational research. In contrast, when evaluating a change in their own practice, interviewees applied rather different criteria of quality — using professional judgement, 'gut feeling', and evidence of pupil response, rather than the rigorous methods and forms of evidence they demanded of reported research studies.

Personal experience of research appeared to make a marked difference to practitioners' awareness of research, and their confidence in assessing the significance and implications of reported research findings. Teachers with first hand experience of research appeared best able to marry the two

perspectives of research and practice — judging research evidence using criteria of quality that researchers might use, and evaluating professional practice systematically whilst still allowing a role for professional judgement.

Few participants seemed to have a vision of evidence-based practice — that detailed aspects of their own practice could or should be directly supported by a body of empirical evidence. Similarly few appeared to consider it likely that empirical evidence could show sufficiently clearly or convincingly that a specific teaching approach led in general to better learning outcomes, to cause them to adapt their own practice. The importance of professional judgement, tacitly acquired through experience, in deciding on changes in practice, was a consistent theme throughout the data.

Personal contacts between practitioners and researchers appeared to increase significantly the likelihood that research might influence practice. LEA advisors, Key Stage 3 Strategy Co-ordinators, ITT or CPD tutors, and colleagues with research contacts often appeared to act as a 'bridge' between the research and user communities. Meetings of the Association for Science Education were also seen as providing a very valuable forum in which practitioners and researchers could meet and exchange ideas, where their different contributions were recognised and valued.

Implications

The picture that emerges from these findings is of teachers of science who are willing to consider research evidence, but, unless already experienced in research, have a limited understanding of the processes of much social science research, and of the strength of the warrant for any knowledge claims it makes. Many science teachers set demanding criteria for 'research', which many studies would find difficult to satisfy. Many of our respondents appeared to set 'research' on a pedestal, and saw any actions of their own to evaluate changes in practice as a somewhat different category of activity. This dichotomy has implications for efforts to increase evidence-based practice in science education. Amongst the implications would appear to be that:

- teacher education (both pre- and in-service) should provide opportunities for teachers to reflect more deeply on the nature of enquiry in education, and to appreciate the differences between research in the social and natural sciences, so as to arrive at a more considered view of what science education research can offer, and of what might count as 'sound evidence' as a basis for action;
- researchers should adopt more rigorous and challenging designs in order to strengthen the warrants for their knowledge claims and the persuasiveness of implications drawn from them;
- researchers, ideally working with teachers, should translate (or perhaps more accurately re-work) their findings into teaching materials and approaches that can be implemented in the classroom and assimilated by teachers into their range of pedagogic practices.

Significantly increasing evidence-based practice is likely to require all three.

In summary, this study suggests that, for research findings to make an impact on classroom practice, they must have:

- *convincing* findings — i.e. from studies with clear, rigorous methods which seem likely to generalise to other contexts;
- which *resonate* with, or acknowledge, teachers' professional experience;
- and have been, or can easily be, *translated* into practical activities and strategies for classroom use;
- which are then widely disseminated through respected *professional networks*.

1 Background

1.1 Aims

The study had the following aims:

a) To obtain a better understanding of the extent to which teachers, and other user groups, recognise and make use of research findings in the course of their normal practice;
b) To explore the factors which promote and inhibit the impact of research in science teaching and learning on practice;
c) To investigate some possible models for the involvement of teachers in shaping research agendas and identifying research priorities.

These aims stemmed from the significant and ongoing debate about the role of evidence in the professional practice of teachers and other potential users of educational research. This research sought to explore these issues through a process of enquiry with *science* teachers, partly because there is a large body of published research available on aspects of science education, and partly because it was thought science teachers in general may, because of their own educational background, be receptive to the idea of evidence-based practice.

1.2 Evidence-based practice

The relationship between research and professional practice is a complex one. In the context of education, some have argued strongly that, in principle, there can be no general, predictive theories to guide practitioners' actions (Roberts, 1984; Bassey, 1986). In the UK, on the other hand, there has been an increasing demand that educational research should provide information on 'what works', in a form that can be applied directly by teachers (Barber, 1999), and more recently in the USA (Slavin, 2002). A recurrent analogy in this discussion is with evidence-based medicine, where practitioners' actions and decisions are based on accepted protocols, supported by explicit evidence (Hargreaves, 1996). The argument is that education should seek to move towards more evidence-based approaches of the same sort. As Slavin argues:

> *Modern automobiles use the internal combustion engine, just like the Model T, but modern automobiles are far more efficient and effective. Physicians could remove ruptured appendices at the turn of the century, but these operations are far less risky now. In these and hundreds of other cases, it is the accumulation of small advances rather than breakthroughs that led to substantially improved practice. This is how evidence-based policies will probably improve education* *[Slavin, 2002: 19]*

Key aims of this study were to explore the extent to which 'research' constitutes the evidence on which practitioners within science education draw in their educational practice and to explore the factors which facilitate and inhibit the use of research.

Calls for evidence-based practice raise a number of questions, including what is the exact nature of research evidence and to what extent can it provide users with knowledge on which to act? There have been some perceptions that much educational research is of low quality and does not (or cannot) inform practice and policy (e.g. Hillage et al., 1998; Tooley & Darby, 1998; Woodhead, 1998). In Taylor's (2002) survey of stakeholders in educational research capacity, many agreed with this view but drew attention to constraints surrounding the generation and use of high quality and useful research, including structural and funding mechanisms, methodological gaps

and shortage of quantitative skills amongst the research community. Another criticism is that educational researchers in general have been perceived as determining their own research agendas, under pressure to report in international journals and with a different focus to 'users' wishing for evidence to inform policy and practice (Davies et al., 2000). Taylor's study highlighted stakeholders' views of the current variety of educational research, with many bemoaning the preponderance of non-cumulative, small scale studies but also recognising this was often a product of funding and structural constraints within the educational research community.

A predominant interpretation of evidence-based practice is that only large scale randomised controlled trials (RCTs) can establish 'what works', and so provide a basis for future practice and policy (Fitz-Gibbon, 2000, Slavin, 2002). Evidence from RCTs and other large-scale systematic research projects can, it is argued, lead to findings that are generalisable to larger populations. Slavin (2002) argues that evidence-based policies and practice, based on rigorous experimental studies seeking to establish *causal* links between programme implementations and outcomes, have great potential to transform the practice of education, as well as research in education. Some, however, consider that the rich form of narrative evidence embedded in case studies may resonate more effectively with tacit professional knowledge (Simons, 2000), and hence, have greater credence with practitioners. Others (e.g. Robinson & Norris, 2001) suggest that 'generalisation' can be understood in different ways and that findings of small scale case studies can, in certain circumstances, reasonably be generalised to a broader population.

Thus, there continues to be considerable debate about the nature of 'evidence' in evidence-based practice — arguments which seem to prolong the battle between 'quantitative' and 'qualitative' methodologies as to which provides the 'better' evidence (e.g. Elliot, 2001). Kennedy (1999), among others, considers arguments over methodology and research genres as futile. In an interview study, she asked 101 teachers to consider a package of articles of different genres (experiment, survey, teacher narrative, case study disciplinary study). No one genre was seen as more persuasive than another. Rather it was other features of the studies which were seen as persuasive. These features included: a particular part of the evidence being particularly convincing; findings that were reinforced by teachers' own experience; the trustworthiness of the author; the overall logic or story line; and the detailed descriptions provided of teaching or of student work. Studies which were seen as most persuasive, most relevant and most influential to teachers' thinking were all studies which addressed the relationship between teaching and learning. Along similar lines, Morrison (2001) argues that judging 'what works' does not depend on empirical evidence alone, such as that from RCTs, but requires findings to be interpreted, weighed, judged and considered. Studies and arguments like these suggest the need to explore the research-practice interface more fully, concentrating on the *interpretation* of research findings and their integration with other knowledge sources of importance to professional practice such as teachers' professional knowledge. Indeed, from his study, Taylor (2002) concluded that stakeholders in educational research have 'little understanding of the mechanisms and processes in which research findings can be transformed into knowledge that can be applied to the daily work of users' (p. 68).

1.3 Professional knowledge

As professionals, educational practitioners have responsibility, autonomy and access to specialized bodies of knowledge (Furlong 2000). Different types of knowledge, each based on distinctive forms of evidence gathered from different sources, influence the actions of teachers and other educational practitioners (Brown & McIntyre, 1993; Loughran, 1999). First there is specific knowledge of the context in which the practitioner is working, including their knowledge of the other individuals involved. This is seldom formally codified and some of it may be tacit. At the other pole, there are

generalised knowledge claims arising from research about correlations and causes, some of which may be theory-based. By their nature, these are abstracted from the particularities of specific settings. As a consequence, it is difficult for a practitioner to judge how far the findings apply to his/her own context. Between these poles of specific context knowledge and generalised knowledge are accounts of other practitioners' practice, ranging from informal oral accounts to more formally documented case-studies. These retain specificity and are closer to practitioners' contexts, but require a judgement by the practitioner about how the information might relate to his or her own setting.

One of the features of much practitioner knowledge is that it is communicated through established practices, curricula and resources that embody decisions of the community of practitioners (for example, about the timing and sequencing of instruction, and about 'standard' methods and approaches). One consequence is that the knowledge becomes tacit and the supporting evidence 'invisible' (Barthes, 1972). Tacit professional knowledge may be used intuitively and thus difficult for individual practitioners to articulate explicitly (Eraut, 2000). Thus, determining the knowledge on which practice is based, or judgements made, is highly problematic for the researcher.

Moreover, if practitioners are to engage in development and change in practice, based on whatever evidence or knowledge source, they have to be able to reflect on their existing practice (Pollard & Triggs, 1997 p9). There are many frameworks of reflective practice which recognise the complexity of influences on practitioners (e.g. Schon,1983; Day, 1999). Some frameworks have been based on empirical evidence and evaluated by examining teachers' ability to articulate their reflections on observed practice. For example, Turner-Bissett (1999) developed a model in which a range of knowledge forms feature in contributing to pedagogical content knowledge. She used the model to illustrate the underpinnings of teachers' observed practice. The model identified contributory knowledge forms as including substantive, syntactic, contextual and self-knowledge, knowledge of learners, models of teaching, and knowledge of educational ends. In a similar vein, Pritchard (2003) developed and evaluated a framework of reflective practice, suitable for use in informing professional development. He interviewed 4 novice and 4 experienced science teachers, observed their practice and gained feedback from their pupils in evaluating and modifying the framework, which included similar knowledge forms to Turner-Bissett's but, in addition, an overarching values dimension. In neither Turner-Bissett's nor Pritchard's framework does research knowledge and evidence feature.

In contrast, Barnett and Hodson (2001) propose that exemplary science teachers use four kinds of knowledge — academic and research knowledge, pedagogical content knowledge, professional knowledge and classroom knowledge. They contend that exemplary science teachers can recognise the boundaries of these types of knowledge and switch quickly and effectively between them in their professional practice, which itself exists in different 'micro-worlds' (science education, teacher professionalism, science curriculum and the particular school culture). Barnett and Hodson's framework was developed following an in-depth interview study of 6 exemplary science teachers. They were able to determine the frequency of use of different types of knowledge statement by teachers in describing and evaluating their practice. Just under 20 percent of comments related to academic and research knowledge with 0.5% related to general educational research knowledge and 1.5% related to specific educational research knowledge. This finding suggests that, although research knowledge is used, it is not as salient a source as pedagogical content knowledge or professional knowledge.

In summary, then, it would seem that all of these frameworks attempt to acknowledge and capture the complexity of individual practice. They suggest that evidence-based practice is not just a case

of being convinced that the given evidence will improve practice but rather a complex process of integrating such evidence into existing knowledge and practice. In our work, we did not seek to evaluate models of reflective practice but to explore the extent to which research processes and research evidence might fit into this complex web of action. However, we have assumed that practitioners have the *ability* to reflect on their own practice in our interview and focus group based study, even though tacit knowledge may sometimes be difficult to articulate.

Finally, in undertaking this research, it should be noted that there are other personnel, besides teachers, engaged in professional practice in the science education community. Curriculum policy-makers, teacher educators and textbook authors both create, and draw upon, the variety of knowledge sources indicated in frameworks of reflective practice. These groups are, therefore, also potentially important 'users' of evidence from research, as their articulation of the requirements of practice through curriculum specifications, or in widely used texts can be a considerable influence on teachers' classroom actions and decisions. Hence, these 'other science education practitioners' were included in our study.

1.4 Use of research knowledge

Although, there has been some previous research which has attempted to explore the extent of influence of research knowledge on practice, normally through voluntary completion of questionnaires, the findings would appear to conflict. On the one hand, some studies draw attention to the lack of research literature and experience in teachers' normal professional development and practice (e.g. Shkedi, 1998; Costa, Marques & Kempa, 2000). On the other hand, some consider the potential and impact of research to be generally positive. Galton's (2000) study of 302 questionnaires returned from distribution within two professional newsletters and a large Australian study (DETYA, 2001), using questionnaires, surveys and interviews, show practitioners' positive disposition to research evidence, particularly from those with senior management positions in schools. However, Kennedy's (1997) review of research suggests that teachers give most credence to research findings which accord with existing beliefs. She proposed that 'research that is conceptually accessible to teachers may be research that does *not* challenge assumptions or introduce new possibilities' (p. 10). This could be research that 'further reinforces the stability of the education enterprise rather than research that challenges assumptions or offers new insights' (ibid.). Development from existing practice is also supported by the Australian study (DETYA, 2001) which found that 'teachers seek out the sources they believe will build on their existing knowledge and that this was a very individual process' (p. 2). Thus, these findings would suggest that the specific nature of research evidence and channels of communication/dissemination may be important influences on the extent of use of research evidence.

One method of enabling teachers to understand the nature of research evidence is to engage in small scale research during initial or in-service training. There have been several initiatives in recent years to encourage teachers in England to undertake action research, through government funding of consortia involving schools and higher education institutions, and through bursaries to individual or small groups of teachers. Teachers' involvement through action-research adds another dimension to reflective practice. Do such teachers have better access to and use of research evidence? There is some existing evidence that this might be the case. McNamara (2002) conducted a baseline questionnaire study, with 100 respondents, within a consortium of 8 schools in the North-West of England embarking collaboratively on school-based action research. This survey showed a range of perceptions of research, with some prominent themes, such as work undertaken by academics being seen as out of touch with real classrooms, and data collection and interpretation seen as technical and statistical. After engagement in the action research consortium,

the teachers were canvassed again, this time with a lower response rate. These responses showed a more positive view of the potential and impact of research than in the baseline survey, with the major benefits from involvement in action research seen as professional development, pupil gains in learning, and increased self-confidence of staff. Evidence from other action research consortia also suggests that teachers are more ready to engage with research generated by others once they have had experience of either doing research themselves (Elliott, 2000), or working closely with peers engaged in action research (Cordingley, 1999). Given these emerging findings from those engaged in action research, one of our intentions in this study was to explore and compare reactions of those who have been involved in educational research with those who have not.

Therefore, for the reasons outlined above, we considered it is timely to explore the impact and potential of research among a particular group of practitioners – those engaged in *science* education. Teachers in one discipline were chosen as some of the research described above, has treated teachers as a homogeneous population, and not discriminated according to the discipline and nature of teaching undertaken. *Science* teachers, for instance, have been encultured into a discourse which gives pre-eminence to the value of empirical data as a justification for belief and action, and might therefore be expected to be more receptive to the implications of educational research individually, or as a community. On the other hand, their grounding in the methodologies of the exact sciences may make them highly sceptical of more qualitative social science methodologies.

Finally, some studies have relied on data collection through questionnaires, which are limited in the extent to which reasoning and views can be probed. In our study, we thus adopted a combination of interview and focus group study seeking to explore views in depth, comparing and triangulating results from these two data sources.

2 Research methods

2.1 Research design

Our basic approach to answering our questions was to conduct a set of 62 interviews with primary and secondary science teachers and 'others engaged in science education'. In addition, we conducted a separate set of 6 focus group discussions with primary and secondary teachers — three of primary teachers, three of secondary teachers.

The interviews and focus groups were complementary in their objectives. The interviews sought to explore how individual practitioners viewed research processes and evidence. Interview questions explored perceptions of the nature of research in science education; the influence of research on current practice and any contribution of research to improving and evaluating practice. A sub-sample of teachers with research experience was deliberately included in the interview sample, to compare perceptions of those with and without research experience and clarify, in addition, what role teachers might have to play in research. The focus groups were set up, in contrast, to explore the extent to which findings from science education research were seen as convincing and persuasive of the need to change practice and to clarify the issues which might be addressed by research. Four centres were involved in data collection and analysis — the Universities of York, Leeds and Southampton, and King's College, London.

2.2 Interviews — data collection

Teachers' perceptions on the nature and use of research may be influenced by their prior experience of educational research. Thus we deliberately chose two different populations of science teachers to sample:

- teachers with no formal experience of education research
- teachers with experience of research, most commonly (though not exclusively) within the context of an MEd or MA course.

We were concerned not to bias the sample towards those who might make greater use of, or hold more positive views about, the role of research in informing their practice, but to collect the views of a cross-section of experienced teachers. Thus teachers were approached randomly but care was taken to ensure that there was an equal mix of primary science co-ordinators and secondary science teachers with a lack of bias towards one particular sex in the sample as a whole. With the sample of secondary science teachers a roughly equal mix of subject specialisms — biology, chemistry, physics — was also sought. Teachers with experience of research were targeted more purposefully, by approaching those who were known to have undertaken a Masters course or engaged in research in some way.

In addition to teachers we also approached other science education practitioners — curriculum policy-makers, textbook authors, curriculum materials developers, teacher educators, examiners — who are also potentially important 'users' of research evidence and whose professional outputs may have a significant influence on teachers' practice. Thus the interviews were conducted with a sample of 62 science education practitioners:

A. Experienced science teachers with no formal experience of research (21 — ten primary and eleven secondary).

B. Experienced science teachers with some experience of research, (20 — 8 primary and 12 secondary).
C. Others engaged in science education (21 — four curriculum policy makers (e.g. from QCA, OFSTED), four textbook authors, four leading participants in recent science curriculum development projects, eight providers of initial and in-service training from the HEI, LEA and independent sectors and one chief examiner (several others in the sample also had examining experience)).

For the sake of simplicity, the term 'others engaged in science education' will be used throughout this report to refer to sample C.

Through semi-structured interviews of 30-40 minutes duration, we explored participants' perceptions of research on teaching and learning in science, and its impact on their practices. Each member of the research team conducted a number of interviews with consistency being established through prior discussion of a transcript of a pilot interview. The outline of the interview schedule for samples A and C is shown in Figure 2.1.

The first two questions sought interviewees' perceptions of the influence of research on their practice. We anticipated that research evidence is only one factor affecting practice and, in some cases, a minor influence. Thus the wording in the first two questions sought to explore where research evidence might fit into the multiplicity of influences on professional practice, such as those identified by previous research (section 1.3).

We deliberately did not define 'research' at the beginning of the interview, but rather sought participants' initial perceptions of the role of research in shaping their own everyday practice. To establish more clearly how participants viewed research, the third question took the form of a Card Sort. Each card showed an activity that may or may not be construed as research (Figure 2.2). All the activities summarised on the cards involved the gathering and analysis of data, but conducted for different purposes and by personnel of different status. Interviewees were asked whether they would classify each activity as research or not. The significance of their responses lay not so much in the choices as in the reasons for their choices.

Question 4 then explored the sources to which participants thought they would look for ideas to improve their practice, and the place of research amongst these; and question 5 asked participants how they would evaluate a change in their practice. The aim here was to see what kinds of evidence were seen as most salient in judging the outcomes of changes made.

Question 6 attempted to broaden the discussion and explore the wider and longer term potential for research in improving science education. And, as background information to illuminate answers to earlier discussions, Question 7, which sought to elicit sources of research knowledge, was asked to round off the interview.

For sample B, that is teachers with research experience, the interview schedule was modified slightly. Participants were initially asked to explain their contact with research. In addition, question 2 was modified to explore the extent of the influence of *their* research on other people. They were also asked at the end 'What changes would enable educational research to make more of a contribution to the everyday practice of science teaching?' as it was felt that their engagement with research would enable them to offer a more informed view of its potential to inform practice and of the factors which facilitate and inhibit this.

1. Do you think that anything you do in your teaching — either in the classroom or in your preparation — is influenced by research?

   If YES:
   • Can you give me a few examples?
   • How large an influence is research? Is it a large influence or a relatively minor one?

   If NO:
   • What do you think, then, are the main influences on how you teach?
   • Why does research not influence your practice?

2. [Wording of Q2 depends on what has been said in answer to Q1]: You mentioned things like *the National Curriculum; the textbooks/schemes of work that you use; the examination syllabuses you follow* as the main influences on how you teach. Do you think that these are influenced by research?

   OR

   I suppose much of your teaching is influenced by things like *the National Curriculum; the textbooks/schemes of work that you use; the examination syllabuses you follow* as the main influences on how you teach. Do you think that these are influenced by research?

   If YES: Ask for examples.
   If NO: Ask what they think these **are** influenced by.

3. We have been talking about research. It might be useful to clarify exactly what we are counting as research. Could you look at these cards, and say for each of them whether the kind of thing that is described on the card is, in your view, **research**.

   CARD SORT here.

   Follow up questions:
   Can you say in a sentence what is the common feature of the ones you regard as research? What is the characteristic that makes them research?
   What is it about the ones you don't regard as research that puts them in the 'not research' category?

4. If you want to improve your science teaching in some way, where would you go to for ideas or guidance?

   Would research have a role to play in this?
   Would this be a major role, or a relatively minor one?

5. We have been talking about improving science teaching. If you or a colleague make a change in something you do, how do you decide if is an improvement?

6. What contribution, if any, could research make to improving the overall quality of school science education? I'm not thinking here just of your own teaching, but of the whole business of school science education.

7. Can I ask you one final question: Where does your knowledge of research come from?

▲ **Figure 2.1 Interview Schedule**

1. A researcher is testing a new 'Thinking Skills' course. The course is being taught to several classes. The children's performance on a test of thinking skills is being compared to that of several control classes which are similar to the others, but who have not been taught the course.

2. A group of OFSTED inspectors are observing teaching and documentation in a school, and writing an inspection report.

3. QCA are reporting on a KS2 Test paper for science / An examination board is reporting on a GCSE science paper, discussing the performance of the pupils on each question.

4. A teacher is administering and marking an end-of-topic test, and using the data to produce a spreadsheet showing pupil marks on each question, to discuss with colleagues in the school / science department.

5. An LEA science adviser/inspector is carrying out a survey to find out about the computer facilities and resources in schools / science departments in the authority.

6. A researcher is visiting a classroom to carry out a detailed study of the actions and discussions of two groups of pupils as they carry out a science investigation, leading to a fully-documented report on how each group went about the task.

7. A teacher is using a set of questions to evaluate pupils' understanding of electric circuits before teaching the topic, and then using the same questions afterwards to see how they have progressed.

▲ **Figure 2.2 Activities used in Card Sort task**

2.3 Focus Groups — data collection

Three focus groups of primary teachers, and three of secondary teachers were used in this research. Like the teachers approached for interview, focus group participants were invited randomly from those within travelling distance of the universities of York, Leeds and King's College, London. Each focus group had 6-8 members and the discussion lasted about 90 minutes. The focus groups explored the extent to which research findings were seen as convincing and encouraged any change in practice. The discussion aimed to establish teachers' perceptions of the extent to which research can provide general guidelines for practice (can tell us 'what works'), and their views on what counts as 'evidence' in relation to their everyday practice. To focus the discussion eight vignettes of real examples of educational research were constructed, each about one page in length, selecting a range of foci and type. Figure 2.3 shows a summary of each vignette and Figure 2.4 shows one full example (number 6). For most examples (1, 2, 3, 5 and 7) the focus was on an aspect of science education considered to be of current importance e.g. conceptual understanding; investigative skills. Two examples (4 and 6) focused on more general issues of pedagogy, such as wait-time and assessment practices. We selected studies which ranged in methodology from a case study (number 3), through descriptive surveys (5 and 7) and surveys followed by focused treatment (2 and 4) to experimental studies (1 and 6). Each study had implications for practice in science education, and each vignette contained a reference to a published source, commonly a journal article or research report.

1. New science lessons improve pupils' grades in science, maths and English
GCSE grades in 9 schools were compared between 12 'test' classes, who experienced 30 'Thinking Science' lessons, and their matched 'control' classes in the same school. The 'test' classes consistently performed better.
Source: Adey, P. & Shayer, M. (1994). *Really Raising Standards: Cognitive Intervention and Academic Achievement.* London: Routledge.

2. Teaching about dissolving 'has wrong emphasis', say researchers
Outcomes of a given test to 66 Year 8 pupils showed their lack of understanding of conservation of mass. A teaching scheme was designed to address this particular misconception resulting in the vast majority showing correct understanding.
Source: Johnston, K & Scott, P. (1991). Diagnostic teaching in the science classroom: teaching/learning strategies to promote development in understanding about conservation of mass on dissolving. *Research in Science and Technological Education,* 9 (2), 193-211.

3. Less able pupils learn to formulate scientific arguments by investigating questions that they generate themselves.
A case study of 5 students in a 'lower track' science class reports a transformation in pupils' ability to formulate scientific arguments following an experimental teaching sequence.
Source: Yerrick, R.K. (2000). Lower track science students' argumentation and open inquiry instruction *Journal of Research in Science Teaching,* 37 (8), 807-838.

4. Waiting for a response improves children's thinking
Data from 394 science lessons showed wait-time rarely exceeding 3 seconds. 96 teachers were trained to extend wait-time, resulting in longer and more unsolicited responses and increased quality of reasoning from pupils.
Source: Rowe, M.B. (1974). Wait-time and rewards as instructional variables, their influence on language, logic and fate control: part one — wait-time *Journal of Research in Science Teaching,* 11 (2), 81-94.

5. Young children's limited understanding of their own bodies
From completing a silhouette to show the inside of their bodies, 122 young children (age 5-11) showed a range of misunderstandings, some of which are illustrated.
Source: Osborne, J.F., Wadsworth, P., & Black, P.J. (1992). *SPACE Research Report: Processes of Life.* Liverpool: Liverpool University Press.

6a. Comments and no marks improve students' achievements
A study of 44 pupils (22 high achievers and 22 low achievers) showed that those with constructive comments on coursework did better on subsequent similar tasks than those with marks and comments or those with marks only.
Source: Butler, R (1988). Enhancing and undermining instrinsic motivation: the effects of task-involving and ego-involving evaluation of interest and performance. *British Journal of Educational Psychology,* 58, 1-14.

6b. More Studies show Comments and No Marks Improve Students' Achievements
A second study by Butler, using 159 year 2 and year 6 children, supports the first, showing that when tasks are engaged in for their intrinsic interest children will much more readily seek help and act on it. Other research supports this finding.
Sources: Butler, R., & Neuman, O. (1995). Effects of Task and Ego Achievement Goals on Help-Seeking Behaviours and Attitudes. *Journal of Educational Psychology,* 87 (2), 261-271. Boulet, M., Simard, G., & De Melo, D. (1990). Formative Evaluation Effects of Learning Music. *Journal of Educational Research*, 84 (2), 119-125.

7. Investigation tasks lack variety, say researchers
From a survey of 600 primary and secondary schools, over 82% of all Sc1 investigations were found to be of the 'fair-testing' variety.
Source: AKSIS project (1998). Unpublished report to the project Advisory Committee.

▲ Figure 2.3 Summary of vignettes of science education research used in focus groups

6a. Comments and No Marks Improve Students Achievements

Ruth Butler, a psychologist from the Hebrew University of Jerusalem has found in an experiment that pupils do better if teachers only put comments on their work and not marks.

Her study involved 132 low — and high-ability pupils in twelve year 5 and year 6 classes in 4 schools. Data were then analysed for 44 pupils in the sample (22 high achievers and 22 low achievers).

Pupils were given two tasks that involved constructing words from different letters. The tasks differed in their design to reduce boredom and practice effects. All pupils had the same teaching, the same aims and the same classwork. Performance on the tasks was then scored. Feedback, after the first task, consisted of three different types: a) marks only, b) comments only, and c) marks and comments. Comments consisted of simply one sentence which provided constructive suggestions of how to improve their work. The effects are summarised in the table below.

Feedback	*Gain*	*Interest in Task*
Marks only	None	High achievers +ve Low achievers -ve
Comments only	30%	Both groups +ve
Both Marks and Comments	None	High achievers +ve Low achievers -ve

Butler argues that the research shows that marks are simply an ego-reinforcement — those who do well getting a positive ego boost whilst those who do badly simply have their self-esteem knocked. Comments, in contrast, provide useful corrective feedback and focus on the task, not the individual achievement. When comments and grades are both provided, it's the grade that gets remembered and not the comment as the ego can still get knocked. Butler thinks the findings have a clear message for teachers' marking practices.

Source: Butler, R. (1988). Enhancing and undermining intrinsic motivation: The effects of task-involving and ego-involving evaluation of interest and performance. *British Journal of Educational Psychology,* 58, 1-14.

▲ **Figure 2.4 Full example of one research vignette**

Participants received seven of these vignettes in advance and questions in the focus group (Figure 2.5) stimulated discussion on:

- whether they were familiar with the research outlined in the vignettes;
- the extent to which they found the research convincing, or credible – and why;
- the ways in which the research outlined in the vignettes was likely to influence their practice.

The eighth vignette (6b), which had a further study on the effectiveness of different types of feedback to pupils, was introduced during the focus group discussion to test whether additional research evidence would lead participants to re-evaluate the significance of the original research — our thinking being that successive studies with similar outcomes might be found more convincing by teachers.

1. Have you heard of any of these research findings or ideas before? Which ones?

2 . Which of the research summaries did you find most convincing?
   • What was it about this research that you found convincing?
   • (To others in the group who did not find this research convincing). What was it about this research that did not convince you? What additional information would you require to be convinced?

3. Which of the research summaries did you find least convincing?
   • Why did you find it unconvincing.
   • Encourage discussion about vignettes where there is disagreement.

4. *At this point, hand around additional vignette entitled 'More Studies show Comments and No Marks Improve Students' Achievement. Give them time to read this and then ask.*
   • What difference does this additional material make to the view you formed of this research from reading the original summary?
   • Why?

5. Which of the research findings would be most likely to influence your practice?
   • In what way(s) would it influence your practice?
   • How would you convince other teachers in your school of the value to their practice of this research?

6. Which of the research findings would be least likely to influence your practice? Ask 'Why not?' if not clear from earlier responses.

▲ Figure 2.5 Focus Group Questions

In addition to the questions about the research vignettes, focus group participants were asked to rate individually, and then discuss, four polar statements about the nature and potential of education research (Figure 2.6). These four statements were constructed as polar to encourage discussion of potentially contentious issues about research, that is — the nature of research findings as seen by teachers; the generalisability of particular research findings; whether research findings can provide practical guidance in areas of national importance; and whether research has a role in teacher development.

1. Most of the results of educational research provide new insights. They add new knowledge.	1 2 3 4 5	Most of the results of educational research are obvious. They are things we knew already.
2. You can usually take the findings from research done in fairly typical classrooms and apply those findings in other classrooms.	1 2 3 4 5	Schools, teachers and learners are so different that there are always problems in applying research findings in classes that were not involved in the research.

(continued)

3. A major issue for science teachers is enabling pupils to do well on national measures of achievement in science. Research findings CAN help us improve pupils' test scores.	1 2 3 4 5	A major issue for science teachers is enabling pupils to do well on national measures of achievement in science. Research findings CANNOT help us improve pupils' test scores.
4. Good science teachers are born, not made. Although people get better with experience, you cannot significantly improve people's teaching with insights from research.	1 2 3 4 5	Even though some science teachers may have more 'natural talent' than others, research provides insights that can help teachers to improve their practice.

▲ **Figure 2.6 Focus group discussion statements**

2.4 Data analysis

The work produced 3 data sets: a set of transcripts of 41 interviews with a range of potential users of research; a set of transcripts of interviews with 21 teachers who had been involved with research and a set of transcripts of 6 focus group discussions. The transcripts were analysed using a grounded-theory approach (Strauss & Corbin, 1994) in which the transcripts were scrutinised iteratively and reflexively for major emerging themes. A qualitative data software package (NUD*IST NVivo) was used to assist in the mechanics of coding and to allow exploration of emerging themes in relation to the sub-samples of interviewees.

The set of codes reflected the issues emerging from the data and the main themes explored:

- Users' perceptions of research including attributes of research, nature of convincing and unconvincing research; knowledge sources for research;
- Barriers and opportunities in using research;
- The potential of research in influencing science education;
- The perceived influences of research on practitioners' own practice;
- Evaluating changes in own practice.

Four researchers coded the transcripts, concentrating initially on data collected at their centre. Inter-researcher reliability was established through blind coding of two interviews and comparison which showed that, initially, 80% of codes were used in a consistent way across researchers. Use of codes with lower consistency was resolved by discussion and comparison of additional transcripts. The coding of a focus group by one researcher was subjected to common scrutiny to add further consistency in coding across focus groups. After coding, the coded data from each of the four centres was merged. Each of the four researchers used the whole data set to establish findings in relation to one of the main themes above. This also allowed another check on consistency of coding across the data set, as the whole data set for one sub theme was examined for consistency by one individual. Each researcher's discussion of findings was then subjected to further checks by another researcher of the coded data set.

3 Overview and structure of this report

3.1 Structure of the report

The 62 in-depth interviews and six focus group discussions undertaken for this research resulted in a large body of data. Since the interview questions and stimulus tasks for the focus groups were designed to explore the relationship between research and practice from several inter-related angles, points were often repeated by respondents in slightly modified forms and revisited from different perspectives. So, whilst the interviews and the focus-group discussions were shaped by the interview schedule and the stimulus tasks respectively, subjects' responses often did not divide neatly into discrete and self-contained responses to each issue.

To minimise repetition, however, this report does not discuss each interview question and focus group task in turn. Instead, it explores four groups of key questions in the following four sections about the research-practice interface, all of which underlie our research aims (see p. 1). The questions and their rationale are as follows:

1. ***Do science teachers (and other science education practitioners) see research as having an influence on science education practice and/or policy? If so, how large an influence is it (relative to others), how is this influence exerted and what kinds of change result?***

   For those practitioners who consider themselves, to some extent at least, informed about research, there are two possible ways in which they might see it as influencing their practice — directly through changes they themselves make to their teaching methods and materials as a result of hearing about a specific research finding; or indirectly through using teaching materials, resources, tests, examinations and other science education policy documents that they believe to be informed by research findings. Both were mentioned in many interviews. In either case, we sought to explore whether teachers of science saw research as a major or minor influence amongst the various factors that shape their day-to-day work. We also sought to clarify what practitioners have in mind when they claim that research has an impact on their practice, by discussing a few examples, and exploring the ways in which users consider an aspect of their practice to have been changed in the light of research. Answers to these questions, reported in section 4, addressed another part of our first aim – clarifying the extent to which practitioners 'make use of research findings in the course of their normal practice'.

2. ***Are science education practitioners aware of, and informed about, science education research? If so, where do they consider their knowledge of research comes from?***

   A necessary, though not sufficient, condition for research to influence practitioners' actions and decisions is that they are aware of, or knowledgeable about, potentially relevant research. A significant point of our enquiry, therefore, was to ask if the practitioners involved in this study appeared to be aware of, and informed about, science education research and, if so, the sources of their knowledge of research. Such information was an essential prerequisite before exploring 'the factors which promote and inhibit the impact on practice of research on science teaching and learning' as if teachers are not aware of research it clearly has little potential to affect their practice. The answers to these questions provided information relevant our first aim, to determine whether or not users 'recognised' research findings.

3. What counts as 'research' for science education practitioners, and what features of a research study are seen as making it 'good' research?

In the interviews and focus group discussions, we began by assuming a shared understanding of what constitutes 'research in science education'. However, we were aware that such assumptions are often a source of miscommunication and misunderstanding between the research and practitioner communities. It was important, therefore, as the interviews progressed to probe practitioners' views of what constituted research, and to explore what were perceived to be the characteristics of 'good', or 'convincing', research studies. The answers to these questions are explored in section 6.

4. What factors influence users' decisions to change, or not to change, their practice in the light of knowledge of research findings, or the availability of research-informed materials?

Only if research is acknowledged to provide sound evidence, however, will practitioners be prepared to consider its implications for their existing practice. Additional factors other than the perceived quality of the research may influence whether or not a piece of research results in any change in practice or policy. Amongst these factors, reported in section 7, are: whether or not the findings reported are considered likely to apply to the practitioner's own work context; whether a practitioner can identify practical implications of a particular research finding; and specific characteristics of the practitioner's work context (such as the views of colleagues). This question also provided further insights into practitioners' disposition towards the idea of research-informed practice and their views of its feasibility, which helped us to address our second aim: to understand better 'the factors which promote and inhibit the impact on practice of research on science teaching and learning.'

The report then considers separately two further issues, raised by the responses to specific interview questions, which lie at the heart of what it might mean for teaching to become more 'evidence-based'. The first concerns how teachers judge the success, or otherwise, of changes they make to their practice for whatever reason (section 8). The core idea of 'evidence-based practice' is that such judgements are sounder if based on the kind of evidence that research can provide. So, we asked, what kind of evidence do practitioners commonly use as a basis for their judgement and what does its nature and extent tell us about the basis of professional judgement in science teaching? In addition, by asking practitioners how they make such judgements, we were able to compare the methods and criteria they think appropriate for assessing aspects of their own practice, and those they apply to other research findings that they may hear about — finding a disparity which we think is revealing. The second issue concerns practitioners' views about the potential for research to influence practice to a greater extent than at present (section 9). We asked respondents about this issue, partly to probe their disposition towards the idea of research informing practice, and as an additional means of getting insights into the ways in which, and the extent to which, they thought it might be possible for research to influence practice and policy. Answers revealed some additional factors, other than those discussed in our consideration of the four major groups of questions above, that hinder or impede the contribution of research to practice.

The final section of the report then draws together some key points from the preceding discussion to reflect on the extent to which science education could currently be said to be 'evidence-based' or 'evidence-informed' ('evidence' here meaning 'evidence arising from research') — and the possibility that it could become more so. This addresses our third aim of exploring how research might make

a stronger contribution to practice and how practitioners might make a stronger contribution to shaping research agendas and priorities.

3.2 Reporting conventions

In the extracts from interviews and focus group discussions that are cited in the sections which follow, the following conventions are used:

- All subjects' names are pseudonyms.
- P1 indicates a primary teacher with no research experience.
- S1 indicates a secondary teacher with no research experience.
- P2 indicates a primary teacher with research experience.
- S2 indicates a secondary teacher with research experience.
- SEP indicates the quote is by a science education practitioner other than a teacher, i.e. a curriculum developer, INSET provider, textbook or curriculum materials author, examiner, or policy maker.

The paragraph number after each quotation indicates where the passage quoted can be found within the whole transcript of the interview or focus discussion.

4 The influence of research on practice

4.1 Introduction

The opening question of the interview asked directly: 'Do you think that anything you do in your everyday practice is influenced by research?' The precise wording varied depending on the nature of the interviewee's work in science education. For teachers, the question asked explicitly about influence on both classroom actions and preparation. Follow up questions then asked for examples of the impact of research on everyday practice, or about influences on practice other than research. The discussion often broadened to explore the range of perceived influences on practice, the sources of knowledge of research, and the communication channels by which individual practitioners became aware of research findings. The latter issues are explored more fully in section 5. This section focuses on perceptions of the extent and nature of the influence of research on science education practice.

4.2 The extent of influence of research on practice

4.2.1 A major influence

Almost every interviewee said that they thought research was an influence on *their practice*, though views differed widely as to how large its influence was. A small number of teachers considered research to be a major influence:

> *I'd put it as quite a major one really … it is an area which I possibly want to go into myself, because I'm so fascinated by it. I love the idea of lifelong learning, always finding out more.*
> *[Colin, P1, para. 56]*

Some gave specific examples to support their view, in James's case, the literacy strategy:

> *I think it (research) has made a major [impact] … for instance, on the literacy stuff. Obviously a lot of that has come out of research.* *[James, S2, para. 314]*

Several others were less specific about how their practice was influenced by research, pointing to very general aspects of their teaching. Ken (S2), for example, rated the influence of research as 'enormous. I'm a much better teacher now than I was. Much more tolerant.' (para. 36). For Tim (S2), experience of research:

> *… was a complete watershed because it changed my view of what teaching was about. It was only a few years into my career but I had not really thought about learning at all.*
> *[Tim, S2, para. 27]*

A high proportion of the teachers who saw research as a major influence on their practice had had some personal experience of research. Other science education practitioners — that is those who were not teachers — also tended as a group to be more positive than teachers about the influence of research on their practice, with around one-third considering its influence to be major. Bill saw research as a starting point for much of his work:

> *The first port of call is our research and analysis department. Much of the research they are involved in is related directly to our core function and the business of … seeking to raise standards through what we find. … [for the recent PISA report], we had a briefing paper and I had access to some of the original materials.* *[Bill, SEP, para. 93]*

Bill did not, however, make clear what actions or decisions were subsequently influenced by this information. Although his comment above was in response to a question about influences of research on practice, Bill appears to be talking mainly about his awareness of research (explored more fully in section 5 below), rather than the impact this knowledge had on subsequent actions.

Keith, a consultant offering CPD for science teachers, saw the influence of research on his work as 'enormous'. He illustrated this with an example of research on primary teachers' understanding of science ideas:

> *I: So how large an influence is research on your work?*
> *K: Oh, it's enormous. … Another project I would mention is PSTS, which is a project in Oxford … about primary teachers' knowledge of science. … I'm writing things for teachers, and I will always refer to that.* *[Keith, SEP, paras. 42-44]*

Similarly Gemma also saw research as providing important backing for the specific practical changes she might advocate in the course of her work as a provider of initial and in-service education for science teachers:

> *I feel it's quite important. I don't like to just tell teachers, do this differently or do that differently. Change your practice without having some background as to why. I think they should do that on what the evidence is.* *[Gemma, SEP, para. 149]*

This perception appears also to be shared by the 'consumers' of CPD:

> *If I'm going on a science course, then it's obviously a science advisor who's presenting that course … I would expect the person presenting the course to be very much abreast of current trends, and current research.* *[Jack, P1, para. 170]*

Some who felt the influence of research was substantial, also noted that its influence was often 'hidden' or invisible. As a result, its effect appeared less than it in fact was:

> *I think, probably, research does have a big effect. But because I'm not using it directly, I'm not regarding it as a big effect, do you know what I mean? I feel that I'm sort of down the line from it, you know.* *[Janice, P1, para. 202]*

Similarly, Dennis, talking of his involvement in curriculum materials development, saw the contribution of research as substantial, but not immediately apparent:

> *I think it is major behind the scenes. It may not seem major in terms of the materials we produce and what we are about, but I think it is major.* *[Dennis, SEP, para. 81]*

We will return to this issue of indirect influences of research on practice later, in section 4.3.3.

4.2.2 A moderate influence

Some interviewees saw research as having a more modest influence on practice:

> *Not a major role. But then I wouldn't put it as minor really. I'd probably go for immediate …* *[Marcia, P2, para. 214]*
>
> *Somewhere in between [major and minor] I would say.* *[Yvonne, P1, para. 43]*

Theresa (S2) also thought the influence of research was modest but felt it was growing:

> *I think it's modest at the moment but I do think it's increasing. I think it's brought to teachers' attention more and more.* *[Theresa, S2, para. 138]*

Gemma, from the perspective of a former teacher now working as a provider of ITT and CPD, saw the underlying influence of research on teachers' everyday practice as major, but that it became less visible, and its influence was perhaps less strong, when translated into practical recommendations for action:

> *It's major in the sense that it underpins it [everyday practice]. But it's less so in trying to translate that into something practical. You have to have an understanding of the research, and the theory behind what you are doing. But when you are actually translating that into what you are doing in the classroom, then you have to leave research behind to some extent, and think about what it actually means.* *[Gemma, SEP, paras. 47-49]*

Lawrence, a provider of CPD for science teachers, also found it difficult to assess the influence of research on his practice. He noted its past influence on his overall approach to INSET, rather than on the content of the courses he now provided:

> *I: So is research a large influence or a relatively small one?*
>
> *L: I find that a very difficult question to answer. I am well disposed to using it, but I cannot say that over that past 10 years I've gone to loads of research papers to inform me about what I should be putting on in workshops and things like that. … When I was in the Secondary Science Curriculum Review I was made aware of quite a bit of the research findings on INSET provision, Showers [a well-known researcher on effective CPD for science teachers] and all those sorts of things … and I used publications based on their findings to help plan INSET sessions. So you could say that I was at that point influenced greatly.*
>
> *[Lawrence, SEP, paras. 30-32]*

Anna, another provider of CPD, described the influence of research on practice in similar terms:

> *I think it's very patchy. ... if you take any one piece of research, it can have had quite an impact. In other areas … it's had virtually no impact at all.* *[Anna, SEP, para. 115]*

For Samina (P1) this variability of impact was directly related to the research topic:

> *It depends on the type of research that's done. If it's on learning styles and thinking styles then it can have quite a major impact. I recently went on a course, not a science course but a learning styles course … and that's had a major impact on the way that I teach. … everybody in this school went on that course and … it's had quite a major effect on … the kind of activities that we prepare.* *[Samina, P1, para. 147]*

4.2.3 A minor influence

Most teachers with no personal experience of research saw research as a relatively minor influence on their practice:

> *I'd say, probably, a relatively modest influence.* *[Ursula, P1, para. 115]*

> *I would say it's relatively minor.* *[Les, P1, para. 35]*

> *I: Do you think that what you do in your teaching is influenced by research?*
> *T: Not much. Very little I would say, these days.* *[Tony, S1, para. 16]*

> *A little, I would say. A little of what I have read I sort of introduce in my teaching.*
> *[Edward, P1, para. 34]*

Some in this group again saw research as playing an indirect or 'hidden role' [Louise, P1, para. 226]. Sally (S1), for example, acknowledged that ideas picked up from CPD courses and subsequently used may be based on research, without this being always apparent:

> *I'd say relatively minor. I'm unaware of things that I might use that I've found out from research. I may absorb things from staff or training days or courses that have been found out or are based on research, but I'm not really aware.* *[Sally, S1, para. 42]*

Owen, involved in ITT and CPD, also felt research was a minor influence on his work, not actively seeking it out, but willing to use it if he encountered it and it appeared relevant:

> *I would have to say it's minor … in the sense that I would not actually look for research to influence what I teach. … if come across it in my reading and it is relevant, then it will be fed in. But it doesn't actually drive what I do. It supports what I do, but it is a minor role.*
> *[Owen, SEP, paras. 52-56]*

Several teachers rated the influence of research as 'a long way down the list' [Patrick, S1, para. 104]. Tony (S1), for instance, highlighted several other factors he felt were more significant in improving practice:

> *I think it's important that you've got a good basis of understanding in your subject and how to get it across … Discipline and the right sort of ethos and good habits are very important. I'd say relationships with the students are probably more important than being up to date with the latest research.* *[Tony, S1, para. 103]*

William, who had personal experience of research, was careful to make clear that it was the *direct* influence of research that he felt was minor:

> *Directly I would say [the influence of research is minor]. I mean in the sense that people actually do something, or change something, as a result of research — and think I am doing this because of whatever. I mean people might do things, or might get ideas from books or whatever … [which] may be saying to do it like that as a result of research findings, but it is very rare that that is made explicitly clear.* *[William, S2, para. 103]*

The view that actions might be based on research without the person taking these actions knowing the research findings on which they were based — or even knowing that they were based on research — came up in several interviews.

Only two people in the interview sample, however, one secondary teacher and one person involved in science education policy, claimed that research had no influence on their practice:

> *In a word, no. To be quite honest.* *[Michael, S1, para. 18]*

> *Not directly, no. Because our role is really supporting teachers in what they do to try and improve the way they present [science] to keep them up to date with their subject knowledge. So not drawing directly on research myself.* *[Becky, SEP, para. 7]*

Becky's comment might, however, be interpreted as questioning the *direct* influence of research, in much the same way as William does above, whilst not denying its indirect and less visible influence.

4.2.4 Summary

In summary, then, most interviewees and focus group participants indicated or implied that they thought research did have an influence on *their* practice. The extent of this influence was usually seen as relatively minor by many teachers without research experience, but as a more major influence by teachers with research experience and others working in science education. Most appeared to be open, at least in principle, to engaging with research findings, even those who saw research as a relatively limited influence on practice.

Nevertheless, although the great majority of teachers indicated that they believed research had an influence on their practice, none spontaneously identified research as the place to which they would have turned first for ideas or guidance on how to *improve* their practice. More said that they would ask colleagues, or local authority advisors, or ITT or CPD providers whom they knew. In one sense, this is not surprising, any form of teaching consists of a community of practitioners (Wenger, 1998), and their knowledge of what constitutes good practice is embedded in that community. On the other hand, the lack of knowledge of research, and the weakness of the relationship between individuals' practice and research, suggests that the teaching of science is a closed practice — that is one in which its practitioners are not readily looking to be informed by rigorous and systematically collected evidence of potentially more effective ways of working.

4.3 How research influences practice

4.3.1 Different forms of influence

The previous section discussed respondents' perceptions of the *extent* of influence of research on practice. In interview, when respondents said that they thought research influenced their practice, they were asked to give specific examples, which were then used to discuss the nature of the perceived influence on practice. Broadly speaking, the responses indicate that the ways in which research was seen as influencing practice can be divided into the following categories:

- specific teaching approaches or strategies devised by the respondent, based on his/her knowledge of a specific research finding, or a collection of studies in a particular area or of a particular kind;

- general approaches to teaching such as 'active learning' used by the respondent, which he or she believed to be supported by research, but without reference to any specific research studies or findings;
- the use of specific teaching materials based on, or directly informed by, specific research studies (or bodies of research);
- the use of teaching materials and/or official guidelines that are believed to be informed by research, such as schemes of work or textbooks though the user is generally unaware of any specific research.

The first two of these might be termed *direct* influences of research on practice – where specific and identified research studies or findings, or broader but less clearly identified bodies of research that are believed to exist, are thought to provide warrants for particular practical choices and decisions. The third are *mediated* influences, through the use of materials which are considered to embody the findings of research. Here the user may not know the research on which the materials are based. The fourth category might be termed *indirect* influences, through using materials which are not explicitly based on research, but are felt to be underpinned or informed by research, in a more general non-specific sense.

4.3.2 Direct influence of research on practice

Most of the teachers with research experience, and a minority of those without, were able to cite specific pieces of research which had influenced their practice.

> *One piece of research I'd read suggested, contrary to all I'd always thought, sit the boys together. So I thought OK, I'll give that a go and see what happens, and in the class that I had two years ago, a year two class, I tried that for a while. I altered my seating arrangements to see what would happen.* *[Carol, P2, para. 53]*

> *I've read somewhere, it's a while ago … there's been quite a lot of research into assessment and testing — testing students on a more regular basis … their progress has been better than a controlled cohort. Where something's been trialled like that and seen to work really, really well, then obviously there are lessons to be learned there. Certainly that piece of research has informed our planning. I've had meetings all this week in terms of planning our Key Stage 3 and somebody said to me I don't see why we've got to test at the end of every half-unit and I was able to say because research has shown that that actually does really boost students' confidence, etc, etc and therefore their progress is much greater.* *[Pauline, S2, para. 176]*

In both these cases, the perceived implications of the research are fairly easy to identify and implement. And, in both examples above, the action is based on a single, unattributed, piece of research rather than a larger body of research evidence. For Pauline, the experimental design of the research study she outlined, with a control group for comparison, and the fact that the intervention was 'seen to work really, really well', appear to be important factors in her decision to act on the finding. The features of research that influence teachers' assessment of its relevance to their practice are explored in more detail later in section 6.4 and section 7.

The type of research mentioned most frequently by teachers, both with and without personal research experience, was research into learners' ideas and understandings in specific science domains. Colin (P1) attributed his practice of starting new topics with a diagnostic test to elicit pupils' ideas to his knowledge of the Primary SPACE (Science Process and Concept Exploration) project:

> *When I was at college I did a lot of work on the SPACE Science Project and in a way that has affected my practice because it is always important at the start of each unit of work to do something diagnostic and elicit for the children where they are.* *[Colin, P1, para. 6]*

Richard (S1) cited APU (Assessment of Performance Unit) findings about the difference in quality of pupils' observations on real objects, compared to photos, sketches and diagrams. He was less specific, however, about exactly how his practice had been altered by his knowledge of this research finding:

> *I do think there's something … in my classroom practice that is influenced. The examples that I thought of were quite some time ago with APU … in Leeds. They'd done some work on observation skills and children's learning, and their research showed a significant difference in learning between objects that were visible, held in the hand, compared with photographs of those objects, [or] sketches, [or] diagrams. The learning loss is considerable as you move from the real, concrete object through to the diagram. I think that influences what I do in the classroom.*
>
> *[Richard, S1, para. 16]*

Elsewhere in his interview, Richard also referred to:

> *… research by Lovell that I was exposed to when I was training ... about the intuitive control of variables, the fact that students perhaps up to the age of 16, the average student is unable to consciously control one variable. That pervades a lot of work that I do, course work, experimental planning and that kind of thing.* *[Richard, S1, para. 20]*

Again he was rather unclear about the actions that he saw as following from this research. In a similar way Thomas (S1) talked with enthusiasm of reading a research report which influenced his actions — but did not explain exactly what changes in his practice resulted from this:

> *'Inside the Black Box', for example. I actively sought to get a copy of it, read though the whole thing, thought it was brilliant, and it did have a very strong influence on what I was doing at the time.* *[Thomas, S1, para. 51]*

A few teachers referred to research that informed their view of teaching and learning, but without suggesting that any specific actions followed from it:

> *I remember listening to work on Piaget when I was doing my PGCE and hating every minute of it. But it makes sense. The idea that we are trying to teach these students to pass exams at a certain level, when their conceptual ability doesn't allow them to get to that level, makes sense to me and … to most teachers.* *[Ken, S2, para. 302]*

Some other examples of the direct influence of specific pieces of research on practice have been mentioned in section 4.2 above. Overall, however, there were relatively few of these. Many more interviewees referred to research findings in more general and unspecific ways, or to indirect influences of research on their practice. For example, Eileen indicated how some current research of interest to her and her close associates influenced her, without pinpointing how:

> *Recently, yes, because I have been doing a lot of looking into accelerated learning and children's styles of learning in aesthetic, visual and auditory and because my daughter is very into it. She's a teacher and she has done part of a degree on it and I was very interested and I have started using that a lot.* *[Eileen, P1, para.10]*

More rarely, a very few respondents argued that a particular teaching approach was implicitly supported by research evidence even though they could not cite the research source or its findings clearly. The following extract from Yvonne's interview is an example:

> *Well, then I started thinking about me teaching science as a science subject manager, and one of the things that I certainly do, and that I try and get across to the rest of the staff, is when they initially start to teach an area of science, to have a really good brainstorming session and find out what the children think first before they do any teaching because often children have quite entrenched misconceptions about things and that has definitely come from research into science but I couldn't tell you where or who I'm afraid (laughter). But I know that it has 'cos that's part of my training. It's something I'm interested in as well.* *[Yvonne, P1, para.35]*

Thomas (an INSET provider) also talked in similarly general terms about the perceived influence of research on management on his practices:

> *Another role is that I would often work alongside a head of department if there were problems to do with standards, and carry out some observations, and then help them to draft their action plan and implement that with the team. A lot of the research on management styles sort of influences that.* *[Thomas, INSET provider, para.23]*

The absence of comments relating to specific examples of science education research would support the view articulated previously that the teaching of science is a relatively closed community of practice. Teachers of science either are not aware, or do not recognise, what is in effect, a substantive body of research evidence about their practice and its implications. Even when they are aware, the lack of comment on how the research had affected their practice would suggest that it is one thing to know about research evidence, but a more significant and challenging task to adapt and use it in a practical and effective manner in the classroom. Simply making teachers more aware or better informed of research evidence is, therefore, unlikely to lead to a substantive change in their practice.

4.3.3 Mediated influence of research on practice: research-based teaching materials

In contrast, major research projects which had produced output in the form of curriculum resources and teaching materials were commonly mentioned as ways in which research informs everyday practice. In over half of all interviewees and focus group discussions, one or more research-based projects such as CASE (Cognitive Acceleration through Science Education), AKSIS (ASE and King's College Science Investigations in Schools) and CLISP (Children's Learning in Science Project) were spontaneously mentioned, and also Concept Cartoons – a project which is based on research into children's ideas and common misconceptions. Other research projects which were mentioned less frequently as being influential on practice included the APU, SPACE and the Nuffield curriculum projects (though many would see these as curriculum development projects rather than research).

The AKSIS project, mentioned by several interviewees, reported research findings and also produced teaching materials designed to help teachers address these. Eve (SEP) reported that its findings made her look more closely at pupils' work:

> *Well, when you hear … that the AKSIS research project showed up that a large proportion of children's graphs are inaccurate ... you say 'oh, I need to go and look at pupils' graphs.' So you go and look and see how that applies.* *[Eve, SEP, para. 9]*

Although Eve's comment is on her response to the research findings, it is the publicity associated with the published curriculum materials that we believe has played an important role in drawing the project to teachers' attention — and providing an immediate solution to the problem of what to do in response.

The Children's Learning in Science Project (CLISP), which ran in the 1980s, was also mentioned by several interviewees as having an impact on their everyday practice:

> *I found the CLISP idea very useful. I have used that quite often, ever since I started teaching, and lots of my lessons certainly in tricky subjects like energy and electricity and kinetic theory matter are based on the things that I learned whilst reading up on CLISP. [Rob, S1, para. 21]*

The most frequently mentioned project was CASE, which was seen as hugely influential in science education, by secondary science teachers in particular. For some it was the only example of the influence of research on practice that they could think of:

> *The only thing I can cite is …… I think vaguely along what I've picked up as CASE lines. But that's the only thing. I've never been on any proper CASE training. I've seen a video about it, and I've spoken to a few people about it and the students sometimes talk about it.*
>
> *[George, S1, para. 5]*

For George, the influence of CASE was that he sometimes thought along what he regarded as 'CASE lines'. Given that the researchers who developed CASE regard it as very important that individuals attend a recognised course of training to learn how to use the materials and the scheme properly, the influence of this research would appear in George's case to be very indirect. Others pointed to more specific influence on their teaching style:

> *Originally, CASE … came to us just as … thirty lessons … They were a very different style to the way that most of us were used to teaching. But gradually we learned, and from going and finding out about the research, we learned that it had the biggest knock-on effect if it affected your whole teaching strategy. [Patrick, S1, para. 21]*

Lawrence, a provider of CPD for science teachers, attributed the impact of CASE to the fact that it had made the research findings accessible by building on research to provide something that schools 'could go out and use':

> *[In] the mid 70s … I came across the first research findings which indicated that, if you were doing Nuffield Chemistry, then the materials we were placing in front of the children were inaccessible to all but 15% of the population. And it only improved to 25% of the population by the time you get to 16 years of age … the people who made those findings became the CASE people. By the early 80s, Shayer had come out with 'Towards a Science of Science Teaching', and then they worked further and … the CASE project was born round about 1990, as something that the schools could go out and use. … they made those findings accessible and more widely known within the teaching force than probably anything that had gone on before.*
>
> *[Lawrence, SEP, para. 56]*

Lawrence's comment also highlights a point to which several other interviewees (mostly science education practitioners who were not teachers, or teachers with lengthy experience) referred, namely the long lead time from the original research showing there might be a problem, to the clarification of that problem, to the development of teaching materials and approaches that might

address the problem, to the testing and evaluation of the effect of these materials when used is considerable. Without this 'translation' of the research findings into usable materials that teachers could use, it is doubtful that the underlying ideas from research could have had as significant an impact on practice.

The examples of CASE, AKSIS, and the work undertaken in EPSE Project 1 on diagnostic assessment, suggest that significant impacts of research can come through providing materials and instruments whose value teachers recognise and adopt, and in so doing adapting their practices. Research whose output fails to make this important step is unlikely to have much effect on practice. The problem for researchers, however, at least in the UK, is that their work is assessed largely by publications in academic journals which teachers never read, and not by the significant effort of translating their ideas into usable materials for teachers.

Whilst CASE was mentioned spontaneously by many interviewees as an example of the impact of research on practice, it was specifically introduced into the focus group discussions by vignette 1, which described one of studies providing evidence of the impact of CASE. For several teachers, in focus groups and interviews, their initial scepticism decreased when they appreciated the scope of the research:

> *I was very sceptical to start with. I thought the claims must be exaggerated. And then I went to a conference and heard a talk on it and I actually started to look into the results that they'd found and they certainly seemed to back up the claims with a lot of empirical evidence over a wide range of different schools. And that, for me, made a lot of difference. So, although I haven't taught it myself, I've certainly become very interested in it and I would certainly want to use it because I've become convinced that it has value.* *[secondary focus group 3, para. 95]*

The point of interest here is that although the information has changed this teacher's values about practice, it has not as yet, changed his practice. For others, however, it was their perception of how the materials might be used in their classroom that changed their view:

> *I was very sceptical to start with, about CASE, because at my previous school you weren't given any training. You were told to go and teach CASE. And although my style of teaching was very CASE styled, that wasn't true for a lot of other staff …and so you didn't see any improvement. Until I'd gone on a training course, and I could see where it was coming from and how I was meant to be in the classroom, that's when I noticed the difference.*
>
> *[secondary focus group 3, para. 101]*

This comment also supports the view advanced by the developers of CASE that the materials alone are insufficient to change teachers' practice.

These issues of what teachers find persuasive or convincing about research are explored in more detail later, in section 7. The frequency with which CASE was mentioned in the interviews suggests that a necessary requirement for the dissemination of research is that the findings are embodied 'implicitly' in curriculum materials and training packages, which are seen as attractive to teachers and capable of being implemented successfully with their classes. This may not be sufficient of itself, however, and additional training may be needed for teachers to understand the underlying approach and principles.

4.3.4 Indirect influence of research on practice

Projects like CASE, CLISP and AKSIS, discussed in the previous section, are all explicitly based on research, or involved research that led to the development of curriculum materials. So, perhaps not surprisingly, interviewees mentioned these when discussing the influence of research on practice. Rather more surprisingly, a few teachers appeared to regard most textbooks as informed by research – and hence that, in using them, their teaching was 'influenced by research'. For example, Jack (P1), when discussing revision texts to help pupils prepare for SATs, commented:

> *I would imagine, when I think about it, there must have been an awful lot of research has gone into the compiling of these textbooks.* *[Jack, P1, para.162]*

He explained his view in more detail as follows:

> *I'm seeing [research] as where somebody has taken the time to analyse some aspect of the science curriculum, and then put their ideas down, and then that information is there, then, for you to read and use. … I don't think the people who write the books, they don't just write the first thing that comes into their head, they've obviously spent time doing their own research.* *[Jack, P1, para, 158]*

Jack, here, appears to be using the word 'research' in its vernacular sense, meaning finding out information about something that you want to know about — in this case, a textbook author using information sources of various kinds to check the details of a piece of science, or find out about current applications of science, before writing a textbook chapter.

Many interviewees also indicated that they considered the documents which frame much of their practice, in particular the Science National Curriculum and the Schemes of Work published by QCA (1998, 2000) to be influenced by research. Louise (P1) expressed a view which was not uncommon:

> *I: ..the National Curriculum, textbooks, schemes of work. Do you see those as being influenced by science education research in any way?*
> *L: Well I'm hoping that they were. The National Curriculum. I hope it hasn't just been pulled out of, out of nowhere.* *[Louise, P1, paras. 52-54]*

This could, of course, equally well be seen as an example of the perceived influence of research on national policy. It is included here as it illustrates one perceived indirect influence of research on practice in the sense that, insofar as one's practice followed these documents, it was automatically 'influenced by research'.

Unsurprisingly, policy documents were identified by the majority of interviewees as a significant influence on practice. In general, primary teachers tended to have a stronger feeling than their secondary colleagues that these were based on research. For some teachers, this research influence was simply taken for granted:

> *I would presume that the National Curriculum has .. that there has been research involved before the powers that be wrote it. Probably they haven't researched into how much time we have to put the National Curriculum into practice! There should be a bit more research into that I think.* *[Louise, P1, para. 62]*

Others implied that only a basis in research evidence could justify the number and scale of the changes recently imposed on teachers and schools:

> *Certainly the National Curriculum [is influenced by research], let's hope so. Yes, I would say so. And that is why, I suppose, we're continually undergoing a cycle of change, particularly in primary education. The last five years have just been non-stop change really, the literacy and numeracy hour, and yes all that has come from research, I'm sure. Well let's hope so. [Yvonne, P1, para. 71]*

In contrast, less than a third of secondary teachers perceived policy documents like the National Curriculum and the QCA Schemes of Work as a way in which research influenced practice. Some, however, mentioned the Pilot KS3 National Strategy which tended to be perceived as having a stronger research element:

> *All the new stuff that's coming out of the Key Stage Three strategy, I can see there's a lot that's been pushed forward, by people like [named researcher]. [Ben, S2, para. 148]*

Almost half of those interviewed who were engaged in science education, but not as teachers, talked about policy documents. On the whole they were perhaps less sceptical than secondary teachers about policy as a way in which research impacts on practice, though most saw the interface between research and practice as more complex. Bill, a participant in policy making, saw the involvement of researchers in the development of policy as a means of ensuring that policy was informed by a research perspective. For him, policy and the documents that represent it, were therefore influenced by research:

> *In an indirect way, in that the people that are involved in, for instance, producing the QCA scheme of work were all people who will have had exposure to research. We are talking about research that probably dates back a while, but that has become part and parcel of the way in which they think and work when they devise things like the QCA exemplar scheme of work. As for the National Curriculum, if by that you mean the statutory orders and the framework, then, well, yes, also. But I think because of the very way in which it is expressed, which is inevitably fairly terse, … any link with research is even more obscured. But again, [research] drove the thinking of some of the people who contributed to that. [Bill, SEP, para. 47]*

An unintended consequence of the National Curriculum, however, expressed by several interviewees, was that perversely it had become a barrier to reflection and innovation, making it harder to introduce ideas and materials based on research, as these may not fit with official guidelines, or with unofficial but authoritative schemes of work. For instance, Simon (S2) made the point that a scheme offered by one of the Examining Bodies did not have a clear foundation in research:

> *On the website for AQA there's now this scheme of work for Key Stage 4 and you won't see any reference to research in that one because it's very superficial, and I'm really concerned that a number of schools will almost turn their back on the research that they've used in the past and go for these, 'oh these are the National Schemes of work'. That is, not just what kids will be taught is a national curriculum, but how they will be taught as well. [Simon, S2, para. 30]*

To summarise, then, policy documents were seen as very influential on practice. They were regarded by many, particularly primary teachers, as significantly influenced by research, with some almost appearing to regard them as 'based on' research. Yet, ironically, no participant in the study cited policy documents as a source they would go to for ideas on how to improve their practice.

Others, however, saw the documents and the framework they represented as a barrier to the impact of research on practice, as they made research-based innovation less likely, perhaps even impossible. It would seem then that the authoritative nature of some documents rests on the implicit belief of many teachers that they must have an evidential base — and that that base is provided by research. Yet such documents typically lack any warrants for their statements of policy. If evidence-based practice is a goal, then should not the profession seek to ask more openly of itself — where is the evidence to justify particular approaches?

The influence of research on policy appeared to be seen by many in terms of the involvement of specific individuals with research experience in the policy-making process, rather than as a reflection of a fundamental commitment to research-informed policy.

5 Practitioners' awareness of research

5.1 Sources of knowledge of research

Section 4 discussed the views that arose in interviews and focus group discussions about the influence of research on practice in science education, and about the different ways in which people saw this influence exerted. In the course of these discussions, many explained how they felt they obtained and maintained their knowledge of research. The final interview question asked interviewees directly where they thought their knowledge of research came from. This section of the report reviews the answers given to this question, and the other indications that arose spontaneously about practitioners' access to research, and the channels of communication between the research and practitioner communities.

5.2 Reading books and articles

As might be expected, many respondents picked out reading as the primary source of their knowledge of research. Most science education practitioners who were not teachers mentioned this source, though fewer teachers did. Ruth, a provider of ITE/CPD, commented that:

> *I buy books and I tend to sort of head for the science and science education shelves in the bookshops. I look for names that I'm familiar with, … of people who are doing research, and try and pick up on those.* *[Ruth, SEP, para. 100]*

Vanessa (a textbook writer) talked of her interest in research on learning, which then relates to her work in science education. Her knowledge of research came from:

> *Books. It tends not to be science specific, but books generally about things like whole brain learning and the learning revolution. … I don't read science education books in as much detail as I read books about students' learning, which I think has got obviously lots to say about how they learn in science but tends to be more general stuff, and my general reading I think contributes to that.* *[Vanessa, SEP, para. 84]*

Neil, also involved in writing curriculum materials and in CPD, said that he read widely both from books and from summaries of research:

> *I've done quite a lot of reading of summarised research and people's own views mixed in with research in books that I've read, classic books in some cases.* *[Neil, SEP, para. 55]*

The Association for Science Education (ASE) appeared to play an important role for many participants. A third of interviewees identified the ASE as a source of their research knowledge, either through reading its journals (a fifth of interviewees), or through interactions at conferences. For instance:

> *I get School Science Review, every issue, and Education in Science, which come from membership of the ASE.* *[Luke, S2, para. 60]*

> *And there's a couple of text books that I've got, that have got research projects in, that have been recommended by the ASE.* *[Marcia, P2, para. 212]*

> *I'm very much behind in knowing what the current situation is as far as research is concerned. But if I did want to know what was going on, I think the ASE would be the first port of call. Either the Journal or the conferences.* *[Tony, S1, para. 142]*

Publications by the ASE were talked about very positively and were perceived to be a good source of ideas and guidance for teachers in the sample:

> *I get Junior Education and I get the ASE Primary Science magazine and ... you're reading it, and you think 'that's a good way of doing it', or 'I could do that'. I do use those quite a lot. ……ASE use a lot of research in theirs. There are always people, quite often in the articles in the magazine, who are doing doctorates and things or are running projects.* *[Janice, P1, para. 208]*

About a third of interviewees saw ASE as an influence on practice (for example, as a source for ideas for improving practice) though comments were not always about the influence of *research* on practice. Nevertheless, on the whole teachers and science education practitioners spoke very positively about its influence:

> *I go to the ASE and to ASE publications because the ASE's got its finger on the pulse and a lot of useful things come out there.* *[Keith, SEP, para. 184]*

The Association appeared to be seen as an important point of contact with research for a wide range of respondents, including those who claimed very limited awareness of research, and for whom ASE publications might be their only source of information. Many, for whom keeping up to date with developments in research was important also used the ASE network.

> *The ASE network is very powerful, I think, and the advantage of that organisation is that it does bring everybody together from so many different backgrounds. So you get the researchers with the advisors, with the teachers, with the independent consultants, you know, it is just an excellent forum for it.* *[Gail, SEP, para. 368]*

Apart from ASE publications (such as *School Science Review*), the *Times Education Supplement* (TES) and *Junior Education* were the only professional publications cited by more than one interviewee (less than 10% of interviewees mentioned them) as a source of knowledge of research). Gemma, a consultant, claimed that she read:

> *School Science Review … or the TES, or something that I can get hold of easily. … For the units that I've been doing [as a KS3 Strategy coordinator] I've bought books as well, to read. But if I had access to a library, I would probably be able to do more. And I've got all the articles that I copied from my certificate course … as a resource.* *[Gemma, SEP, para. 220]*

In many discussions, books were mentioned as a source of knowledge of research which had influenced practice. Many of those mentioned, however, were not specifically about science education research. The importance of books as a source of knowledge of research was greater for primary teachers, with just under half mentioning it:

> *Yes definitely, the one that I got when I was teacher training .. I had it in my head as well for the interview but I can't remember, sorry. But without a doubt that is research about how children learn science, about how to teach it so we can optimise learning and so on.*
> *[Samina, P1, para. 31]*

Professional journals, books, and curriculum resources were also widely seen as sources of ideas for improving practice. Some practitioners referred to these generically without naming specific publications:

> *I think we have some good educational journals and books as well in libraries that I would go to. For all teachers that is a good source of improvement. Research journals from Universities as well, that's a good one because those are up to date with .. the current curriculum .. how it is affecting the students' or pupils' education, … journals, newspapers like the TES, for example, books, colleagues you know, other teachers and perhaps I would go on the Internet.*
>
> *[Younis, S2, para. 114]*

This comment by Younis is unusual in including *research* journals as a source of ideas for improving practice. Only among those familiar with research were research journals mentioned, if at all. Indeed one interesting point is the scarcity of reference to research reports and journals amongst practitioners who were not teachers. For them, the ASE, through its publications and meetings, was overwhelmingly the major source of their knowledge of research. Policy makers, providers of initial and in-service teacher education, and other 'mediators' of research in our sample also appeared to rely heavily on the ASE network. This finding reinforces the view that academic papers serve the function of communicating research findings to other researchers, and of 'quality control' — but that those researchers who do not engage with the practitioner community, either through professional journals or other means, are unlikely to affect practice.

Teachers indicated that reasons for not reading research at its primary source in research journals included lack of time and inaccessibility, both in terms of practical access and of readability. Some argued that there was a need for distilled accounts of up to date research outcomes to be disseminated to schools, in a form that is quick to digest. Some of the interviewees saw professional journals such as *School Science Review* to be meeting this need, but others indicated that they would welcome an even more concise dissemination format.

> *I think [research] does have a role to play but I think what is important is that it has got to be accessible and I think it has got to be easy to understand. It has got to be available, it has got to be there in such a way that you can get to it and it has got to be presented in a user friendly manner which people will be able to use in their teaching and be able to understand.*
>
> *[William, P2, para. 101]*

Some digests of research, such as those produced by the APU, *Inside the Black Box* (Black & Wiliam, 1998), and *Working Inside the Black Box* (Black, Harrison, Lee, Marshall, & Wiliam, 2002), have notably achieved wide dissemination amongst practitioners. Nevertheless, whilst we can see the appeal of short digests of research findings, comments like that above appear at odds with the reactions of many focus group participants to the vignettes presented. Here requests for more information, or a disposition to question research findings on the ground that insufficient information was provided, were common. Thus, we are led to question whether brief summaries of research studies would be sufficiently convincing to stimulate serious reflection, leading perhaps to change, in cases where the findings diverged from what practitioners believe they 'already know'. Thus, whilst short reports of research may be a mechanism for dissemination, we doubt whether they are a mechanism of change.

Many of the interviewees (28/62), both teachers and other science education practitioners, highlighted the difficulty of disseminating research findings effectively to teachers in school:

> *But I think it's quite difficult for a teacher to find access to research, apart from School Science Review and the TES. Where else can we look? And a teacher's less likely to buy a book than I am. I hold them up at the front of the course and say – 'this was really interesting, would anyone like to borrow it? You know, you don't have to buy it'. And they don't borrow it. They think I'm sad for reading it.* *[Gemma, SEP, para. 229]*

Books with titles such as *Good Practice in Science Teaching? What Research has to Say* (Monk & Osborne, 2000) and *Teaching and Learning Science: A Guide to Recent Research and its Applications* (Bennett, 2003) have been published in the last decade to address this problem. Moreover, it could be argued that the researchers in science education, as a group, have done more than most educational researchers to explore ways of disseminating the findings of their work to practitioners – perhaps sometimes at the expense of communicating them effectively to the wider educational research community. Yet the findings of this study suggest that this not insignificant effort has had only partial success, inviting the question of whether it is well-directed.

5.3 Knowledge of research from personal contacts

The other major source of knowledge of research mentioned in the interviews was personal contacts — for example, with colleagues and other teachers. Bill (involved in policy making) also saw personal contacts as important, but this meant that ideas were influenced by someone else's perceptions:

> *Much of what I now get is mediated … briefing papers from our research and analysis, … but also talking to people who are very much involved in research. We've had conversations over the years and some of those will have led to me saying - well, yes, that's interesting, I'd better find a bit more about it. But again, it's usually been in a fairly digested form. And that worries me a little bit because I think one ought to be able to stand back and make your own mind up about something. As soon as it is mediated you have somebody else's view imposed on it.*
> *[Bill, SEP, para. 148]*

For a great many people (26/62), colleagues or advisors were an important source of information about research, and were often seen as useful 'filters' who could both help make research more accessible and draw attention to particularly useful or interesting studies. There were, however, interesting differences between primary and secondary teachers. Primary teachers were more likely to refer to advisors while secondary teachers spoke more often about turning to colleagues, perhaps reflecting the fact that primary science specialists are quite likely to be relatively 'isolated' within their school, while secondary science teachers are part of a science department. Marcia (P2) welcomed her local advisor's practice of routinely circulating information on current research:

> *Our science advisor sends quite a lot of documentation through the post to do with things that have come up, that are new, bits of research. He tends to have summarised it all, which is quite nice, … and he sends that round to all the science co-ordinators in the authority.*
> *[Marcia, P2, para. 212]*

Almost a quarter of interviews referred to examples of research knowledge being used, often in conjunction with colleagues, and invariably combined with practitioner knowledge and experience. Often, the practitioner perspective was the primary concern:

> *When we talk about it we wouldn't think to ourselves 'oh my word we are using research now'. We think this is a good idea and it fits in with our ethos and so we will try it. We will do that*

> *first and then we might look at the research findings that have backed it up. But we wouldn't look at research first and say 'oh there are so many more improved results, therefore we will do it'.* *[Hazel, S2, para. 54]*

Teachers involved in research were seen as mediators of it to other colleagues. Theresa (S2) saw ideas arising from her colleagues' involvement in research as one means of influence on her department's practice. Over half of the teachers who had some involvement in research talked about the influence of research on their own practice. However, a few of the teachers with research experience (3/20) felt that the positive impact of their own involvement in research was not always passed on to colleagues, or that its impact was bound up with other influences:

> *I: So do you think that your experience of research has had any influence on the practice of any of your colleagues, or in school more generally?*
> *M: I'm not sure. I think practice is a little bit too far. I think maybe my opinions in meetings and various things may well have changed. Primarily because of the research, but I think there are other factors, as well, involved in it. I think that our practice as a department has changed, maybe slightly as a result of the research that I did, as a result of seeing what's going on outside.* *[Marcus, S2, para. 84]*

Within the constraints of the professional context, some areas of expertise or aspects of experience may be easier to pass on than others. The extent to which a teacher's research concerned issues and decisions that are within his/her direct control was seen by William (S2) as an important factor:

> *I think the research that I did in relation to children's ability to provide explanations in science has had some effect on the way I've organised my teaching since then in science. ... and because I am responsible for planning work for others, then it can filter through to them as well. I think the other two research things I looked at, about the role of the subject coordinator and the use of setting in the school, has influenced [my practice] to a lesser extent, mainly because they are more whole school things over which I don't have an enormous amount of control.* *[William, P2, para. 35]*

In general, teachers with experience of research provided greater detail in their answers, more specific answers, perhaps referring to a particular body of research rather than research in general, and tended to engage more critically with research they knew about:

> *Quite a few people who have done research have come and spoken about their research, which sometimes has been taken on board as a whole school and made part of the school policy and the running of the school. And other times it has been hotly debated and we've continued with what we have been used to doing.* *[Farida, P2, para. 7]*

Conversely teachers without research experience often seemed apologetic, or even defensive, about their lack of knowledge of research:

> *I don't think I have a great deal, if the truth be known. What I've learnt over the years … is through in-service training courses. I don't do much reading of research. I don't go out and buy books about research on education.* *[Michael, S1, para. 217]*

As regards sources of ideas for *improving* practice, colleagues were seen as the most important source of ideas and guidance for all interviewees. This was invariably the first source mentioned and, in a few cases, the only one:

> *I would speak to colleagues in the first instance. And ask how they've gone about things and did they find it successful.* *[Jack, P1, para. 146]*

> *Talking to colleagues, that's a vital interchange of ideas, I think, in terms of I tried this and it worked really well, or I tried that and it fell flat on its face, or whatever.* *[Pauline, S1, para. 28]*

> *I think, within school, I would probably seek the advice of people who either had a specialism in that area or had more experience than me, such as a science coordinator or perhaps just other teachers in the school who had more experience in the area that I was wanting information about.* *[William,P2, para. 97]*

For teachers, this kind of 'sharing good practice' within a department or school was commonly mentioned as a way of improving practice. As in the comments above, however, research rarely seemed central to this sharing process. Rather, what it suggests is that secondary science teachers are essentially embedded in a community of practice where the cultural norms and values are shared and co-constructed. Changing ideas about what counts as good or effective practice can only be achieved by working with that community or with key individuals within it. Research is more likely to affect practice when new ideas are adopted as a whole department, or even whole school, practice.

For teachers in primary or smaller secondary schools, however, interactions with colleagues often involved going beyond the school or the science department. For example, one primary teacher talked about seeking advice from science co-ordinators at other schools via an LEA 'intranet' [Marcia, P2, para. 184] and others described turning to secondary science school teachers for ideas:

> *The next thing I thought of was talk to other teachers, science teachers, especially high school teachers.* *[Yvonne, P1, para. 187]*

Like teachers, most of the other science education practitioners interviewed saw colleagues as an important source for improving their practice. Here the research dimension was rather more obvious, and integrated with professional practice. About half of this sub-group mentioned the role of colleagues as a source of knowledge and ideas about research. The following remark is typical.

> *Where would I go? Um, the first step would be the colleagues that I've got. If there was something that I felt I needed to look at in more detail, for example, if we were doing a training unit on a topic that I didn't know much about, or if there were some strategies that I wasn't sure about, I would go to them and say — have you got any strategies for, or have you come across any good practice on, or do you know where there is research on?* *[Anna, SEP, para. 81]*

For this group, however, in contrast to many teachers, colleagues often included academics who are actively engaged in research, or people with personal experience of involvement in research. There was a sense in many interviews that the closer interaction with this research community enabled a 'natural' process of diffusion of knowledge, collectively raising the awareness of all. Colleagues were commonly seen as the first place to turn when seeking ideas to improve practice:

> *First of all I would probably ask colleagues with relevant experience or other contacts I have in the world of education who I thought might know the answers or where to find the answers. I've done that on many occasions, looking for either particular reports, particular books, particular points of view. So I would use perceived experts and their knowledge to point me to the places or resources that might answer the questions, and give me something to read.* *[Neil, SEP, para. 245]*

A few secondary teachers with experience of research also mentioned tapping into the academic community as a source of information. Again it appears to be the personal contact which is important. As James (S2) put it:

> *… where one's done some work, linked with the University, you get to know people who would be actively engaged, or who are university-based, or college-based. And if you wanted to know about specific things, there are certain people whom I would go to and say, or give them a ring and say, 'What do you know about this? What do you know about that?' I have done in the past. And they say, 'Well talk to so and so, or read this, or look at that'. So it's people first, I think.* *[James, S2, para. 240]*

Almost half of primary teachers referred to the influence of the LEA and LEA Advisors as sources of professional help and ideas:

> *Very often I go to the Science Inspector because we had a very good Science Inspector and so I could go to him for help, we also run Panel Groups, Science Panel Groups where we share ideas and thoughts ….If there is something specific like we needed some work for able children and I didn't know where to get it from, then I ask the Science Inspector… I have very little time to do the reading. I have to rely on other people to do that for me.* *[Eileen, P1, para. 148]*

Given the frequency and importance of professional interactions, the presence or absence of a culture of seeking and evaluating evidence seems to be a potentially important factor in determining the extent to which research evidence and processes impinge on practice. A 'critical mass' of practitioners familiar with research processes and sources may also be needed to make possible the productive discussion of research evidence. This suggests that it is not the interface between the research community and the individual teacher which is the main conduit for dissemination, but the interface between the research community and the community of practice in which teachers of science are embedded. External agencies, such as LEA advisors and in-service training providers, may be able to create and/or support such a community of practice, which recognises the importance and value of research.

Although we have chosen to discuss the role of the Association for Science Education in the section on sources of information of research evidence, it could just as easily have been discussed in this sub-section. For many commented on its importance as a network where practitioners of all sorts, including researchers, could meet and exchange ideas and views. Hazel (S2), for instance, saw science as being in a better position to disseminate research findings to practitioners than other subject areas, because of the ASE:

> *I think science education is very well served by the ASE in a way that perhaps other subjects aren't. … I don't think some other subjects really have anything that they could turn to, to help them improve their teaching and their learning.* *[Hazel, S2, para. 198]*

It seems clear that the ASE is regarded very widely by very many science education practitioners as an invaluable network for professional support and dissemination of ideas. Thus, the findings of this study would suggest that subject specialist associations are one crucial mechanism for disseminating research and fostering a community where its findings are debated and, in some cases, used.

5.4 Continuing Professional Development (CPD)

In-service training courses were the most frequently mentioned vehicle for disseminating research findings to teachers (in 32/62 interviews). Some felt that this channel of communication from research to practice could be developed further:

> *Somewhere between the researcher and the teacher there seems to be a gap. Some of it … comes through in-service training courses. But I think more could be fed through to teachers that way.* *[Michael, S1, para. 210]*

A primary teacher in one focus group also saw in-service courses as a more useful source of knowledge of research than books:

> *I think some of the research tends to come down through courses, doesn't it. You're fed it when you go on a science course. I'm thinking of the Concept Cartoons, you know. That was research done and then it's been brought down into the classroom. So I think that's where we tend to get our research findings from, that we put into practice, rather than just reading a book and thinking, 'Oh I'll try that'.* *[primary focus group 3, para. 706]*

This example shows that one major means of transforming practice is by offering resources, instruments and strategies which teachers value and adopt — even though they may be unaware of the research evidence supporting their use. Research in social psychology would suggest that changing behaviours is reliant on changing beliefs and attitudes (Ajzen & Fishbein, 1980). We, however, would question whether such a model is applicable to teaching where often, it is changing practices, through a range of simple and easily adoptable resources, that leads to a change in values.

A somewhat different view was articulated by a secondary teacher in another focus group who suggested that:

> *It would be nice to have some INSET days where you can actually just come into the university and just look at the research that's available, yes, absolutely, or have people who are doing the research come and actually show us what they've done and talk about it.* *[secondary focus group 2, para. 687]*

It is questionable, however, whether this would be an effective means of engaging with research, as most research is reported in academic journals written for other researchers. Engaging with such a resource requires an understanding of the discourse and values of the research community, which differs significantly from that of practitioners. Not surprisingly, perhaps, there were more references to in-service courses introducing teachers to general educational research than to reports of research in science education. Several interviewees mentioned courses on learning styles, able pupils, and management issues. Often these were seen to have had a significant impact on practice:

> *The learning styles will have a major, major impact. It's had a major impact on this school because everybody in this school went on that course and it's had quite a major effect on the way that they deliver the lessons.* *[Samina, P1, para. 147]*

> *I think since then the only bit that's had a major impact has been the accelerated learning programme and [named researcher]. I went to a course in [name] University for a day, about three years ago, it was just being introduced, and many of his ideas, based on brain research, use the analogy that teachers are like car mechanics.* *[Ralph, P2, para. 16]*

Most teachers saw in-service courses in general as having a fairly direct impact on practice. There was a general feeling, however, that these courses play at best an indirect role in increasing the impact of *research* on practice. The research basis of the ideas presented may be very obvious or explicit in some training courses, such as those associated with the KS3 National Strategy, or it may play a more 'hidden role' [Louise, P1, para. 226]. Given that the research evidence on professional development suggests that some understanding of the theoretical base of any practice is a pre-requisite for its successful adoption (Adey et al., 2003; Guskey & Huberman, 1995; Joyce, 1988), the questionable impact of research through CPD courses is, perhaps, not surprising.

Many teachers mentioned the pyramid model of dissemination of ideas, whereby research ideas are seen as 'cascading down' [Janice, P1, para. 58] or having a 'knock-on effect' [Primary focus group 1, para. 651]. Similarly Theresa (S2) talked of sharing information with colleagues about a piece of research which had impressed her:

> *I went on a course, some years ago now and it's the first time that I came across 'Inside the Black Box' about formative assessment and that the research on that and I was particularly interested in that and so I circulated the information. [Theresa, S2, para. 35]*

However, there is a significant gulf between being aware of, or knowledgeable about research and acting on its implications.

Local Education Authorities were seen by some teachers as an important channel for disseminating research findings to practitioners:

> *I think that [research] should be a major influence [on science education]. I think as long as the science research is disseminated to the [Local Education] Authority, in turn to the schools through the co-ordinators, and through to the staff, then I think we can keep up to date. [Samina, P1, para. 143]*

Some interviewees, however, were more sceptical about the extent to which LEA staff kept up to date with research findings in science education. Linked perhaps to this perception, an LEA science advisor interviewed drew attention to a shift in the role of LEAs that made them, in his view, a less effective means of communicating research findings to schools. He was concerned by the shift in his role from offering support and guidance to teachers to a monitoring role.

> *Our role has shifted significantly. We are now much more in a monitoring role. Our supportive role is very much on a consultancy basis, and therefore we're saying to schools, 'This isn't good enough,' almost like an OfSTED approach, but leaving them with it unless they buy our support in. I think that's a slightly sad change in the way that we operate. [Thomas, SEP, para. 117]*

For some interviewees, an important source of knowledge about research was their initial teacher training course:

> *My picture of science educational research comes back to doing my PGCE eight years ago and how much of that I've still got in terms of common misconceptions and that kind of thing. That stays with you but as you build your experience you find out that kind of thing, along the way. [Pauline, S1, para. 36]*

A minority relied on initial teacher training as their sole source of research knowledge:

> *It's come from teacher training basically and all these names of these authors that came from a recommended list of books that do that sort of research on teaching of science, my knowledge really stems from there and I can't say anything else has really added to it since teacher training.* *[Samina, P1, para.159]*

> *Um really most would go back to college, when I was at college and we did look at more research there, things like we were .. for our dissertations we had to go into schools and carry out our own research, compare what we had found out to research by others. Mostly on learning styles, not subject specific, so a lot of it would come from college.* *[Ursula, P1, para.123]*

Initial training clearly has a part to play in teachers' development of understanding of educational research. If this foundation is not adequate, not recognised or not built upon, it may be difficult for teachers to develop skills and understanding needed for evidence-based practice. For many teachers, in-service training was a way in which research could impact on practice, though it did not necessarily lead to clearer understanding of the nature of educational research. Just over half of those interviewed mentioned Continuing Professional Development (CPD) (or in-service training) as an important source of ideas for changing and improving their practice. Some, like Yvonne (P1), saw it as the main source, and felt that research was an important element:

> *I: If you want to improve your science teaching in some way, where would you go for ideas or guidance?*
> *Y: Well the first thing I thought of would be teacher training courses, the kinds of things we get sent or we can ask to go on at the teacher training centre ….*
> *I: Does research have a role to play in that?*
> *Y: Yes, I would say so. Especially in the kind of the courses that are run by the teacher development centre because that's always kind of what's going on currently in the climate of teaching, so yes I would say so.* *[Yvonne, P1, paras. 185-191]*

A quarter of all interviewees saw in-service training as informed by research, or providing access to research ideas and findings. Interviewees were, however, vague about *how* trainers accessed or transformed research findings, suggesting that the ways in which such courses draw on research and translate research findings into implications for practice is far from transparent. There was no evidence in the interviewees that a convincing warrant from research is the primary factor persuading teachers to adopt strategies suggested in in-service training.

5.5 Personal involvement in research

Several other sources of knowledge of research were mentioned less frequently in interviews. Amongst these were contact with PGCE students, the Internet, and professional bodies other than the ASE. Another source of knowledge of research which was explored in some interviews was the interviewee's personal experience of research. This will be discussed more fully in section 7.6, as one of the influences on the impact of research on teachers' practice.

5.6 Summary

At a quantitative level, the frequency with which different sources of research knowledge were cited was in the order: in-service training and professional journals (both 60%); colleagues and books (both 44%); initial teacher education (24%). Responses from our sample of science educators are similar to those in Galton's (2000) wider survey of 302 headteachers' and deputy headteachers' views, where in-service training (80%) and official publications (76%) were the most frequently cited sources of information about research, with courses leading to further qualifications (74%), journals (65%) and other teachers (37%) also prominent. Together, the evidence suggests that it is a combination of interaction through professional networks and independent reading that provides practitioners with their research knowledge. That practice is influenced by a combination of professional interactions and written sources is also supported by McNamara's baseline survey (2002) of teachers setting out as action researchers. For these teachers, colleagues (85%) and books (80%) provided the most valuable sources of information about teaching. Thus, researchers need effective input into in-service training and professional publications to support critical awareness of educational research – dissemination through research journals is insufficient. We suggest that more could be done to make any research base of in-service training transparent.

6 What counts as 'research' in science education, and what makes research 'good'?

6.1 Introduction

As we have seen in sections 4 and 5 above, the great majority of our respondents said that they saw research as having some influence — direct or indirect — on their everyday practice. Most were able to talk at length about how they felt they gained their knowledge of research that might bear on their practice, through reading, informally from conversations with colleagues, or more formally through initial or in-service teacher education. This, of course, raises the question of what these respondents were counting as 'research'. In the interviews, we did not probe this at the outset; it seemed better to assume a certain level of shared understanding in order to initiate the interview, and then to return later to probe each respondent's boundaries of the term 'research' more explicitly. As explained in section 3, we did this with a Card Sort activity in which each interviewee was asked to classify a number of given activities, each briefly described on a card (see Figure 2.2), as 'research' or 'not research', and to discuss the reasons for their decisions. It is these reasons, rather than the classifications themselves, that are of most interest. In the course of the discussion that arose from the Card Sort task, many respondents indicated the criteria they used to judge an activity 'research', or to judge it 'good' research and it is those judgements which are discussed here.

6.2 Attributes of research

6.2.1 Finding out

All interviewees classified some of the activities on the cards as 'research'. Several (fewer than a quarter of the sample) took the view that all of them were research:

> *I would put them all into the category of research. … I think they are all setting out with a question that they want to find out something about. They all have some gathering of evidence and they all have some evaluation of the evidence… on a more or less rigorous basis.*
>
> *[Helen, SEP, paras. 47-51]*

> *I would say that they all of them, in a sense, could come under research … wherever you are … generating new knowledge, from the data and from practice, you are researching.*
>
> *[Ralph, P2, para. 42]*

The key criterion used here appears to be the gathering of data (or evidence) to answer a question, or to generate new knowledge. This was also seen as important criterion by interviewees who classified only some of the given examples as research. For example, Becky (a policy-maker) highlighted the importance of *new* knowledge, describing research as 'gathering in information which hasn't been collected in the same way before' (para. 95). For most interviewees, other factors in addition to information collecting were important in judging an activity as 'research'. Amongst these were its purpose, the way it was carried out, its scope and scale, the person(s) carrying it out, and their objectivity.

6.2.2 Purpose

About three-quarters of interviewees mentioned the purpose of an activity as a criterion for deciding whether it was 'research'. Having a reason for collecting data was seen as important in

judging an activity 'research':

> *If … it's just purely data handling, without actually using that as evidence to challenge an idea then I would say no, it's not research.* *[Eve, SEP, paras. 63-65]*

> *I'm looking for a clear sense of purpose and that leads to knowing not only why they're doing it, but what use are they going to make of the data that they've produced.* *[Ruth, SEP, para. 56]*

Several interviewees were more specific about the kinds of purpose that were important for educational research, in particular, an overall aim of improving teaching or learning:

> *It's for a purpose… you're trying to establish some good practice or other. You're trying to improve your teaching or … your resources.* *[Nancy, S2, para. 156]*

> *I can't see the purpose of any research that doesn't actually engage with enhancing children's learning, not educational research, can you?* *[Keith, SEP, para. 156]*

6.2.3 How it was carried out

For many interviewees, having a purpose was a necessary but not a sufficient condition for classifying an activity as 'research'. The overall approach to the enquiry, and the way data were collected and analysed were also seen as important by over half the interviewees in deciding whether an activity could be counted as research. For some, systematic enquiry is synonymous with research:

> *Some systematic way of answering that question … that's research.* *[Chris, SEP, para. 71]*

> *If they [OfSTED] find a school that's doing well, and they document how they're doing it, … then that can be passed on to others. They're doing it in a systematic way, so I think it is research. … Yeah, that's a kind of research.* *[Kathy, P2, para. 298]*

The mention of 'passing information on to others', in the second extract above also suggests a notion of research as producing public, rather than private, knowledge. Some interviewees went into more detail about what being 'systematic' might mean. Several mentioned comparison of situations or groups. Luke (S2) reasoned that 'research … should compare a situation, evaluate some action to what effect has it had' [para. 96]. Others thought that:

> *It helps if there is some sort of control. It depends what you're doing of course, but it helps if there's some sort of control to measure against.* *[Valerie, SEP, para. 149]*

> *Research involves more than just one group, it should have different groups of … children or whatever … to have perhaps a control group and compare how those groups would do in different circumstances, and what would impact on that, and then hopefully draw a conclusion to answer the hypothesis.* *[Ursula, P1, para. 87]*

This approach was described in a few interviews as making the research 'scientific':

> *The idea of control classes. For me tends to put it more on a scientific sort of basis.* *[Louise, P1, para. 148]*

> *I would expect them [the researchers] to have a similar group of pupils of the same sort of age that they are comparing against. This sort of research [referring to a card being classified as 'not research'] is more like market research and it is not what I would call scientific research.*
> *[Fran, S2, para. 126]*

This notion of comparison as an essential criterion of research was articulated somewhat differently when talking about card number 7 — a teacher collecting test data in his/her own class. Owen (INSET provider) considered that this was not research 'because it is staying within the school'. However, 'if she extended it or made comparisons or anything else, I would then sort of start veering towards, yes, she's doing action research of some sort.' [para. 90]

Similarly, Louise (P1), argued that card number 4 (an OfSTED team carrying out a school inspection) was 'not research' because:

> *it's …an individual inspection report. If that was then being compared, or collated with lots of other inspection reports, then maybe I could think of it in terms of research. But when they are actually writing the inspection report, it's just writing down what they've seen, what they like and what they don't like.* *[Louise, P1, paras. 164-6]*

Comparison and a broader scope (section 6.2.4) are again being used here as key criteria in judging an activity 'research'.

A few interviewees (5/60) argued that research should involve testing a prior hypothesis:

> *When I am considering research I am looking for some sort of hypothesis that the researcher is going in with … they have got some idea of where their research is going and that they are testing that.* *[Fran, S2, para. 126]*

Some other interviewees, however, perhaps in contrast to this hypothesis-testing view of research, emphasised the open-ended character of research, exploring questions whose answer is unknown, without any clear prior expectation:

> *For me research is when you have a question and you don't know what the answer is and you are going looking for an answer. … you might end up finding out that your initial question was wrong. … you certainly don't know when you start out what's going to happen at the end of it.*
> *[Carol, P2, para. 146]*

Such views may reflect a rather empiricist view of enquiry — in which questions are raised, and can be answered by data collected relatively unproblematically through observation. The possibility that our theoretical frameworks and ideas may influence the questions we think worth asking, the data we collect, and the interpretations we place on them, is not mentioned.

6.2.4 Scope and scale

Issues of the scope and scale of an enquiry were, as we might anticipate, important in subjects' judgments about the quality of research, which is discussed further in section 6.4 below. Indeed some of the extracts cited above, about comparison and the use of control groups, are partly about the scale of the enquiry and the breadth of its data base. For some interviewees, scope and scale were also salient considerations in judging an activity to be 'research' or not:

> *I wouldn't call it research if I'd just done it in my own school, but because it was all put together … and it was all the schools in our LEA and … other LEAs, I'd call that research because it's much bigger. The sampling's much bigger.* *[Janice, P1, para. 120]*

> *I think why I was putting some in the category of research and some not is because if it's small scale, and focused on one classroom or one institution, I suppose I was thinking of it being too localised to necessarily have an application which when published would necessarily be useful to another school.* *[George, S1, para. 125]*

Such arguments fit with the views of those Slavin (2002) and others who argue for large scale experimental trials of educational initiatives.

6.2.5 Objectivity

Several interviewees identified objectivity — in the sense of having a certain 'critical distance' from the data and a willingness to look at it critically — as a criterion of research.

> *… although you're going in with perhaps a model or a question, or a hypothesis, or an idea, you are looking at whatever it is you're finding, critically. And you're looking at what it is you've set out to do, critically. …. your methodology may, you know, be wrong, so that you may not be generating valid and reliable information, so that needs to be something that you are able to do, willing to do.* *[James, S2, para. 192]*

Lawrence (a provider of CPD) relates this issue to his own experience of report writing, and suggests that quantification may be a means of increasing objectivity:

> *I've also been aware of the fact that in writing a … report myself, I may have been rather more subjective than I would like and I would never want to hold it up and say this is a research paper. If we could, however, begin to characterise their responses and then put numerical values to these in some way or other, if it became more objective then I would say yes it could be research.* *[Lawrence, SEP, para. 137]*

Again, this comments portrays a rather simplistic view that quantitative research is inherently more objective than qualitative research, whereas all research findings require interpretation. Quantitative findings are, in many senses, as subjective as qualitative findings.

One card which produced a range of widely differing views as to whether an activity could be regarded as 'research' was card number 2, describing an OfSTED inspection. Interviewees' uncertainty seemed to depend on how far the systematic method deployed by OfSTED addressed the issue of subjectivity, as the following extracts show:

> *OFSTED has a very clear methodology of inspection. Therefore their findings should be derived from an objective set of criteria, rather than being subjective. Therefore the inspection report is providing information about something which had to be determined by observation and analysis. So that again, to me, is research.* *[Owen, SEP, para. 134]*

> *Their intentions you could characterise as research. Whether, whether or not we're going to agree that they have been objective and that we can place great reliance upon their findings, that's still an open question.* *[Lawrence, SEP, para. 175]*

No, I don't think it is [research]…. because they are coming in knowing what they are looking for. They are coming in with a set of criteria. To me that's not open enough to be research.
[Carol, P2, para. 96]

For one interviewee, a systematic approach to enquiry, implemented by a trained researcher, was necessary to avoid the potential bias in data collected by someone directly involved in a situation:

If you just rely on … standard questionnaires and interviews giving feedback from teachers, teachers have a view about what goes on in their classrooms, but it's often not the students' view and it's often not the view of an impartial observer and, therefore, if you are trying to gain a view of the impact of some new teaching approach, of some new curriculum material … you've got to have some systematic way of answering that question. That's research. And the people who are trained to do that are in higher education. *[Chris, SEP, para. 71]*

6.2.6 Research — a specialised activity?

The final sentence of the previous extract seems to suggest that knowledge of who conducts an enquiry is salient in deciding whether or not it is 'research'. Whilst this was not a common idea in the interviews, some interviewees did imply that research was a specialised activity – and that something which was a part of 'teachers' normal practice' was not, therefore, research. The following extract is an example of this point of view:

I: The ones that aren't research [cards 3, 4, 5, 6, 7]. What is it that puts them in the 'not research' category?
ST: I think a lot of these are tasks we do all the time. They're standard teaching tasks. I wouldn't regard my marking a test and finding out which questions they struggle on as research. You know, it's told me, OK, maybe I've taught this one a little bit wrong, maybe, you know, I can teach this a little bit better. But it's a one-off, you know, it's within that particular class and it will inform my teaching for next year, but I think it's so small I'd hesitate to call it research.
[Patrick, S1, paras. 94-96]

James (S2), however, saw systematic data collection and analysis in the context of his own teaching as normal practice ('things we do all the time') but nonetheless research:

[reading from card] 'A teacher is administering and marking an end of topic test and using the data to produce a spreadsheet showing pupils' marks on each question to discuss with colleagues in the science department.' Well, yeah, it's a very closely focused piece of research, isn't it? Which could then focus on either the pupils or … on the test itself. Those are the sort of things we do all the time. So, I guess, yeah you could say that that was a type of research, certainly.
[James, S2, para. 180]

For some, like Lawrence (a provider of CPD), activities of this sort might be research:

[It] would depend very much on exactly how I'd carried out the exercise and how objective I really thought it was. *[Lawrence, SEP, para. 145]*

6.3 Overall perception of 'research' in science education

At a general level, in distinguishing between activities they had classified as research and non-research, interviewees argued that research was: done with a purpose in mind, carried out in a systematic and objective manner (often using controls or comparisons), would be used to inform action, and more credible if it was large scale. In contrast, activities classified as 'not research' were characterised as: just collecting information, part of normal practice, subjective, or small scale. In both cases (research and not research), for individuals, often just one or two of these features were dominant in their thinking. Many teachers without research experience professed limited understanding of research criteria, notwithstanding their general comments on purpose and methodology.

From the interviews as a whole, there appears no single common, or even dominant, view of the criteria which make an activity ' research' in science education. Rather, different activities are seen as research by different interviewees, provided they fulfil the important criteria of having a clear purpose and a systematic approach. About a third of interviewees mentioned both purpose and approach, with the majority concentrating on one of these.

Finally, it may be worth noting some features of research which might have been mentioned, but were notable by their absence. For example, no interviewee suggested that a research enquiry should have a clear theoretical or conceptual framework, although five did argue that having a prior hypothesis was an important criterion. The dominant emphasis was on systematic empirical enquiry — comparing cases, or seeking evidence of correlations that might indicate possible causal links.

Differences between teachers with and without research experience were not great. However, those with research experience tended to articulate clearer views on the nature of research and were somewhat more prepared to envisage research taking a variety of forms from individual action-research to large-scale studies. Looking at the Card Sort cards, one teacher with research experience referred directly to this, as he commented that:

> *I would say that they all of them, in a sense, could come under research, small scale, and I know some teachers or LEA advisors doing their Masters or whatever would be expected to do some very small scale [research]. … I think these are …generating new knowledge, from the data and from practice.* *[Ralph, P2, para. 42]*

Methodological issues were commented on more frequently by teachers with experience of research and by 'other science education practitioners' than by teachers without research experience. Many responses from all groups lacked specific detail, suggesting for instance that data should be collected systematically but saying little about issues such as validity and reliability.

The conclusion we derive from these data is that many teachers appear to lack a clear understanding of social research and of the criteria for making judgements about its claims. Rather, their ideas are based either on models of empirical enquiry and hypothesis testing borrowed from the physical sciences, or on more diffuse lay conceptions of enquiry.

6.4 What features of a research study make it 'good' research?

Section 6.2 above has identified some of the characteristics of an enquiry which are seen as important in deciding if it can be called 'research' — its defining characteristics. The same features were also referred to by many interviewees and focus group participants when discussing the *quality* of research studies. A particular characteristic of a study might, for example, make some respondents unwilling to regard it as research — whereas others classified the study as 'research' but saw the same characteristic as important in judging its quality. Ideas about the features of research which ensured its quality arose in many interviews. They were also explored directly in one focus group task, where participants were asked their views on specific examples of published research, presented to them as short vignettes.

It is not surprising that the boundary between what is research, and what is good research is also blurred. The term 'research' carries an evaluative, as well as a descriptive, connotation. So classifying an enquiry as 'research' often carries an implicit positive evaluation. 'Research' becomes synonymous with 'systematic' or 'sound' enquiry.

Several focus group participants referred to methodological factors when deciding how convincing a piece of research was. Of these, the issue raised most frequently was the scale of the study, and the extent to which the choice of sample or setting could be regarded as representative.

> *T: A class of five, it's not enough.*
> *I: So what would convince you?*
> *T: Well you'd want to see something similar done in a variety of different schools with, you know, normal schools …* *[secondary focus group 1, paras. 139-141]*

> *It's not a convincing piece of research when you have such a small sample. Especially a hand picked sample, presumably. And not necessarily with your ordinary, average teacher either …* *[secondary focus group 1, para. 386]*

> *… a case-study of 5 students, it's too small a sample really. Five students in a less able science class and they did it once. It would depend which way the wind was blowing, I would imagine, what results [you got]. You know, they did it this morning when there was a howling gale, the kids would be climbing up the walls. If they did it in July when it's nice sunny day, you might get a completely different result. As a piece of research I felt that was very wishy washy in quality.* *[secondary focus group 2, paras. 208-212]*

Such teachers do not seem to recognise the point made by Darling-Hammond (2002) that medical research, for instance, 'typically uses small sample experimental research as the basis for establishing the possibilities of effects and uses large correlational studies as rough indicators of possible relationships that require further examination' and that 'researchers recognise that mixed methods of research serve complementary purposes' (p. 15).

Some teachers did acknowledge that quantitative data from small scale studies can have some value, but placed greater trust in findings from larger scale studies:

> *For me to rate and value … research I've got to be absolutely convinced of the basic reliability, the validity, so sample size is important though that is not the be all and end all … even some of the anecdotes can be absolutely gob smacking …. but for the most part the educational research I trust a great deal is … when that is done with large sample sizes, when it's done across the world...* *[Simon, S2, para. 54]*

Several of the extracts above also raise the issue of the transferability of the findings to other settings, a point to which we will return in section 7. Another influence on the thinking of several respondents was their background as science graduates. Some refereed explicitly to this as backing for their views.

> *I'd want to see more evidence that that actually has an impact. Four schools to me is, as a scientist, it seems ridiculously small. I mean we're teaching about sample size and four doesn't do it for me, I'm afraid.* *[secondary focus group 3, para. 331]*

One Head of Science interviewed saw his colleagues' science background as a significant influence on their views of educational research. Scientific research was taken as the 'model' for all research, and social science research then seen as of lower quality.

> *I've got a couple of teachers here, both in their forties, […] they've done research extensively in chemistry and have done a lot of time in University in chemistry, not in education as such. And they see research as a scientific thing. They don't see education research as a scientific process, which it is, it's got to be, the way it's got to be put together. But it isn't necessarily perceived by them as such.* *[Ken, S2, para. 224]*

The tendency to privilege an idealised model of scientific research when judging reports of other people's research might lead us to expect that teachers would use such a similar model to evaluate changes in their own practice. Yet, when asked about this later in the interview, very few teachers appeared to use such demanding methodological standards or criteria. Comments like those above may, therefore, reflect a rhetoric used to discuss research carried out by others, and tell us little about the methods practitioners actually use to assure themselves of the good sense of following one course of action rather than another.

7 Putting research into practice: factors which matter

7.1 Introduction

The previous section considered the views of interviewees and focus group participants on what counts as 'research' in science education, and which features of a research study were seen as making it 'good' (or not good) research. 'Good', however, is not necessarily the same as 'convincing', or 'persuasive' — or, more importantly, sufficient to lead to action. In this section we will explore some of the factors that appear to influence whether or not a research finding leads to a change in some aspect of practice. Amongst these are:

- the practitioner's judgment as to whether or not a reported research finding is applicable to his/her own setting or context;
- whether or not a research finding is congruent with other kinds of evidence, and with a practitioner's views, beliefs and values;
- how clear the practical implications of a reported research finding are;
- the relevance of a research finding to practitioners' current concerns and priorities;
- practical and contextual factors, including time to access research and to reflect on its implications, and the practical feasibility of making the kinds of changes that appear to be involved, in the practitioner's own context.

One factor which emerged as likely to influence many of the above was practitioners' own personal experience of research, or past or present involvement in a research project. This is explored in the final part of this section.

7.2 Applicability of research findings to one's own context

As we have discussed in sections 6.2.4 and 6.4 above, the size and choice of the sample of students, schools, or contexts involved in a study were factors to which many respondents referred when deciding that it was or was not research, or when assessing its quality as research. Not surprisingly, the same issue arose again in discussing the applicability of a research finding to settings other than those in which the research was done.

Concerns about the scale of some reported studies emerged frequently in focus group discussions, sometimes expressed as a perception that you can prove anything with a few hand picked students.

> *T: It's not a convincing piece of research when you have such a small sample. Especially a hand picked sample, presumably. And not necessarily with your ordinary, average teacher either, which in a sense you need if it's going to give us lessons that are transferable across the board.* *[secondary focus group 1, para. 381]*

> *T1: The thing … from the actual vignette, which … struck me, was it was data from only 44 pupils, which I thought, 'Wow, I could pick 44 pupils, and … get results'.*
> *T2: That was my biggest reservation.* *[secondary focus group 3, para. 281]*

A quite common perception was that research findings might not transfer to difficult classes — with the implication that researchers may choose more 'comfortable' classes for their research. In

the extract below, the speaker apologises for such scepticism, perhaps because of the presence of 'researchers':

> *I'd want to know about the schools as well, because obviously all schools are very, very different and … this might have been nine particular schools, where it was particularly going to work, you know. Not that I doubt research material. That sounds awful, but I'd want to know…have they been hand chosen? Have you tried to do it [at the] end of the day with a difficult Year 7 or whatever?* *[secondary focus group 3, para. 129]*

A related, but somewhat different concern, was that positive research outcomes might be achieved by 'excellent' teachers, working in privileged settings:

> *The CASE material, the 'Thinking Science' stuff — the impression that you get from that material is one of two things. Either the people who are doing the teaching are so super-dooper that nobody else is ever going to be able to do what they're doing, or they've been done with classes of 15 or 20. Now that's not realistic, I'm sorry to say. That's the impression you get from the material. And you've got a class of 30 in front of you, that makes a big difference.*
> *[Ken, S2, para. 312]*

Where this 'impression' had been obtained from, however, was unclear as it was not specified in the vignette and the research was undertaken with normal size classes. Rather, it is possible that, as research has shown, when confronted with anomalous data, individuals find a number of ways of rationalising their rejection (Chinn & Brewer, 1993, 1998).

In all focus groups, some teachers said they would want to know contextual and background information before making a judgement about a piece of research, particularly if the claims made by the research appeared too good to be true, or vague and meaningless.

> *I just thought when I first read this …that there were just so many questions that I wanted to ask about it. So I've put it also as 'some reservations'. I wanted to know more about the groups who did it and whether you have to do all 30 of them to get those — lots of those sorts of questions. I'm quite prepared to believe the trials, I just need a bit more back up information.*
> *[secondary focus group 1, para. 79]*

Indeed, there were suggestions that a research report became less believable if it made claims that seemed implausibly sweeping:

> *It's the hundred percent thing, isn't it. There's nothing that's sort of hundred percent for every child in every class, is there? I think initially, as soon as you read that, that's what it's trying to say and you're automatically, sort of, your instinct is to be anti that anyway.*
> *[primary focus group 3, para. 230]*

Several focus group discussions referred to the complexity of human behaviour as inevitably limiting the generalisability of educational research:

> *T1: I mean children are so complex, the human personality's so complex that it's so difficult isn't it. I mean, the government can't decide on MMR, which is reasonably straightforward compared with most educational research, it's hardly surprising we can't agree that something done in a classroom a hundred miles away is going apply to our classroom.*

T2: Yeah, but there's medical research, very sort of definite evidence, isn't there? Not that there isn't in educational research, but the nature of the evidence is a lot different, a lot more open to interpretation. [primary focus group 3, paras. 600-602]

The important difference here may not be the nature of the evidence, but rather the clarity of the measure. In many medical cases, the outcome is clear cut; the medical condition of the patient either improved or did not. In the educational case, the judgement as to whether better learning occurred, and the measurements that support this, are significantly harder to make.

Other teachers raised the possibility that some impressive research findings might be the result of a Hawthorne effect, with students' attainment raised simply by virtue of the fact that they and their teachers were involved in the study. Similarly, some suggested that teachers who get involved in research projects are likely to be those who are most effective and successful anyway:

The other thing is that kids often respond more when you take an interest in them. So a small group, they may start to raise their attainment because someone's taking an interest in them. [secondary focus group 3, para. 293]

My gut feeling on these sorts of thing, always, is that, this is perhaps overly analytical, but I always think that the very nature of getting involved in a project like that tends to make me think that probably there are good things going on in these places anyway. And whether it's actually these particular activities that have an effect, or whether it's the enthusiasm or interest that's been previously expressed by the schools to get involved in the first place, whether that's an indicator of maybe there's some better stuff going on in the classrooms or in the schools anyway. [secondary focus group 1, para. 75]

Some of the comments above might be attributed to the fact that we asked the focus group participants to discuss several very short vignettes of research studies (see Figures 2.3 and 2.4). It seems clear that effective communication of research findings depends on providing adequate contextual information to answer the more obvious questions of potential users about the choice of research subjects and settings. Without this many potential users are unlikely to be persuaded of the relevance of the findings to their own contexts. This, however, raises a dilemma for those who argue (as several of our participants did) for the need for concise, accessible accounts of research findings, as a means of communicating to busy practitioners. Several interviewees argued for short digests of research findings to improve access to research (section 5.2.1). Careful judgments are required in writing such accounts, to ensure that abbreviation does not remove so much contextual information that the account no longer appears persuasive.

7.3 Resonance with experience and belief

Although issues of scale and scope, and methodological considerations (such as the use of comparisons and controls), were central to the discussion of what counts as research and what is good research, one other factor was mentioned more frequently than these in discussing how persuasive, or convincing, specific research findings were. Many teachers, when discussing the focus group vignettes, referred to the extent to which a finding resonated with their own experience, or was in line with their views and beliefs, or with their department's policy and practice.

I tend to look at things that I can often relate to as either currently in my practice, or […] that's happened to me and that's a good way of solving that. [primary focus group 1, para. 244]

> *I'm not convinced of the one about the less able pupils* [vignette 3]. *… I'm less convinced about that because of my experiences being the opposite.* *[primary focus group 3, para. 396]*

> *I am the sort of person who does like to find an expert's point of view. So when I read … that I put it through the filter of my teaching experience … and it makes sense to me from my own point, background of experience. I would put quite a bit of faith in that and try and use it.* *[Neil, SEP, para. 119]*

Thus, as Kennedy (1997) also noted, research was more likely to influence practice when the findings accorded with experience or beliefs. This tendency for research findings to be used as confirmation of existing practice was echoed in the focus group discussion of the first polar statement – about the extent to which research results are obvious or provide new insights. Although many agreed that research findings can provide new knowledge, there was also a feeling that this was more acceptable when it confirmed the value of existing practice. Such comments are in line with a large Australian study (DETYA, 2001) which found that 'teachers seek out the sources they believe will build on their existing knowledge and that this was a very individual process.' (p. 2).

> *T1: …. at the same time I do take on board a lot of new views coming up, but it's usually things that you know inherently, … It's quite often research backs up how you feel about things.*
> *T2: Yeah, it's not arrogance, it backs you up.*
> *T3: I'm the same I wrote 4* [agree that most results of educational research are obvious] *for the same reason.* *[primary focus group 1, paras. 665-669]*

Other teachers talked of being convinced by research findings which confirm their personal skills and experience — rather than the weight of 'research evidence' alone convincing and changing minds. In fact several saw knowledge from research as often hard to separate from knowledge from other sources:

> *I: Which of the research summaries did you find most convincing?*
> *T: I suppose for me it was CASE because I have already got pre-conceived ideas of how successful it is. And having been involved in teaching it as well I know how successful I've found it. So it's hard to separate that knowledge …* *[secondary focus group 3, paras. 67-69]*

Both focus group participants and interviewees saw rigorous research designs which used large samples as more persuasive and believable. However, unless the research outcomes bore some relation to what they believed or might expect, almost all focus group participants indicated that they would not be prepared to act on the results. Conversely, most participants seemed quite willing to act on (or at least to consider acting on) research findings which accord with their prior beliefs, even if the research design was seen as less than wholly sound.

Thus, there seems a fine line to be drawn between research which resonates with prior beliefs and that which simply states the obvious:

> *And some of the things are obvious aren't they. Like a couple of those pieces that we read about the pupils' misunderstandings of the science concept. We know that and people spent a lot of money on this research and you think, well why, because we already knew that.* *[secondary focus group 3, para. 832]*

We might ask, is it possible for a piece of educational research to be simultaneously convincing and surprising? Furthermore, these teachers' views suggest that the transformative potential of any research may be highly constrained — that is, research will only lead to a change in practice when the new practice can be readily assimilated into existing practice rather than demanding substantial change.

In summary, for focus group participants, the research presented in the vignettes was seen as convincing if it had resonance with teachers' experience, was seen as generalisable to other contexts, and came from studies that were seen to have a sound design (usually involving a large sample). As regards research design, both interviewees and focus group participants often used a prototypical 'natural science' model of research as a touchstone of quality — in line with the views of educational researchers who argue for the greater use of randomised controlled trials in educational research (Fitz-Gibbon, 2000; Slavin, 2002). Many science teachers become familiar with the research methods used in science, through undergraduate projects and the like. Unless they have also engaged in educational research, they may have rather less familiarity with social science research methods. The generally greater confidence in discussing these issues of teachers with some educational research experience suggests that it would be valuable to include some discussion, or better still experience, of social science research methods in initial and in-service teacher education.

7.4 Practical implications of research findings

Even if a practitioner is persuaded of a research finding, he or she cannot act on this unless they are able to identify specific practical actions which might follow from it. The lack of more rapid and widespread influence on the practice of science education of ideas arising from research, such as Piaget's model of concrete and formal operations, or the constructivist view of learning, has sometimes been attributed to the difficulty, for teachers, in seeing exactly what practical actions might follow from acceptance of the broad finding, or principle. Gail (a provider of CPD) expressed this very clearly in her interview:

> *[Research findings] can be a little on the impenetrable side. And if they are made accessible then the likes of me and ordinary teachers can get hold of them more easily. I think … theory is no good on its own. It is necessary and very important, but the question is, what do I do with it in the classroom? And if you don't have that question answered, then it doesn't influence you. It needs to be, so what do I do then? If this is it, how do I react? How do I do something differently with the children? If I haven't got that anchor it's difficult.* *[Gail, SEP, para. 368]*

Gemma (a provider of CPD) made much the same point, when she commented:

> *It's as if they [teachers] want someone else to do all the theory and then just tell them what's going to work. They want it translated. The teachers just want it distilled into what they should do, that will definitely make a difference.* *[Gemma, SEP, para. 229]*

The issue of perceiving the practical implications of research findings was raised explicitly by the second polar statement pair used in the focus group discussion (see Figure 2.6). Apart from this instance, however, it did not feature prominently in focus group discussions. This might be partly a consequence of our choice of research vignettes with relatively clear practical implications. One, for example, was Budd Rowe's study of the effect of wait time (vignette number 4). A high proportion of participants in all focus groups claimed familiarity with the results of this study and several indicated that they already used this in their teaching — though not all were aware that it was a research finding:

T: Yeah, number 4 [is convincing] *which I actually do already. I find that that's the best way forwards, I mean, waiting for a response. Some children are very hesitant to speak out to start with. And sometimes it's better if you give a little bit of time to think. Maybe it's a minute, maybe it's two minutes, maybe it's three minutes. […]*
I: And were you aware that was something that you were doing in, yourself, that piece of research
T: That was something I would do, I mean I wasn't aware of it being recent research, it's something that I do a lot of. [primary focus group 1, paras. 68-72]

In the interviews, specific research findings were identified as influences on their practice by just a few individuals with no experience of research — which necessarily limited the amount of discussion of the issue of identifying their practical implications. An example given by one teacher — about teaching control of variables — was seen as linking easily to current teaching emphases:

In terms of 11-16 work research by Lovell that I was exposed to, if you like, when I was training...about the intuitive control of variables, the fact that students perhaps up to the age of 16, the average student is unable to consciously control one variable, so that pervades a lot of work that I do when we're looking at course work, experimental planning and that kind of thing. [Richard, S1, para. 20]

Other comments, however, suggest less clarity in distinguishing between findings and their possible implications. Marcus, for example, argued that:

Research needs to be relevant to play a major role …something that I would think, 'Oh yeah, I would like to do that! I want to do that!' [Marcus, S2, para. 200]

Again, in this discussion, context was a factor which inhibited the adoption of research findings, one focus group member arguing that differences between teachers and schools meant that implementing practices based upon research findings was inherently problematic:

You've only got to look round this table, three completely different schools, three completely different teachers. I could think of teachers in my school that are so different from each other and we've got a whole range of learners that yes… I could imagine that there would be problems you know applying the research findings that have been done in one set of circumstances to a completely different set of circumstances. [secondary focus group 2, para. 585]

A rather different issue was raised by one interviewee, a practitioner who was not a teacher, when commenting on the influence of the Cognitive Acceleration through Science Education (CASE) project. His comment highlights the long time scale of the research programme which eventually led to the CASE teaching materials:

And then suddenly we came through to the mid 70s…. I came across the first research findings which indicated that if you were doing Nuffield Chemistry then the materials we were placing in front of the children were inaccessible to all but 15% of the population. And it only improved to 25% of the population by the time you get to 16 years of age….. So that was having an impact upon me. But the people who made those findings were the people who became the CASE people. Because by the time they got to the early 80s, Shayer had come out with 'Towards a Science of Science Teaching', and then they worked further and came out with their findings in the late 80s and the CASE project was born round about 1990, wasn't it, as something that the schools could go out and use. So that is a good example, because they made those findings

> *accessible and more widely known within the teaching force than probably anything that had gone on before.* *[Lawrence, SEP, para. 56]*

The fact that a group of researchers took almost two decades, to articulate in detail a set of practical actions that might follow from research findings which they saw as important, suggests that identifying the practical implications of research findings is far from trivial. Hence, it may be expecting too much of individual practitioners to leave this step to them. The subsequent impact of CASE, and our own work on diagnostic assessment which has sought to translate research tools into usable items for the assessment of children's knowledge and understanding of key scientific concepts, suggests that this 'translation' into practical actions may be essential for wider impact of research on practice. It is also surely a step in which researchers themselves need to be deeply involved — and to come to see as part of the research process.

Perhaps the most salient comment here is on the relative rarity of discussion on the practical implications of research findings. This reinforces our sense, discussed earlier, that the impact on practice of specific research findings, through practitioners' direct knowledge of these, is very limited. Much more commonly practitioners would refer to the use of certain teaching materials or guidelines as a means by which research influenced their practice, or acknowledged their use of broad teaching approaches, such as 'active learning' or practical work. Although unable to point to specific research findings that supported these aspects of their practice, many teachers expressed their conviction that there 'must' 'surely' be research evidence that these ways of teaching are more effective than other alternatives.

7.5 Relevance to practitioners' concerns

Several interviewees commented that research needed to address practitioners' concerns if it was to have an impact on practice:

> *I think [researchers have] first of all have got to be very, very clued into what are the political, cultural pressures on schools, on the day to day running of schools and teaching. […] You've got to research what is needed.* *[Ralph, P2, para. 76]*

> *There's no point in just sending volumes of research out to teachers, because it won't be used. […] it has to be relevant.* *[Marcus, S2, para. 200]*

Several respondents drew particular attention to the current focus on measurable improvements in examination and test results — stating, or implying, that unless research findings appear likely to help enhance these performance indicators, it is unlikely to be taken up:

> *The school, especially the Head, is driven by results. All he is interested in is that we improve our results. And whatever method or whatever way you want to teach and whatever learning goes on in the classroom is not really important. The results at the end of the day. We need to raise our level of results so that is what drives us. That is what drives at the moment. It is just results, results, results.* *[Edward, S1, para. 162]*

Other teachers also referred to the influence on practice of examination syllabuses, and of 'teaching to the test' in order to maximise their students' performance in national tests and GCSE:

> *In an ideal world you would want more time, better resources and more opportunity to actually read research and be better informed. But the fact is, that we don't have that time. The SATs are*

very much to the forefront. We're very, very aware of results that we've produced there, and so that seems to drive the science teaching. [Jack, P1, para 26]

The perception that an accountability culture significantly limited the influence of research on practice emerged in the discussion of the third pair of polar statements in the focus groups. In discussing whether research findings can or cannot help teachers improve test scores, many focus group participants thought that research had the potential to achieve this outcome. Within several discussions, however, questions were raised about the appropriateness of harnessing research to the pursuit of pre-determined policy goals, rather than broader educational objectives:

T1: If children's motivation increases, and children's understanding improves, then obviously I'd say that research is very valid, but if the research was carried out, for how can we improve children's test scores and this is how it's done, I'd think, well, that's a bit frightening, a bit sad.
T2: I think my view was like that. To have a curriculum that's perhaps test driven, was my concern, and that more research to make that better was the (wrong way) to go. So therefore I put it towards the middle. But like you said if it was actually improving the whole aspect of science, it would be different. [primary focus group 1, paras. 737-739]

Such comments highlight the a dilemma that confronts researchers seeking to make education more evidence-based. Better public examination grades are a common lay measure of improvement in the educational system. Yet, in contrast to the situation in medicine, there is significant disagreement amongst educators as to whether such examinations are a valid measure of educational attainment. Thus, if there is little agreement about what constitutes a legitimate measure of enhanced effectiveness, how can practice become more evidence based?

7.6 Time constraints

The most commonly mentioned barrier (in three-quarters of interviews and focus groups) to the influence of research on classroom practice was time. Time, rather than reluctance to change, was the issue for Marcus (S2):

At the moment, because of time constraints, it's a minor role. I would like to think that I would be able to have the time to read more research, to look at more research, which would develop the way that I teach. Even at my age I can learn new tricks. [Marcus, S2, para. 200]

The majority of interviewees referred to the severe time pressures on teachers in the current climate and a sense that there was very little spare time for teachers to explore research evidence for themselves.

The way things have changed, quite dramatically, over the years is literally there is no thinking time. […] You do not have the opportunity to sit and think and discuss things and thrash things through. I mean your average interaction with colleagues is measured in seconds rather than in minutes, these days. [James, S2, para. 60]

Part of the issue of time constraints was the rate of change within education. For many teachers, there was a feeling that the pressure of covering constantly revised curricula squeezed out both the time to engage with research or to change their practice to accommodate research evidence.

> *I think one of the hardest things at the moment with schools is because courses are changing. You always seem to be trying to develop a new course so that you don't necessarily have enough time to actually think about the actual [course being taught].* *[Sonia, SEP, para. 100]*

> *I'd like to think though that research would have a part to play but they would have to reduce the content, or give more time to some which is not going to happen. The present climate in terms of the delivery of the curriculum is a constraint, and it's a time constraint. More so perhaps in schools like this. … In an average comprehensive there's probably more time spent thinking about how to get the children to learn, whereas here it is mainly delivery of the curriculum. [This is] a very high achieving school and in schools like this, there's very little effort put into looking at the way children learn. … It's very much delivery of the curriculum, especially in years 10 through to year 13.* *[Steve, S1, paras. 138, 158]*

An offshoot of this issue was raised by one teacher who argued that trainee teachers are now immersed in an environment where there is very little reflection on research findings during initial teacher training. This, he felt, could have a significant impact on future attitudes to educational research, given that for some of the interviewees their initial training course was a major source of their knowledge of research:

> *I think the problem is there is less time for […] trainee teachers actually in the University because of the amount they're expected to spend in school. I think there's a general feeling that they should spend as much time in school as possible, because that will make them good teachers, and I just think that's nonsense.* *[James, S2, para. 336]*

Lack of resources, including staff, were also seen by some interviewees as potential barriers to impact of even the most striking research findings:

> *It might be a brilliant piece of research but if you don't have the time and resources and the money and the staff to do it, it's not doable. It's brilliant but what use is it in the real world.* *[secondary focus group 2, para. 256]*

The last comment suggests again a perception of research as something isolated and separate from practice, carried out in artificial and highly controlled contexts.

Several teachers saw the attitudes and views of colleagues as a major barrier to the impact of research on practice:

> *I: What do you think are the barriers to using research evidence?*
> *T: People who are stuck in their ways and don't want to change.* *[Eileen, P1, paras. 288-291]*

One practitioner involved in science education policy-making suggested that whilst research might provide a source of ideas for already 'good' science teachers, for others different sources of support are likely to be more effective:

> *They [teachers] do get the messages but whether they are willing to receive the messages is a different issue. Good practice users will selectively take what they think will help them. And the satisfactory practitioners will follow the good practice use. Those who struggle… then there are different things about why they struggle in the classroom. And research isn't going to help them. They may read research, they may be interested in it, but if they are struggling on a day to day basis with children in the classroom they need a totally different support mechanism.*
>
> *[Dennis, SEP, para. 37]*

Views like those of Dennis are in line with the widespread perception, expressed particularly in the interviews, that research is only one of many influences on a teacher's everyday practice, and not perhaps the most significant one. On the other hand, educational research on behaviour management and learning styles (section 5.1.4) might well underpin the 'support mechanisms' that Dennis sees as of more immediate value to teachers struggling with class control. In fact some interviewees did cite research in these areas when discussing the impact of research on their own practice.

7.7 Impact of practitioners' experience of research

Personal experience of research is likely to make a significant difference to a practitioner's awareness of research findings, confidence in assessing and interpreting research, and considering its implications for their practice. Indeed, it was for this reason that we chose to include 20 teachers who had had some experience of research in the interview sample.

Several of these teachers saw the research study they themselves had carried out as having a significant, and beneficial, influence on their practice:

> *The research I did for my MA influenced my practice more than it ever would anybody else's, who read my report … as a result of that I know that the students I teach are getting a better deal than they were before I did it all.* *[Ken, S2, para. 184]*

Whilst Ken doubted whether his research would have as significant an impact on the practice of someone reading his report, other teachers talked of how their involvement in research had impacted on departmental decisions or practices, for example through more systematic evaluation of the different courses offered to students:

> *One of the things we did was we asked them why they chose Chemistry and why they chose the particular syllabus. And we used that as a basis for how we advised them. So that was one thing. The other thing [was analysis of the AQA and Salters courses]. It's certainly made us more aware of the strengths and weaknesses of the two courses …helped us to sort out the activities that we do on the two courses.* *[Nancy, S2, para. 28]*

Personal experience of research was seen to impact on teachers' everyday practice in various ways. Sometimes this influence was very specific and had a very immediate or direct effect on teaching and learning. One theme that emerged in several interviews was the use of research to elicit and document pupils' misconceptions in specific areas of science, and the positive impact this can have.

> *'The Earth in Space' for Key Stage Three, we have to look at topics such as why there are 24 hours in a day, why there are seasons, annual cycles. Some of the some of the ideas that the pupils had were absolutely astonishing and I can honestly say that, if I hadn't done the research prior to teaching the topic, I still wouldn't have any idea that they still had these misconceptions.*

> *… It's changed the structure of the topic, because I have gone from just teaching it straight through, like I would imagine most teachers do, to establishing with the pupils their ideas. … So yeah it's made a big change to the way I teach that subject. [Quentin, S2, para. 34]*

> *After that example that I've just given you [a spider is not an animal] we actually did a departmental meeting which took quite a big chunk of time discussing this and realised that the scheme of work that we were working on at that time was not a hundred per cent adequate, and we had to add to it and make clarifications of certain topics. [Younis, S2, para. 42]*

Some teachers found it difficult to articulate exactly how their personal experience of research had altered their practice whilst recognising that it had, in significant ways:

> *I think it must have [influenced my practice], although it's hard to quantify. My research involved talking to students, much like you and I are talking now, interviewing them. And I think that must have meant I see it a bit more from their point of view these days. So I think that has to have changed my practice over the years, but I'd be hard put to tell you exactly how. [Luke, S2, para. 24]*

For several, the lasting benefit of their involvement in research was their sense that they had gained a new perspective, or way of thinking about things:

> *I think a lot of the ideas that I was exposed to at that time, and the kinds of things that I'd been reading around that time, tended to set a pattern of thought, a set of ideas, that have certainly influenced me and made me think quite critically about a lot of what's come afterwards. [James, S2, para. 20]*

This sense of research skills — and increased confidence in marshalling ideas and evidence — comes across from Ken's account of his efforts to improve girls' involvement in science:

> *The biggest example of how [research] influenced what I did was when I was at [a previous school]. There was a debate going on about girls in science. Somebody wanted to trial single sex science classes in year 9. Now when this was brought up I was very, very against it. I came into comprehensive education. I don't like single sex schools. Using some of the skills that I'd learnt, I spent time in libraries and time talking to people about this idea, and actually changed my own mind and became the person who did the presentation to governors, did the presentation to staff, and actually was the person who, through the research I'd done, … was the biggest backer of it. … That was from using the skills that I'd done the MA with, I used those skills … I think it is a skill, doing research. I think it is a skill using a library, for instance. [Ken, S2, paras. 39-41]*

Ken's commentary supports evidence from this study and others (Cordingley, 1999; Elliott, 2000) that teachers' experience of the processes of research adds a dimension which facilitates a more evidence-based approach to teaching. James (S2) on the other hand identified the experience of being part of a 'research culture' as the influential factor:

> *I'm sure that my little flirtation with the educational research I did, it wasn't so much the work that I did myself, it was being in an environment where you were with and talking to other people and to people at the University and to colleagues who were doing similar things, who said have you seen this, have you seen that, have you looked at this, whatever. [James, S2, para. 44]*

One aspect of this, as Hazel (S2) suggests, is that personal contacts can draw your attention to particular pieces of work of which you might otherwise be unaware, or can result in you paying them more attention than you otherwise might:

> *There are people I know who do research like [name] and he is doing research into modelling. But also the work that [name] did for the project on misconceptions. Although we don't refer to it every day, we know about it, and we know it was important.* *[Hazel, S2, para. 38]*

Simon (S2) also remarked on the lasting influence of some individuals he had encountered when involved in research, who had helped him see more clearly the possibility of linking research and practice:

> *The main people that were influential in setting that up, I have great gratitude to them because it really opened my eyes …that was a good example of how attempts were made to form some kind of integration or some real communication between on the one hand the research findings and on the other hand the chalk face.* *[Simon, S2, para. 19]*

The last quotation, in particular, illustrates a more general, but less tangible outcome of these teachers' involvement in research — an enhanced ability and willingness to engage in critical self-reflection about their own practice.

Several teachers with some experience of educational research also mentioned the effect of their involvement on their *overall* perception of research. Whilst some felt this experience made them more critical in certain ways, in general, however, their experience made them more positive about the potential impact of research on their practice:

> *I think [the experience of doing research] makes me more aware of the role of research and the importance of research and what research can give you … what you can learn from it. So I think deep down you know research is important but, unless you do your own, I don't think you are always convinced that it can have a real effect on what you are doing in a classroom.* *[William, P2, para. 55]*

One thread that ran through several of these responses was about the presence or otherwise of a 'research culture' in the teacher's own place of work, with expectations and opportunities for engagement with research evidence and reflecting systematically on practice. Often this distinguished teachers from other science education practitioners, for most of whom keeping abreast of research was very much a part of their role. Even among the teachers, however, there were considerable differences in the extent to which individuals appeared to be, or felt themselves to be, part of a community that valued research. Although there was a tendency for teachers with research experience to report closer involvement with research, this was not invariably so. Some teachers without research experience were clearly well informed about some research, whilst some with research experience appeared to have subsequently lost all contact with research. In general, teachers with personal experience of research appeared more able to incorporate ideas and evidence from research into their own teaching, and were more confident and more positive in responding to research that they subsequently encountered.

8 Evaluating changes in practice

8.1 Evidence and decision-making

Teaching involves many choices and decisions — ranging from the choice of course, and teaching programme, and teaching materials, to the minute-by-minute decisions and choices that have to be made in the classroom or laboratory. Advocates of evidence-based education argue that educational research should aim to provide the sort of evidence which can directly inform choices and decisions about matters of practice — to tell us 'what works'. In the long run, they argue, better decisions and choices are those which are based on the sort of evidence that research can provide, rather than on informal experience or established practice — and these can lead cumulatively to the improvement of practice (Slavin, 2002). It therefore seemed salient in these interviews to probe teachers' views on how they made decisions about their practice — and in particular about how they judged whether a change they had made had in their practice 'worked', and was an improvement on what had gone before. The question was asked towards the end of the interview, with the aim of illuminating the importance, and the feasibility, in teachers' perceptions, of using systematically collected evidence to inform judgments and decisions.

8.2 Measures of pupil learning

When asked what evidence they would use to evaluate a change in practice, more than three-quarters of the teachers interviewed talked about assessment of pupil attainment, in particular national tests and public examinations:

> *Well, results obviously. Teacher assessments. So … at the end of a topic, say, some sort of formal assessment, SATs.* *[Yvonne, P1, para. 203]*

> *In terms of results it's fairly easy to gauge. We do keep all our records on a central computer from year to year so we can see if there is an improvement there.* *[Quentin, S2, para. 134]*

Tim (S2) referred to the practice, which he felt was common amongst science teachers nowadays, of using:

> *Baseline data and concrete measures of attainment …We do use that data quite a lot. That seems to have happened and what caused it? Is it because of different material or a different teacher or a different approach?* *[Tim, S2, para. 87]*

As previously noted, a few teachers in the sample commented very forcibly on the importance their school management attached to results in public examinations and national tests, suggesting that this evidence over-rode all others in judging a change or innovation:

> *It's sort of performance management. … that is the bottom line … Teachers are being sacked or they're not being promoted, and schools are being named and shamed. There's an unpleasant climate. So all we are interested in really are those statistics.* *[Ralph, P2, para. 58]*

In such contexts, it seems likely that a new approach would be considered for adoption only if there was evidence that it could lead to measurable gains on these measures.

It is also worth noting here that the outcome indicators to which teachers referred were almost always *overall* measures of attainment in science, rather than measures directly related to a specific

change. The priority currently given to such measures clearly poses a significant challenge to anyone seeking to improve science teaching cumulatively though the introduction of more effective teaching approaches in specific topic areas.

8.3 Professional judgement

Although assessment strategies and measures of pupil learning were often the first things teachers discussed when asked how they would evaluate a change in their practice, many also referred to less systematic indicators of improved learning that might precede any summative assessment:

> *It's usually a personal, subjective judgement, when you're actually teaching the subject that you feel they've got a far better understanding of it, and when they do their assessment the results which they produce there.* *[Jack, P1, para. 178]*

Rob (S1) felt that, in practice, judgments were based largely on these less systematic indicators, though he clearly felt that more formal indicators would be an improvement:

> *I don't think we analyse enough our results to quantify any changes we've made to see whether they've been successful. I think we measure our success generally through responses of the children and the feeling that we have after completing the new approach. So it's very woolly, really, and if we were more scientific, if you did analyse it properly, we should be able to quantify exactly whether there has been any change.* *[Rob, S1, para. 143]*

Several teachers, on the other hand, appeared to regard pupils' reactions and responses during the teaching as their main indicator of success. When asked how they judged the outcomes of a change in practice, several highlighted the quality of pupils' verbal responses as an indicator that they would use:

> *Personally it's generally from verbal feedback from kids. I'll question them and if they've picked up on what I've done or what they've done, and if I can see a change in the way that they are answering questions or the way they are talking back, then I'll think it's had an effect.* *[Ben, S2, para. 256]*

> *Well … you've got the gut feeling and the actions of the kids and the vocabulary they use, the kind of non-written signs and the more elaborate explanations they give, the kind of chronological or sequencing or cognitive good thought processes you can see going on, there's that. The rounded feel you get to the lesson.* *[Colin, P1, para. 227]*

Richard refers in similar terms to quality of written work and evidence of ideas learned, but then goes on to talk about pupil engagement and motivation. For most teachers (29/40), these were important indicators of improvement:

> *Quality of work, written work, ideas. So if you felt there was an improvement to something in a lesson, you would hope that that was reflected in the work of the students in some way, perhaps in some written work, their ideas, the quality of work, the number of books that got handed in when you next wanted them in, that kind of thing. So there'd be all those kind of factors. … If there was an improvement then you would expect, with the attendance, that would be measurable. You'd expect punctuality. There'd be enthusiasm, there'd be less level of disruption, you know, all of those factors.* *[Richard, S1, para. 159]*

In many of these responses, there is a sense that decisions inevitably involve professional judgment, which is difficult to specify precisely. As Bill (SEP) put it:

> *I suppose the bottom line [when judging if a change is an improvement] is going and looking at it and then making a professional judgement. Now, professional judgement, saying exactly what that constitutes and what one takes on board in making that is extremely difficult. Nevertheless I think that it is enormously valuable.* *[Bill, SEP, para. 107]*

For many practitioners this 'gut feeling', or 'gut instinct' [Patrick S1, para. 124], came with experience and influenced how a practitioner prioritised, or even interpreted, 'evidence' in the decision-making process. The bases of professional judgement were difficult to articulate, but involved evaluation of pupils' reactions in various ways:

> *It's difficult to describe it really. Sometimes you really know that it's really gone well … the feedback you get back from the students … And sometimes you really try to do something and it just falls flat and you think, why didn't that get a response. So you learn, I'm saying, I suppose, you learn through experience, through taking a risk, trying something new, seeing how it goes and taking it from there.* *[Pauline, S1, para. 164]*

Most practitioners (31/62) felt that experience played a key role in developing their professional judgement. The ways in which different kinds of evidence are interpreted and evaluated can change over time. Many teachers saw teaching as involving a continuing process of comparing new situations with others encountered in the past:

> *… past experience comes in … because obviously as you go through the years teaching, then you have got something to relate that … feedback to. You have got a bank of experiences … You are constantly making comparisons with, you know, when I did it this way, this is what happens, and when I have done it this way, this is what happened.* *[Tim, S2, para. 87]*

8.4 Varieties of evidence

The picture we get from interviewees' comments on evaluation of change is of professional judgment about the response of pupils to new methods and approaches, set against the background of an education system in which data on pupil attainment data plays a dominant role. In the interviews, very few examples were given of systematic collection of evidence to reach conclusions about the effectiveness of a teaching intervention or innovation. One, from a teacher with research experience, was of a department that had chosen a new specification or course after discussion:

> *The AS course was new last year. So at the end of the first year we gave the students a questionnaire and we analysed the results. And one of the things that came out was that we really had to rush the third module in order to get it finished. And the students didn't feel very confident with that bit of the course at all.* *[Nancy, S2, para. 218]*

Another came from a provider of curriculum enhancement activities commenting on his normal practice of getting feedback from participants:

> *Trialling is probably enough, really, at that stage. I haven't done it yet, with this new resource. Where I've done it is with the events that I've been developing over several years which is, these conferences, scientific conferences for kids, where the kids are the centre of attention and what we do there, we do evaluate every event.* *[Neil, SEP, para. 281]*

In both these cases, the data obtained appears to be participants' views rather than 'hard' outcome measurements.

Both in these comments, and those of the previous section, there is a striking contrast between the rigour of the criteria that many teachers in the focus groups appeared to apply in evaluating given accounts of research, and those that teachers commonly apply when judging the success of changes in their own practice. Whilst performance measures are frequently mentioned, and clearly play a major role in many teachers' lives at present, these are almost entirely general measures of attainment in science, and not specific measures of the success of a particular change in achieving its specific objectives. Personal involvement in a change of practice not surprisingly heightens attention to other less measurable features, such as the 'sense' of how well the change is working, of the quality of the learners' engagement and responses, and so on. As we have seen, some respondents regarded small-scale local enquiries by a teacher in his/her classroom as 'not research', and significantly more questioned the quality as research of small-scale studies and the generalisability of their findings.

It would appear that many of our respondents set 'research' on a pedestal, and see any actions of their own, or of other individual teachers, to evaluate changes in practice as a somewhat different category of activity. For some science teachers, this view of research may stem from their own experience of, or learned ideas about, the methods and criteria used in research in the natural sciences. Whilst some seem to take a 'natural sciences' view in evaluating examples of educational (social science) research that they encounter, and others claim to be influenced by it, few seem to adopt such a systematic approach when evaluating more local or specific changes in their practice.

This dichotomy has implications for efforts to increase evidence-based practice in science education. There are, of course, several possible interpretations of what evidence-based science education might mean — ranging from the use by science teachers of methods, approaches and materials for which there is already documented evidence in the public domain that 'they work', to the more systematic collection and use by teachers of data on the outcomes of their own current practices as a basis for making (and evaluating) these and any changes they might make in them. As regards the former, few teachers talked about teaching methods, approaches and materials for which they believed there was documented evidence that 'they work', in the sense of helping more pupils to attain specific outcomes. The only example mentioned was the CASE materials — and when some of the evidence for their effectiveness was discussed in the focus groups (vignette 1), its persuasiveness was frequently challenged. Teachers — perhaps particularly science teachers — seem to set demanding criteria for 'research', which studies aiming to show that a teaching approach 'works' may find difficult to satisfy. This suggests two possible responses: either that teacher education (ITT and/or CPD) aim to provide opportunities for teachers to reflect more deeply on the nature of enquiry in education, so as to arrive at a more considered view of what is possible, and what might count as 'sound evidence' as a basis for action; or that researchers adopt more rigorous and challenging designs in order to improve the quality of their findings and the persuasiveness of implications drawn from them. Increasing evidence-based practice is likely to require both — and an acknowledgement that professional judgement will still play a role in acting on the evidence base.

A rather different vision of evidence-based practice is one in which teachers make more systematic use of data collected on their own practice to inform decisions about what needs to be changed, and whether changes that are introduced do in fact 'work'. Their practice is then informed, not by their awareness of the reported findings of research carried out elsewhere, but by research evidence which they themselves have collected, perhaps using tools and approaches originally developed by

other researchers. Here the issue seems to be raising the status of this sort of activity (which some teachers regard as 'not research' as it is part of 'normal practice'), and providing tools that enable it to be done more thoughtfully, more systematically — and, not least, more easily, by busy practitioners.

9 The potential of research to inform science education practice and policy

9.1 Introduction

Most of the questions asked in the interviews focused on practitioners' views of their current situation. One question, however, explored their views on the *potential* of research to inform practice and policy, and how that potential might be realised. Our aim here was to throw further light on interviewees' disposition towards research in science education — do they see it as a significant influence leading to improvement? Another was to enable interviewees who felt that research currently had little direct impact on their everyday actions to talk about their view of the research-practice interface and how the situation might be different. Finally, we believed that participants' answers might throw light on perceived barriers to the greater impact of research, and ways in which these might be overcome.

9.2 Direct impact on science education practice

Over half of the interviewees saw research as having the potential to have a major impact in improving the quality of science education, with about a sixth seeing research as having the potential for a definite, though more minor, role. Just under a third were more doubtful about the potential of research to help improve the overall quality of science education.

Many of the interviewees (36/62) saw potential for research to influence their own science education practice. Marcus (S2) saw this in terms of research confirming the value of current practices, and so bolstering teachers' confidence and self-image:

> *I think it [research] can play a larger role. We've got a lot of teachers out there who are very, very keen, very hard working and are trying their best to do a good job. And I think they would appreciate help from research to say, 'Yeah, this is a good way of teaching'.*
>
> *[Marcus, S2, para. 268]*

Comments like Marcus's above are very unspecific about type of research, or its focus. Several interviewees, however, identified learning in specific areas of science as an area in which research could play a role:

> *Well, I suppose we could find out if there are any particular areas of the science curriculum that the children in general fall down on. [...] You question whether you are asking the children to do too much, you know, to learn something that's not really in their capabilities.*
>
> *[Louise, P1, para. 246]*

> *I think research into investigating how children learn in science, in particular, is really, really valid and I think that has and will continue to make big improvements into science. Especially I am very interested in looking at how children learn at the early stages in nursery [...] and how kids formulate their ideas and how that develops throughout their growth*
>
> *[Yvonne, P1, para. 215]*

This is perhaps not surprising, as a great deal of research of this kind has already been done, and this is a types of research with which many science teachers will be familiar. Whilst endorsing the perceived value of this research, these teachers seem essentially to be asking for 'more of the same'.

There were just a few examples of specific research questions relating directly to classroom practice that practitioners thought they would like answers to:

> *I would very much like to see a study which took children who were just taught mostly concepts and see where they went to compared with children who were taught enquiry. And at the end see who made the grade, when it came to do something really amazing like, you know with computers or something like that, to see who was the person who had the ideas, the thinking person.* *[Eileen, P1, para. 220]*

In general, teachers with no personal experience of research were positive about the potential influence of research but often very unclear about what this might involve:

> *I think it is real difficult nut to crack isn't it. I mean training teachers is one thing but to try and get research to improve something like teaching is a, it's a real hard nut to crack. I wouldn't know where to start personally.* *[Anthony, S1, para. 337]*

The vagueness of the latter comment raises questions about the role of teachers in setting the agenda for educational research — are they best deployed in assisting to formulate research questions or in reviewing the ideas and proposals generated by the research community?

9.3 Potential impact on science education policy

Throughout the interviews we explored interviewees' views on the role of research in informing policy in science education, including the official and semi-official documents that constrain or influence their practical actions. Several interviewees talked about the potential for research findings to influence policy such as the National Curriculum and assessment. Michael's view would apply equally to any large scale 'official' innovation:

> *… the National Curriculum was thrown at us a number of years ago now and I question how much research was put into it beforehand. Had the research been put in to find out what was successful and what's not successful, then perhaps what they put out in the first case, the original case, might have been more successful. In other words finding out what works, first, before these innovations are put into practice.* *[Michael, S1, para. 194]*

A small number of teachers saw the potential of research in stimulating more radical review of practices, including the National Curriculum. These interviewees saw research as potentially providing a more systematic justification for their own sense of dissatisfaction with the current science curriculum:

> *I think particularly for the sort of children I predominantly teach, [research] could make a case for dropping the National Curriculum, for making science less of an academic, must pass exams, situation.* *[Luke, S2, para. 172]*

> *I think it's got a crucial role to play really. The more I teach science the more disillusioned I become. You do get a feeling that lots and lots of children find it irrelevant to them. […] So I think research has got a role to play there. First of all find out what do people need to know when they go into the big wide world, in terms of science, find out what children enjoy learning about in science, and then develop a curriculum that is suited to them.* *[Rob, S1, para. 163]*

Some interviewees focused on one specific aspect of National Curriculum practice, particularly the assessment regime. Chris saw research as a means of demonstrating a better alternative, and so stimulating change:

> *What would be top of my priority at the moment in terms of research and development would be assessment. I think the current forms of national external testing are having a very seriously negative effect on science education. I don't think it will change without the effective demonstration of better ways of doing it, that politicians will trust.* *[Chris, SEP, para. 168]*

In general, science education practitioners who were not teachers, and teachers with some experience of research, were more articulate about the potential for research to influence the context and framing of science education than teachers with no experience of research. This finding suggests that contact with research develops a better understanding of its potential role.

9.4 Realising the potential of research

In discussing the potential of research, interviewees frequently voiced opinions as to why the potential of research was not being realised. One key issue was access to research, with communication and of dissemination research findings being seen as a problem:

> *I think [research] can make a hell of a difference, a hell of an improvement, with better distribution and access of the research material.* *[Quentin, S2, para. 162]*

> *Well I think it can make a lot, I think it, I think it has got an enormous contribution to make, but I think it comes back to what I've said before … it is a question of communicating the findings of research.* *[William, P2, para. 121]*

Practitioners' perceptions of access to research, and the communication of research studies and their findings have been discussed in more detail in section 4 previously.

Another issue seen as critical to realising the potential of research was its quality. Colin, for instance, argued:

> *Obviously it's got to be good quality research, get rid of all the bias of statistics and sample numbers. All I can say that if I was Head of the school, or if I was a Science Inspector, I would want to see people taking research seriously.* *[Colin, P1, para. 279]*

Interviewees' views on what constitutes research of quality have been discussed previously, in section 6.2.

Rather than stressing research quality, several respondents saw aspects of the current educational context as a more significant barrier to the impact of research:

> *I do think it's possible [for research to have a greater impact on practice]. I don't think the fault is on the research side. I think the fault is in the organisation of schools and education in general. It doesn't allow it to play a part …* *[Ursula, P1, para. 119]*

For Hazel (S2), the key to greater impact of research was that:

> *We would have to be less results driven. That would be the biggest change. People who get good results are scared to change in case their results go down. Schools who are successful may not see why should they change.* *[Hazel, S2, para. 230]*

Comments throughout interviews and focus groups made reference to national tests as the currently dominant measure of educational success. The following extract from a focus group discussion typifies the frustration felt in concentrating on a narrow measure of success with attendant restrictions on the potential influence of research:

> *T: I think there are broader issues — not simply to do with the opinions that people hold about the research. The bottom line is … will it get my school better marks? That's a Headteacher's question. Will it get my school better results? I'm not absolutely certain whether my Head really cares whether the kids enjoy science or not, or whether they are science thinkers or not, or whether they would even want to pursue careers and interests in science. But if I get better GCSE results next year, than I did this year, then she'll be happy.*
> *[secondary focus group 1, para. 658]*

> *T: … we're now made so accountable on the basis of exam results, aren't we. Our survival, in a sense, depends on it, whichever sort of school we're in. And it is very sad that now getting good exam results doesn't actually relate to being a scientist any more.* *[ibid., para. 666]*

Comments such as these were typical of views expressed throughout interviews and discussions about the influence of league tables on classroom practice:

> *Everything is about getting them [pupils] through those SATs and through their GCSE with the highest possible marks for grades, levels or whatever they are. And I find this quite dispiriting because I have always believe if you are a first rate teacher, inspiring teacher, then good performance in examinations must follow. And yet now, all we have are systems and the mechanics of getting the kids through examinations just seems to me to be getting in the way of proper teaching.* *[Lawrence, SEP, para. 305]*

There seem, therefore, to be conflicting messages in current national educational policy. On the one hand, teachers are encouraged to engage with research evidence, including direct involvement in research through initiatives like the *Best Practice Research Scholarships*, with the overall aim of improving pupils' performance as measured by national tests and public examinations. Such engagement is small-scale and suffers from the limitations of 'local' evidence identified by Hielbart, Gallimore and Stigler (2002), and implied in many of our respondents' comments cited earlier. Nevertheless, engagement with teacher-led research can develop research skills and reflective attitudes towards research findings — pre-requisites of evidence-based practice. On the other hand, however, the dominance of national tests performance as the singular measure of pupils' learning is seen by many practitioners as a major constraint on reflection and change in practice. This is an example of what has become known as Goodhart's law, named after Charles Goodhart, a former chief economist at the Bank of England, who showed that performance indicators lose their usefulness when used as objects of policy. The importance of the singular or selected indicators means that other components of the system, which in their own way are as significant, become neglected. Perhaps not surprisingly then, research that does not contribute to improved performance is ignored.

9.5 Removing barriers to change

Given the pressures to improve pupil performance on the currently dominant 'high stakes' measures, and the high workload of all teachers, realising the potential of research to improve practice may not be easy. Teachers with research experience were asked what changes might enable educational research to make more of a contribution to the everyday practice of science teaching. Several suggested that greater contact with universities would help, in particular closer collaboration between teachers and researchers:

> *I'm sure there's a lot of research, educational research going on at universities but we don't see a lot of it in schools. I think more communication with the local schools and colleges, communicating any results and making them more available to us. Perhaps getting us more involved in their research and then whatever results come out of that research will be more tangible to us.* *[Younis, S2, para. 150]*

Collaboration was seen by Ben (S2) as helping to remove some of the negative perceptions that some teachers may hold of researchers, as removed from classroom practice:

> *I think it [research] should be an influence. I think it would be nice if people that were involved in teaching were more involved in it … A lot of teachers are very negative because they don't see the people in the classrooms.[…] It gets people's backs up ... and people judge the people giving out the advice and the research negatively, because they don't see them doing the bit in the classroom. Whether or not they've done it in the past doesn't matter. They don't see it. You can get over that barrier, and I think it could affect it for the better.* *[Ben, S2, para. 268]*

In one sense, this comment is true. However, it is difficult for researchers to engage in a meaningful way in classrooms. Effective teaching rests on good relationships which take significant time to establish and sustain. To engage in any meaningful way would require considerable time commitment from the researcher and reduce the time they could devote to research.

Simon (S2), on the other hand, saw initial teacher education as a vehicle for increasing the impact of research on practice:

> *Where something has got to change is PGCE courses where far more time I believe should be spent on the students, getting a grasp of how the children learn [..]I really do feel that a huge area of mainly educational research is just not tackled anywhere near enough at the moment.* *[Simon, S2, para. 70]*

A few respondents suggested that incentives, including financial ones, were needed to increase attention to research:

> *I: And how do you think changes might be achieved,*
> *T: I'd be hard put to say that, maybe just mailing heads of department with stuff and saying well if you read this out at your science meeting we'll give you a £20 voucher to buy something.* *[Luke, S2, para. 220]*

We would be very dubious, however, about the value of such a suggestion. Some even felt that direct imposition would be needed:

> *I think it's got to be forced upon the local authorities. I think the LEA advisors have a big role to play in this.* *[Marcus, S2, para. 264]*

Behind many suggestions of ways of increasing the influence of research on practice and policy was a sense that the profile of research needs raising in the eyes of policy makers as well as teachers. Development of stronger and more effective research communities may mean the encouragement of effective dialogue, critical evaluation and trust between teachers, LEA and other advisors, policy makers and professional researchers. Comments throughout interviews and focus groups, suggested, as we have seen, that the presence of research communities of this sort is currently patchy at best. Perhaps, however, this is not surprising. The research community is, after all, relatively small. For instance, the number engaged actively in research and development in science education we estimate to be of the order of one hundred people in the UK. Not surprisingly, their engagement with policy-makers is limited.

10 Conclusions

10.1 Summary of main findings

It may be useful at this point to summarise briefly the main points which have emerged from this study.

Almost all of the practitioners interviewed thought that research was an influence on their practice, though only a few felt it was a relatively major one. Many saw research as a 'background' influence on practice — possibly quite substantial, but 'built in' to materials and routine practices and so implicit at the point of use. Ways in which the practitioners interviewed saw research as influencing their practice fell into four categories:

1. specific (where knowledge of a research finding influences a specific piece of teaching);
2. general (where research is believed to lend support to some aspect of general teaching style or approach);
3. mediated (through using teaching materials produced by a research project);
4. indirect (through using teaching materials, or following guidelines, that are considered to be informed by research).

Instances of the first category arose in only a minority of interviews. Few teachers gave examples of the influence of particular pieces of research, or research findings, on the way they undertook a specific piece of teaching, or attempted to achieve a particular learning outcome. More commonly research influences were referred to in general and unspecific terms (category 2 above), for example as supporting a teacher's preference for using practical work, or activity-based learning. The use of teaching materials devised by a research project was mentioned in over half of the interviews and focus group discussions, as an example of the influence of research on practice (category 3). Here the user might know that the materials are based on research but not be able to outline the research findings which underpin them. Some participants did not make a clear distinction between materials arising from research projects and those produced by curriculum development projects (such as the various Nuffield and Salters projects), treating all of these as 'research' outputs. A surprisingly large number of interviewees, mainly teachers without personal experience of research, saw research as influencing their work through the textbooks, curriculum guidelines and schemes of work they used, which they took to be based on, or to draw systematically on, research (category 4).

Most interviewees saw reading as one important source of their knowledge of research. Publications of the Association for Science Education (ASE) appeared to play a key role, with others mentioned only infrequently. Several mentioned lack of time to read books and journals, and the inaccessible style of research reports, as barriers to impact of research. A few interviewees suggested that short research digests might help address this. Reactions of many focus group participants, however, suggested that condensed reports often fail to persuade, if their findings do not immediately resonate with experience or expectation, partly because of the absence of critical contextual detail.

Personal contacts between practitioners and researchers appeared to increase significantly the likelihood that research might influence practice. LEA advisors, Key Stage 3 Strategy Co-ordinators, ITT or CPD tutors, and colleagues with research contacts often appeared to act as a 'bridge' between the research and user communities. People in these groups were more likely to be seen as the source of ideas for improving practice than researchers (or research reports) directly. For many

teachers, these 'mediators' of research had the important role of integrating research knowledge with professional (and possibly also local contextual) knowledge. Again the Association for Science Education (ASE) was seen as a very valuable network, enabling many of these contacts, and information-sharing between researchers and users more generally. Interviewees' comments, however, often suggested that practical ideas were valued more than an understanding of the evidence supporting them — though others (in particular some ITT/CPD providers) felt the need to be able to present the evidence which supported approaches they were advocating.

Whilst interviewees were invariably willing to talk about 'research', there did not appear to be a single common view of the criteria which make an activity 'research'. Purposeful and systematic enquiry, involving collecting data, to answer a question or solve a problem, were mentioned in many responses. Comparison with a control group was widely seen as a sound research design, as was having a large and representative sample. 'Objectivity' — having a critical distance from the question investigated or the approach being evaluated — was also seen as important by many. By contrast, activities that did not merit the label 'research' typically lacked at least one of these characteristics. Many practitioners acknowledged a lack of experience of social science research methods and appeared to have little feel for the differences between knowledge of the social and natural worlds — and hence for the methods which might be appropriate for gaining each, or the criteria for assessing knowledge claims. As a result, they tended to judge all 'research' against criteria appropriate to the natural sciences. This was not, however, reflected in the methods that participants said they used to judge the effectiveness of their own practice or to assess the impact of changes they introduced — suggesting that self-evaluation is not seen as 'research', and so not subject to the same criteria as are used to appraise reports of research.

In assessing a reported research finding, many teachers were unconvinced of its relevance to them if the context in which the research was carried out, or the sample of students or teachers involved, appeared 'untypical', or different from their own situation. A Hawthorne effect, or a favourable setting, were often suggested as reasons for a positive reported outcome. As noted earlier, this demand for extensive contextual information in order to assess reported findings conflicts somewhat with the requests in some interviews for short summaries or digests of key research findings as a means of dissemination. In several focus groups, participants also expressed scepticism about findings that appeared 'too good to be true'. Several suggested that evidence in educational contexts was always likely to be more equivocal and qualified than in, for example, medical contexts — and was more persuasive if this were acknowledged.

A key factor for acceptance of a research finding appeared to be its resonance with experience and belief. Teachers seemed generally sceptical of findings that were surprising, or out of line with their professional experience. Findings were more likely to be acted on if their practical implications were clear, and could be relatively easily put into practice, perhaps initially in relatively small ways. For this reason, research projects which had gone on to produce teaching materials based on their findings were generally more widely recognised, and had had a greater reported impact on practice. For many practitioners, the initial decision to use a particular set of research-informed teaching materials appeared to be based on a judgement about their potential usefulness in their own context, to address perceived problems in their current practice. Knowing that it had backing from research was reassuring, but secondary. The pressures on schools and teachers to improve performance on currently-used outcome measures were widely noted as a significant constraint on action, and on 'experimentation' to improve learning outcomes.

Personal experience of research appeared to make a marked difference to practitioners' awareness of research, and confidence in assessing the significance and the implications of reported research

findings. Teachers with first hand experience of research appeared best able to marry the two perspectives of research and practice — judging research evidence using criteria of quality that researchers might use; evaluating professional practice systematically but acknowledging that decisions drew also on professional judgement. Some teachers with research experience were able to give specific examples of changes in their practice, but others, whilst convinced that their research experience had altered their practice in significant ways, found it difficult to articulate these clearly. Several talked of an enhanced ability and willingness to reflect in a self-critical manner on their own practice, and of the importance of a 'research culture' in their place of work in sustaining this.

10.2 Implications for researchers and practitioners

Most of the participants in this study were positive about the actual and potential influence of science education research on their everyday practice, though few were able to give specific examples of ways in which their practice was shaped by research findings or insights. We might therefore say that a majority appeared to consider their practice to be 'research evidence-informed'. The contribution of research, however, appeared to be seen largely in terms of drawing attention to learning difficulties (such as common misconceptions), or to the consequences of differences between learners (such as gender or ethnic differences, or differences in learning styles), so that these can be 'taken into account' in planning and acting. This falls some way short of believing that there is — or could be — research evidence that some *specific* courses of action in response to these issues are more likely to work (or to work more often, or with more learners). Few participants in this study appeared to consider aspects of their practice 'research-based' in this stronger sense, or to believe or expect that research could provide evidence to warrant particular actions and choices in specific teaching situations.

This perception of the role of research in informing science education practice has implications for both the researcher and practitioner communities. First, we should acknowledge that many of the decisions which practitioners make, even quite substantial ones such as choice of textbook or GCSE specification, are ones for which they rightly assume there is no research evidence. This inevitably engenders a sense of taking key decisions about practice on the basis of professional judgement. Second, we should acknowledge that science education practitioners are largely correct in seeing few, if any, examples of research-based teaching approaches — if by that we mean teaching programmes or interventions which have been shown, by research, to be more effective than other ways of achieving the same learning outcomes. Research in science education has been more successful in documenting teaching and learning difficulties than in systematically testing strategies and approaches for ameliorating these. If we are serious about moving towards more research evidence-based practice, then more effort will have to be devoted to developing and evaluating ways of addressing recognised problems, in order to find if some 'work' better than others, and to marshal the evidence in support of such claims. The practitioners involved in this study appear to be telling us that they are more likely to be convinced by large-scale comparative studies, which demonstrate a clear effect. Researchers need, therefore, to consider undertaking more studies of this type.

One important implication of such a shift in emphasis is that researchers would be obliged to think harder about the practical implications of their findings. The views of practitioners in this study suggest that research evidence alone, even when the findings in the research context are clear and convincing, is unlikely to lead to change. A key reason is that too much work remains to be done to transform the research findings into specific practical *actions*. This is not work that can reasonably be left to practitioners, though working *with* researchers they may have a very valuable contribution

to make. For researchers, the effort of articulating (as a working hypothesis) what they consider to be the practical actions that follow from their research findings is a valuable (perhaps essential) part of the research process, in clarifying the findings, and making it possible to communicate them to others. This study shows clearly that, where researchers have 'translated' their findings and insights into teaching materials or programmes, or specific guidelines for action, this has led to significantly greater impact on practice.

Conversely, the findings of this study also have implications for the practitioner community. The dichotomy between the standards and criteria used to assess reports of research, and those used to evaluate aspects of one's own practice, are very apparent. If research is to contribute more effectively to the improvement of science education, then this will require practitioners to examine more critically the evidence, or lack of it, on which their practice is currently based, and to use more objective methods to evaluate the impact of changes in their practice. Such a change will, however, require institutional support, to establish the structural conditions needed for evidence-based practice. Whilst a questioning and reflective attitude is an attribute of an individual teacher, his or her working climate is conditioned by the structures and documentation that support and constrain science teaching at a school, local and national level. These may encourage or discourage the use of research to inform practice.

At the local level, institutional support might mean financial support and encouragement to engage in higher degree study, or to get involved in research initiatives. However, national level structures set the scene for local engagement, and these attracted considerable comment throughout the study. Teachers currently appear to receive conflicting messages about the extent to which research evidence-based practice is encouraged. On the one hand, the research basis for practices encouraged by major policy initiatives as the National Curriculum and Key Stage 3 National Strategy are not made explicit. Some teachers see this as implying that professional knowledge, based on experience, is more important and valuable than research evidence. Others assume that the initiatives are fully informed by research, even though this is not made explicit.

On the other hand, teachers have been encouraged to engage in small-scale action research relating to their own practice, through initiatives such as the DfES Best Practice Research Scholarships. For teachers, such activity has immediate meaning and relevance, but the extent to which it is carried out systematically and with regard to previous research can vary considerably according to the nature and level of support within and external to the school. Such local knowledge is 'concrete but almost always incomplete and sometimes blind and insular' (Hiebart, Gallimore & Stigler, 2002: 8). The evidence obtained through action research may have meaning, and be persuasive, for those involved. The external validity of small-scale research was, however, questioned by many participants in our study, and its findings may lack persuasion for others not directly involved. There are, however, other kinds of benefits. Teachers with research experience in our study were more prepared than others to consider a range of data collection and analysis methods as constituting research, in line with evidence from action research consortia (Cordingley, 1999; Elliott, 2000). Providing teachers with opportunities to engage in action research extends their skill base and contributes to the development of a culture of evidence-based or evidence-informed practice.

Action research as a CPD activity could either build on research skills developed in initial training, or remedy their absence. So to what extent does initial teacher training develop the perspectives and skills required for evidence-based practice? A recent change in the *Standards for the Award of Qualified Teacher Status in England* (TTA, 2003) has resulted in this sole reference to 'evidence':

> *They [trainee teachers] are able to improve their own teaching, by evaluating it, learning from the effective practice of others and from evidence.* *[point 1.7]*

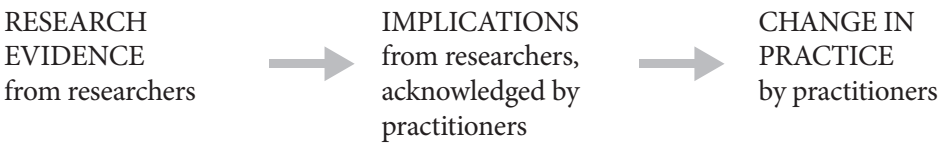
This statement scarcely places evidence-based practice at the core of professional development. Indeed it is not entirely clear what it means by 'evidence' – does it come from large-scale research studies, from one teacher's action research, or from another source? Hiebart, Gallimore and Stigler (2002) argue that some of the problems of aligning the knowledge generated by researchers with the practical knowledge of practitioners are a consequence of the lack of a professional knowledge *system* in the teaching profession. There was little evidence of a 'system of knowledge' or 'theory of practice' underlying participants' responses in our study. The educational policy documents which specify the requirements of initial teacher training are similarly lacking in a clearly articulated 'theory of practice'.

Just as 'evidence' in the QTS Standards is left open to interpretation, so, in much educational writing and discourse, is 'research'. We have already noted the absence of a single, common view of educational research amongst the participants in our study, and their tendency to evaluate research using 'natural science' criteria. This is perhaps not unsurprising given the science background of participants. Science education practitioners seem, however, relatively uninformed about methods of educational research, or social research more generally. The professional training of science teachers needs, perhaps, to do more to develop understanding of the strengths and limitations of social science research methods and knowledge claims, if more evidence-based practice is to become a reality. A better understanding of research skills and tools might also help to resolve the apparent dichotomy between participants' rigorous criteria for assessing the research of others, and their reliance on professional judgement and 'softer' assessments of how well activities went, when evaluating their own practice.

In summary, then, this study suggests that, for research findings to make an impact on classroom practice, they must have:

- *convincing* findings — i.e. from studies with clear, rigorous methods which seem likely to generalise to other contexts
- which *resonate* with, or acknowledge, teachers' professional experience
- and have been, or can easily be, *translated* into practical activities and strategies for classroom use,
- widely disseminated through respected *professional networks*.

Traditional models of evidence-based practice have taken a rather linear, top-down approach:



The limitations of such a model have emerged from studies across a number of public policy domains (Nutley & Davies, 2000; Nutley, Walter & Davies, 2002) and are supported by our findings. Nutley and Davies' alternative model has researchers and users working together with a continuous interaction between knowledge creation, validation, dissemination and adoption. The need for interaction and networking between teachers, researchers and policy makers in developing and

supporting an evidence-based culture seems to be a strong message from our study. National and local structures which support such networking were suggested by many of our participants as a means of realising the recognised potential of science education research in improving practice, and should be actively encouraged.

Ultimately, the science education community — both teachers and researchers — needs to generate a knowledge base to underpin its practices, and to consider more frequently the epistemic questions: How do you know that this practice is effective? What is the evidence? Only a common shared value, that it is better to act in ways for which there is evidential support of this sort, will drive a stronger engagement between the communities of researchers and practitioners. Whilst teaching remains very much a 'form of life' rather than deliberately planned actions in pursuit of stated objectives, what we observe is the enactment of a set of cultural practices guided by norms that are often tacit (Donnelly, 1999). These are 'values that emanate from practice and become sanctified with time. The more they recede into the background, the more taken for granted they become' (Willard, 1985:444). Such cultural norms are distinguished from other rules, not by reference to any lack of authority, but rather by the unconscious force they exert over human actions. Milne and Taylor (1998) characterise such norms as myths — narrative accounts of collective experience — where the 'historical and contingent quality of established patterns and beliefs and practices is replaced by an unwarranted sense of naturalness and inevitability'. Only a conscious attempt to ask explicitly for their justification and rationalisation can open up the black box of current practice for inspection, reflection and for deeper consideration of the contribution of research.

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