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Valuable insights on curriculum, teaching, and learning may be gained from research, and it is the aim of this section to bring significant research information to the attention of science teachers, with a view of helping them in their important work.

Assessment for Inquiry: Supporting Teaching and Learning in Primary Science

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Abstract

This article reports on findings from a two-year project – 'Improving Science Together' (IST) – undertaken in 20 primary and 4 secondary schools in Bristol, UK. The project was funded by AstraZeneca PLC as part of the national AZ Science Teaching Trust initiative, and had as one of its aims the development of science teaching and learning through targeted assessment and 'focused teaching' of specific inquiry skills. The research team made participant and non-participant observations in every school and held interviews with teachers to find out how they responded to using this approach, and how they managed its implementation. Our data suggest that participation in targeted assessment and focused teaching has increased teacher confidence and led to a greater willingness to undertake investigative work in the classroom. Another effect observed has been enhanced clarity of learning intentions in science lessons and the provision of more appropriate scaffolding of children's learning. This has led to assessments of specific scientific inquiry skills becoming more useful in helping teachers to identify and communicate effectively to children how to improve. Children in observed lessons had a clearer understanding of what was expected of them, and so were more motivated and likely to remain on task. The implementation of the strategy has been most effective where teachers have understood the importance of providing opportunities to carry out whole investigations that enable the children to apply their full range of skills as independently as possible. For this reason, it has also been more appropriate for teachers of the 7 -11 age group than for 5-7 classes, as developing skills in isolation from an inquiry context can be less meaningful for younger children.

Key Words: formative assessment, scientific inquiry, primary, teaching skills.

INTRODUCTION

Formative assessment is widely regarded as central to a 'constructivist' approach to teaching and learning science in primary schools (e.g., Harlen & Osborne 1985; Ollerenshaw & Ritchie 1997), since it involves the 'elicitation' of children's 'misconceptions' which can then be 'restructured'. However, much of the emphasis in formative assessment in science has been upon conceptual elements of children's learning (e.g., Russell *et al*, 1991) rather than procedural or investigative skills – what Harlen (2000) has referred to as the 'process skills' of scientific inquiry.

The ASE/Kings College London Science Investigations in Schools (AKSIS) project (1998-2001) has re-focused attention upon children's procedural learning of scientific inquiry skills, and how these can be taught explicitly, both in isolation and in the context of 'whole investigations.' AKSIS has highlighted the need for 'targeted learning' of scientific inquiry skills, and has developed a number of classroom strategies to teach specific elements, such as describing patterns in data (Goldsworthy *et al*, 2000a, 2000b, 2000a, 2000c). This re-visits a long-running debate within the science education community, which could be briefly summarized as 'holism versus atomism.' For example, Millar (1989) explored what he saw as the problems inherent in making scientific processes 'explicit' and the difficulty of distinguishing between processes and skills. He argued that the cognitive skills required in scientific inquiry are general to everyday life, and that, therefore, formal instruction in them is unnecessary. An approach to science in which particular processes can be applied to investigate phenomena is based, in Millar's view, on an inductive view of science, which ignores the need for judgment and intuition. He recommended a clear separation between 'skills' that can be taught (e.g., reading a thermometer) and 'processes' that cannot be taught (e.g., deciding what to measure or observe). This view was supported by Woolnough (1989), who advocated a 'holistic' approach to teaching and learning scientific inquiry, as an 'atomistic' approach in which skills are broken down into their constituent elements and taught separately, and risks eroding scientific attitudes, such as curiosity and the underlying motivation to explore the world.

However, the educational climate in England has changed considerably since 1989, and the position advocated by Millar and Woolnough has come under pressure, partly from inspection evidence (OfSTED 1999) indicating that investigative elements of science have been under-taught in primary schools, and that pupil achievement in this area tends to be associated with clear learning objectives. The explicit sharing of tightly-defined learning intentions with children has been promoted through high status Literacy and Numeracy Strategies (refs DfEE 1998, 1999) and the AKSIS project has drawn attention to the difficulties associated with a diet of 'whole investigations' in primary schools without support for children to develop the multiple procedural skills needed. There has been a tendency for teachers to place a heavy emphasis on children's ability to construct a 'fair test,' and this has been a key indicator used to assess progress in scientific inquiry. The result of this has been a neglect of the other skills and processes of scientific inquiry – in particular the interpretation of data and the evaluation of inquiry are areas that have been identified as in need of development (Goldsworthy et al., 1998). A consensus has emerged, in which the strategies promoted by AKSIS are recognized as necessary, particularly for 'higher-order' skills, such as interpretation of data, whilst acknowledging that the key to supporting development of children's process skills is providing them with opportunities to carry out scientific enquiries, as independently as possible, supported by teacher questioning at appropriate points (Harlen, 2000).

Within this theoretical framework, the Improving Science Together (IST) project (2000-2002) emphasized the need for formative assessment (Black & Wiliam, 1998) of children's scientific inquiry skills in order to inform what we have termed 'focused teaching' to address those elements perceived as problematic. Funded by the AstraZeneca Science Teaching Trust, as a partnership between 24 primary and secondary schools in Bristol and South Gloucestershire U.K., their science advisers, and Bath Spa University College, the project initially set about developing strategies for formative assessment of scientific inquiry in the participant schools, seeking to balance the tension between 'holistic' and 'atomistic' approaches by considering on both discrete skills and overall procedural understanding.

RESEARCH QUESTION AND METHODOLOGY

The research, upon which this paper is based, took place as a key element within the wider IST project, funded by the AstraZeneca Science Teaching Trust. One of the key aims of the IST project was:

- to improve and sustain the quality of teaching of science in primary schools, particularly through teachers' use of formative assessment strategies and the appropriate teaching of specific process skills.

The corresponding research question, within an action research framework (McNiff, 1988; Elliot, 1991 ref), was as follows:

- How can the project teachers improve their formative assessment and focused teaching of scientific inquiry?

The two main cycles of the action research coincided with; the first and second years of the project. The actions taken included:

- workshops and discussions during central cluster meetings to develop teachers' understanding of scientific inquiry
- individual support by project tutors in developing school frameworks and teaching strategies
- incorporation of teaching strategies from the AKSIS project (Goldsworthy et al., 2000a, 2000b, 2000c) in classroom teaching
- team teaching between the teacher with responsibility for leading science teaching (science subject leader) and their colleagues

Details of these actions are included in the accounts of each cycle below. The sources of data collected to inform evaluation at different stages included:

- Teacher responses to questionnaires at the start, mid point, and end of the project.

(The questionnaires included some quantitative responses on a 5-point scale and some written responses to questions.)

- Headteacher responses to questionnaires at the mid point and end of the project.
- Teacher comments in semi –structured group discussions (scribed by tutors)
- Tutor participant observations
- Teachers responses in unstructured interviews with tutors
- Samples of medium term planning

Additional data came from the external evaluation of the project and Office for Standards in Education (OfSTEDsted) inspections of some of the project schools.

The Progress of theAction Research Project, Cycle 1 (Year 1)

Contexts and constraints

The development of the focused assessment strategies resulted from attempts to work with theoretical models of the importance of formative assessment in children's learning in science, within the particular contexts in which the project teachers were working. As Alexander (1992) recognized, the quest to develop 'good practice' involves attempting to reconcile different, often conflicting elements: theoretical understanding and research evidence, the values of the participants, political contexts, and pragmatic considerations. This section will explore the tensions between these areas that became evident in the IST project and describe the progress towards some possible resolutions through the action research cycles.

Assessment of scientific inquiry is considered to be undeveloped in Primary teaching (OfSTED 1999), and this was reflected in initial questionnaires to teachers, which indicated their lack of confidence in this aspect of their practice. They found it difficult to identify the different elements of scientific inquiry and to decide what would constitute progress in each element. Goldsworthy et al. (2000c) highlighted the importance of teachers having a good understanding of progression in the different skills and processes of scientific inquiry, in order for their feedback to pupils to be specific and therefore useful to them. We wanted our approach towards formative assessment of scientific inquiry to support teachers in developing this understanding and devised activities accordingly.

Whilst participant teachers recognized the importance of assessment as a formative process (Black & Willam, 1998), they were working within a climate of accountability in which summative assessment data is required to demonstrate children's progress towards nationally set targets of attainment (OfSTED 2002). This required them to track children's attainment in scientific inquiry over time and keep a record of it, as well as developing assessment strategies that would have a more immediate impact on teaching and learning.

Another contextual constraint that teachers identified was the limited time allocated for teaching science; in many cases this was only one afternoon a week. This is national concern (Sutton, 2001). A pragmatic constraint on the amount and types of assessment practice was class size, and, hence, the time available for teachers to assess each child – in any one lesson teachers can either assess fewer children across a greater range of criteria, or more children across a narrower range of criteria. There was also a concern amongst the project teachers that they often asked pupils to record the entire process of an investigation in a written report, and that this was burdensome for many children. It reduced their enjoyment of science, and also took up a considerable amount of the time available for practical work.

Action taken

The teachers took part in various workshops and discussions on days when the whole project group met together, and were also supported by tutors on an individual basis in their own schools.

The teachers found the AKSIS activities (Goldsworthy et al. 2000a, 2000b), which involve comparing imaginary children's responses to tasks and analysing them, useful in clarifying their own understanding of assessment criteria for scientific inquiry. This in turn enabled them to feel more confident in providing constructive, yet specific feedback to the children in their schools.

Another of the means of developing a more focused approach to the teaching of scientific inquiry was to support the teachers in identifying the aspects that are particularly prominent in certain conceptual areas of the science curriculum. For example, studies of habitats do not lend themselves to learning the control of variables strategy through a 'fair test,' but would be appropriate for making hypotheses and testing predictions about where different organisms would be found. The teaching of specific skills, such as using a thermometer, could be related to relevant topic area, such as materials. This linking of procedural and conceptual elements helped teachers to make decisions about what an appropriate inquiry focus might be for particular units of work.

Where an opportunity for a whole investigation had been identified, the planned focus helped teachers to make decisions about which parts of the investigation would be more strongly 'scaffolded' by the teacher, and where the children would be expected to make more independent decisions. This would depend on where the intention was to focus teaching on a particular element (e.g., identifying patterns in results and making generalizations), and where the children were expected to apply skills developed in previous experiences (e.g., devising and using a table of results). Sometimes children were asked to record only particular aspects of the investigation rather than the whole process, with that aspect forming the focus of the assessment for the lesson. This had the benefit of making more of the teaching time available for practical work rather than written recording.

The increased clarity of learning objectives was intended to lead to clarity of focus for assessment and to facilitate marking work and giving constructive feedback. This meant that children were clearer about the expectations, and teachers were no longer trying to assess the full range of processes in each investigation. Focused teaching could then be used for groups or the whole class, where the assessment indicated particular areas for further development. Tables 1 and 2 contain extracts from a teacher's planning and record keeping to illustrate focused formative assessment in an investigation into the effect of hanging different masses on elastic bands.

Evaluation of Cycle 1

The following comments from teachers, at the end of the first year of the project, illustrate their greater confidence in teaching scientific inquiry as a result of adopting a more 'focused' approach:

> *"As a result of the project, I have a much clearer understanding of the aims of science teaching and feel clearer about how to promote scientific inquiry. Consequently, I am more positive, and this has helped the children to participate in scientific activities with greater enthusiasm."*

Some teachers commented on how the focused teaching had appeared to support children in carrying out whole investigations:

> *"Teaching one aspect of an investigation in detail... has benefited all children, but the benefits to the less able children have been quite staggering. They have been able to focus and take in one aspect at a time."*

The teachers felt that the focused approach to

Table 1
Extract from a Lesson Plan Exemplifying a Focussed Teaching Approach

Previous Learning: *Use of AKSIS 'Getting Grips with graphs software package to develop understanding of tables and line graph, including choosing a suitable scale*
Scientific Inquiry Focus; *To represent data in a line graph and use this to identify patterns in the data*
Learning Objectives: *To be able to transfer data from a table to a line graph* *To be able to make a generalization in the form of an 'or .. or' statement based on interpretation of the line graph*

Table 2
Extract from a Record of Formative Assessment Arising from the Above Lesson

Group of children	***Development Needs to be addressed in future teaching***
Most of class	*Use of headings in tables to show units of measurement used* *How to phrase a generalization.* *Develop phrases and vocabulary for describing patterns in graphs.*
Higher attainers *Kate, Paul, Lucy, Tom, Steve B*	*Improve accuracy of plotting points* *Provide opportunity for more independence in drawing and interpreting graphs.*
Lower attainers *Jim, Hannah, Mike, Suzy*	*Provide a ready made table a model* *Develop use of comparative vocabulary to describe similarities and differences (heavier/stretchier).*

assessment was manageable given the constraints of time and class sizes:

> *"I now try to limit what I am assessing to one or two skills and concentrate on one group in depth."*

There was evidence from teachers' planning and lesson observations by tutors that the teachers were using their assessment of scientific inquiry to inform their teaching. Teachers' perceptions of their own work supports this:

> *"I feel more able to assess children at different stages of a topic – using what they know to move onto the next part of a unit of work, rather than simply assess at the beginning and end."*

Teachers' responses in questionnaires and during interviews, at the end of the first cycle of the project, indicated that the strategies developed had proved useful in developing their teaching skills and meeting their needs for an assessment system that was manageable within the constraints under which they were working. However, there was evidence that this approach had not yet been fully disseminated through the participating schools. There was a need in cycle two for effective strategies to be developed for embedding this approach in whole-school practice.

Cycle 2 (Year 2)

The second year of the IST project aimed to disseminate the focused assessment and teaching strategies developed by the project teachers to other colleagues in their schools, and to develop whole-school approaches to the assessment of scientific inquiry.

Participant teachers, who had responsibility for science across the school, used their understanding of progression and the requirements of different science topics in the curriculum, to map out foci for scientific inquiry in long– and medium-term planning for the whole school. Teachers examined existing units of work in science to see which skills and processes were naturally emphasized by the content, and decided where skills would be taught in a decontextualized way before being applied. They also identified parts of each unit where the holistic context would be maintained, but in which there would be a particular focus on one aspect of scientific inquiry, such as data interpretation. This was important in ensuring that the breadth of scientific inquiry was assessed.

An example of one school's planning for focused teaching and assessment of scientific inquiry (Wheatfield Primary) for Year 5 (9-10 year olds) can be seen in Table 3. This example illustrates how the school has identified specific skills to be taught (e.g., designing a table to record repeated measurements), and has planned for the development of cognitive 'process skills' (Harlen, 2000) through units of work (e.g., applying previous knowledge and understanding when suggesting explanations for results). The plan also indicates in bold those process skills specified as a focus for assessment in each unit. This was an attempt to resolve the tensions of holistic and atomistic approaches, and the need for both formative and summative assessment.

Linking formative and summative assessment had advantages in raising the profile of scientific inquiry in project schools by giving it the status of a subject to be formally assessed, and children's progress monitored by subject leaders, or other

Table 3

Yearly Science Plan for Focused Teaching and Assessment

5A Keeping healthy	• Measure pulse • Repeat measurements • Numeracy (Bar/line graph & what it shows) • What do graphs show?	• Identify variables • Predictions • Plan number of measurements • **Relate conclusions to understanding**
5B Life cycles	• Using a hand lens/microscope	• Careful observations • Compare • **Fair tests – Identify and control variables** • Repeat measurements • **Draw conclusions**
5C Gases around us	• Explain in terms of scientific knowledge • Measure volumes • Observations & explain	• Making/repeating measurements • Similarities and differences • **Explain in terms of scientific knowledge**
5D Gases around us	• Explain • Careful measurements (tables/graphs) • ICT sensors (temp) • Thermometers	• **Ideas into a form that can be investigated** • Prediction • Decide what evidence to collect • Fair test • Describe trends in results, draw conclusions • **Identify patterns in data – use to make predictions** • Does evidence collected support prediction?
5E Earth, Sun, Moon	• Making tables	• Turning ideas into a form that can be identified • Plan a test to measure or observe • Prediction to decide what evidence to collect • **Predicting with a reason** • **Do the results support predictions? Is evidence good enough?**
5F Changing Sounds	• Phrasing questions	• **Turning ideas into a form that can be investigated** • Deciding whether evidence supports predictions • **Making generalisations**

managers, within the school. This was important in motivating teachers, who were not as directly involved with the IST project, to prioritize the assessment of scientific inquiry in the face of considerable other demands on their time. This, in turn, provided motivation for schools to provide staff development that would support teachers in making the judgments through a greater understanding of progression, which also informed their less formal, ongoing formative assessments during lessons.

Evaluation of Cycle 2

At the end of the IST project, a wider range of teachers in participating schools had developed their understanding of the elements of scientific inquiry, and this had led to increasing clarity within their learning objectives, and increasingly focused formative assessment of both procedural and conceptual elements of science:

> *"Staff have increased knowledge of scientific inquiry skills which are taught systematically. Formative assessment is in place all across the school – R- Y6." (Headteacher in participating school)*

Figure 1 summarizes teachers' perceptions of the change in their use of specific formative assessment strategies over the project period. The columns in Figure 1 show the difference in the project teachers' rating of their use of different forms of assessment (on a five-point scale) between the beginning and end of the project. They suggest that teachers have shifted slightly away from strategies associated with summative assessment (e.g., pencil and paper tests) towards more observation-based assessment, such as observations of a group of children carrying out activities or using floor books (in which a teacher scribes the children's utterances as a record of their ideas). Such strategies are likely to provide more detailed and valid assessment data, and are more consistent with the changes to practice envisaged in the project aims. The increases are not as large as we had hoped, but this may reflect the use of a diverse range of strategies. Also there may be an inherent reluctance on the part of teachers to respond by putting a score of 5, as they feel that there is always room for improvement.

Once teachers had become more focused in their assessment, they felt more confident to identify and communicate more effectively to children what they needed to do to improve their scientific inquiry work. One teacher identified her

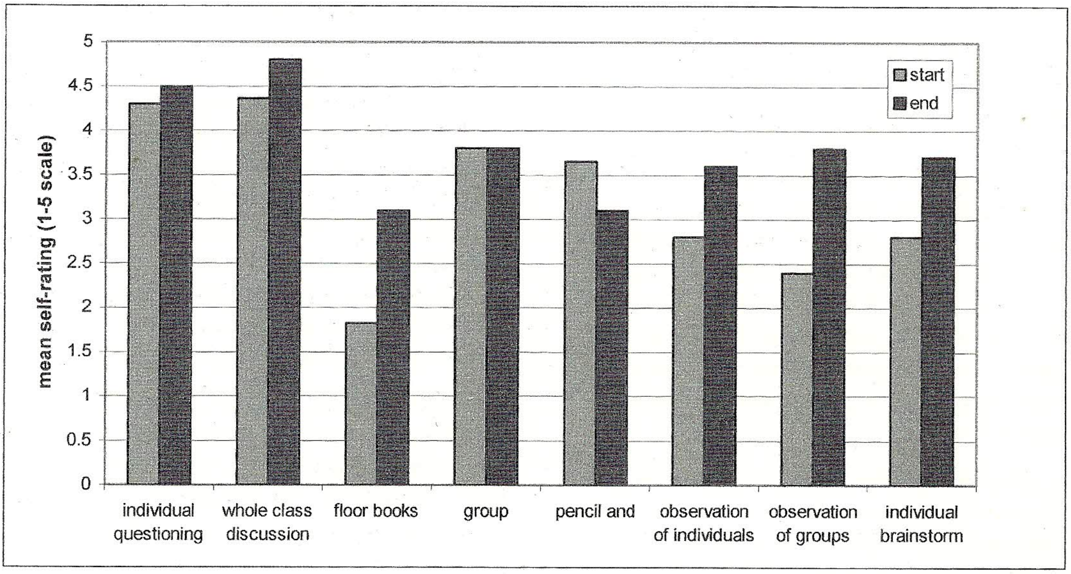

Figure 1: Teachers' Perceptions of the Change in Their Use of Specific Formative Assessment Strategies

strengths in teaching science at the end of the project as:

> *"developing success criteria for children, so that they know they have achieved the objective of the lesson, teaching specific skills."*

The impact on children's learning of this approach to formative assessment and focused teaching is supported by the following extract from the OfSTED inspection inspection report on one of the project schools (2001), which noted in the case of science that:

> *"Recently pupil's attainment has improved.... The improvement is the result of improved assessment and target setting."*

There was evidence that increased clarity of learning intentions had given participant primary teachers a better understanding of the elements inquiry, so that they were able to provide more appropriate scaffolding for children's learning:

> *"Primary teachers involved have significantly developed their understanding of and ability to teach scientific inquiry skills... On the whole, the teaching of scientific inquiry skills has become more systematic and structured." (South Gloucestershire advisory teacher for science).*

It appears from our observation data that through focused teaching, children in the project schools developed a clearer understanding of what was expected of them, and so became more motivated and likely to remain on task. As a result of this, participating teachers felt that they were remaining in control of the classroom environment, whilst giving the children the opportunity to develop their independence in scientific inquiry. This increased confidence of teachers in their ability to organize and manage practical work seemed to be an important factor in the increased incidence of scientific inquiry taking place in the project schools:

> *"The message that an investigation does not have to test every skill, but can be more focused, has made teachers throughout the school more willing to teach scientific inquiry" (science subject leader).*

The needs of the participant schools to establish a system for tracking children's attainment was addressed though the action taken, and most schools were happy with systems they were able to put in place for this, with the following comment being typical:

> *"There is clearer guidance for planning scientific inquiry and termly assessments are organized. Staff confidence in assessing scientific inquiry has increased. Our new tracking system shows progress across the Key Stage" (Headteacher).*

The strategy of teaching particular skills in a decontextualized way, in order for them to be applied later, was found to be more appropriate for Key Stage 2 (7 -11 years) than for Key Stage 1 (5-7 years). Presenting inquiry skills in isolation was less meaningful for younger children, and they found it more difficult to abstract the underlying concept and apply it in a new situation. However, teachers of the younger children still found it useful to choose a scientific inquiry focus for teaching and assessing, as long as it remained within a holistic context.

DISCUSSION

This project has highlighted the need for Primary teachers in England to develop their practice in formatively assessing and teaching scientific inquiry skills, whilst working within a range of external pressures and constraints. This may also apply to teachers working within similar constraints in other countries. Such constraints include the model of assessment imposed on schools by central and local government, requiring them to track children's progress quantitatively, the curriculum time available for teaching and assessing science, and their own understanding of scientific inquiry skills and procedures.

That teachers work within tensions and contradictory demands in their everyday practice has been recognized (Nias, 1989; Cortazzi, 1990). The tensions identified by the IST project in developing approaches to formative assessment of scientific inquiry were:

1. Holistic versus atomistic approaches.

2. Breadth of assessment versus depth of assessment.
3. Children's independence versus teacher control.
4. Assessment for learning versus assessment for accountability.

Holistic versus atomistic approaches

The AKSIS project challenged, what seemed to be an implicit assumption in teachers planning, that in any scientific inquiry the children would be learning all the constituent skills. (Goldsworthy et al., 2000c). This assumption was evident in the views and teaching of most of the IST project teachers at the beginning of the project. The targeted learning exemplified in the AKSIS projects could be seen as taking an atomistic approach in which individual skills are isolated and taught in isolation from the context of a scientific inquiry (Harlen, 2000). Framing clear learning intentions for children requires the use of specific, relatively narrow success criteria, such as those promoted by the UK government Literacy and Numeracy Strategies (refs DfEE 1998, 1999); arguably this could detract from the 'wholeness' of scientific inquiry.

Claxton (2002) questions the extent to which the current emphasis on clearly focused learning objectives actually leads to 'better' learning. However, he also suggests that moving between focused and more diffuse forms of thinking is important in developing children's learning power. In this respect, the IST project's 'focused teaching' model, in which children are taught some specific skills and processes, but are then expected to apply them in the context of a real investigation, could be seen as bridging the gap between atomism and holism.

Breadth of assessment versus depth of assessment

For the project teachers, the narrowing of the focus in any one lesson enabled them to make the assessment of a whole class of children more manageable. They were able to consider the particular aspects identified in the learning objectives in more depth. This appeared to enhance their ability to make judgments about children's learning and their understanding of progression in scientific inquiry. As a consequence, they were more able to make unplanned assessments when children demonstrated progress at other times. Formative assessment needs to be clearly related to learning goals (Assessment Reform Group, 1999), and depth of understanding of these goals is crucial in helping teachers make judgements (Crooks, 2001). However, this approach can be criticized for sacrificing breadth for depth, appearing to ignore children's ability to apply their understanding of scientific inquiry in different contexts. It is widely acknowledged that understanding is context–dependent (e.g., McCormick et al., 1995) and that procedural skills are often dependent on concepts (Harlen, 2000). For example, prediction depends on subject knowledge. Most project schools addressed this by ensuring that different strands are revisited in different contexts over children's time in primary school. This had the additional benefit that teachers were developing their assessment over a full range of aspects of scientific inquiry, rather than using children's ability to plan a fair test as their main indicator of attainment.

Children's independence versus teacher control

The process of using formative assessment information to decide on 'next steps,' and for the child to receive constructive feedback, was key to the success of the IST project. Harlen (2000) emphasizes the need for this to be expressed in positive terms that will help the child see what is to be done to improve. In their discussion of the benefits of 'targeted learning', (Goldsworthy et al. (2000c), argue that children need to understand the feedback given, and that targeted teaching can help them to understand, for example, what is meant by a 'good explanation.' This can be understood in terms of developing the metacognitive dimension of children's learning (Adey, 1997).

The intention of the focused teaching and assessment approach is that by gaining a greater understanding of scientific inquiry, children will be enabled to work more independently, when undertaking their own inquiries. A concern is that a shift in emphasis towards more tightly focused objectives and teacher-directed activities could lead to fewer opportunities for this independent work to take place. However, the responses of the teachers in the project suggest that teachers actually feel more confident about giving children greater opportunities for independent work, when they believe that the children have the skills needed to tackle it. Doyle (1983) suggests that removing some of the 'ambiguity' and 'risk' associated with open ended investigative tasks can increase pupils' confidence and self esteem. This was evident from some of our observations.

Assessment for learning versus assessment for accountability

Although formative assessment has a purpose that is distinct from summative assessment (Assessment Reform Group, 1999), the same teaching strategies were applied (e.g., observing children, listening to them, questioning them, analyzing their drawing and writing) by several project schools to both. By helping teachers use their formative assessments to inform their summative judgments both were strengthened. The external demand for summative judgments (OfSTED 2002) was useful in motivating teachers to give careful attention to the processes involved, and their increased confidence in their formative assessments gave teachers a greater confidence in the validity of summative assessments that they had made themselves.

Summary and Implications

Our evaluation data suggest that successful implementation of the targeted assessment and focused teaching strategies developed through the IST project were of great benefit to the schools involved. However, in considering whether these have wider currency, it needs to be emphasized that success depended upon teachers' understanding of the importance of providing opportunities to carry out whole investigations that enable the children to apply their full range of skills as independently as possible. If focused teaching and assessment strategies are applied in the absence of a clear understanding of the holistic nature of investigative work, there is a danger that elements of scientific inquiry will be taught in isolation and become less meaningful to the children.

The 'assessment for inquiry' approach developed during the IST project is being disseminated locally through education authorities, and nationally and internationally through the Astra Zeneca Science Teaching Trust (AZSTT) website (www.azteachscience.org.uk).

Further studies of teachers understanding and use of formative assessment in science are needed to explore whether focussed teaching leads to exclusively atomistic approaches neglecting holism, and to explore the impact on children's understanding of the nature of scientific inquiry.

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