ASE-King's Science Investigations in Schools (AKSIS) Project
Second Interim Report to the QCA November 1998

The AKSIS Project (**A**SE-**K**ing's College London **S**cience **I**nvestigations in **S**chools) is a three year project is focused on Key Stages 2 and 3. The project is funded by the Wellcome Trust.

What is a Scientific Investigation?

The AKSIS project has developed its description of investigative work from discussions and written comments with teachers. Not all teachers agree about what activities can be called science investigations but the teachers who have worked with the AKSIS project have identified the following two characteristics of investigations:

- In investigative work pupils have to make their own decisions either individually or in groups: they are given some autonomy in how the investigation is carried out.
- An investigation must involve pupils in using investigational procedures such as planning, measuring, observing, analysing data and evaluating procedures. Not all investigations will allow pupils to use every kind of investigational procedure, and investigations may vary in the amount of autonomy given to pupils at different stages of the investigative process.

This definition is used in the document that follows.

Performance in Investigations

An overwhelming majority of teachers at both Key Stages 2 and 3 thought that performance in investigations had improved since the introduction of the National Curriculum (79% at KS2 and 73% at KS3) with only a small percentage (6%) thinking that performance had got worse.

Summary of recommendations

Programmes of Study

1. **The emphasis on practical investigative work in Sc1 should be maintained. Investigations should encourage more decision-making by pupils.** This requires changes in the way in which the statutory orders for the National Curriculum are written so that there is a shift in emphasis from investigations as products, often written products, to investigations as processes. This also requires changes in assessment and reporting procedures (see 8 and 9 below).

2. **More emphasis should be placed on reflecting on results and evaluating.** Pupils should be encouraged to interpolate, extrapolate and use patterns in data to identify anomalous data. Evaluation should be integrated as part of the investigative process rather than be seen as an 'add on' that can be done alone by pupils.

3. **The variety of investigations used in schools should be increased.** Again this requires changes in both the way in which the statutory orders for the National Curriculum are written and the way in which investigative work is assessed. The AKSIS project has developed descriptions of six different kinds of investigations that should be considered for inclusion in the National Curriculum.

4. **Better integration of theoretical and experimental aspects of science should be encouraged.**

5. **Both whole investigations and part investigations should continue to be encouraged by the statutory orders.** Part investigations allow for teaching focused on parts of investigational processes.

6. **The emphasis on the contents of Sc2, 3 and 4 should be decreased**, in order to allow sufficient time for investigative work. The emphasis is currently given by both the quantity of content that is specified and by the way in which different parts of the National Curriculum are assessed.

7. **The use of terms used in orders for the National Curriculum for Science should be written in unambiguous language.** In investigative work in school science words are used that have come to acquire a technical meaning in that context and these words are used differently by different teachers, e.g. fair test.

Assessment, Moderation and Reporting

8. **Assessment, moderation and reporting procedures must be made to match the desired emphasis in the curriculum.** Current assessment and reporting procedures are leading to a investigations being seen as unimportant at Key Stage 2, in contrast to Key Stage 3 where GCSE assessment procedures are already acting to maintain an emphasis on investigations. **Teachers' assessments of investigations work should be aggregated with the external assessments made by SATs** in order to restore the prestige of investigative work. Teachers should submit their assessments

of pupils investigative work before receiving information about grades awarded for other parts of the curriculum.

9. **The assessment procedures for GCSE and the National Curriculum should be made to match one another.** Teachers see a discontinuity in the emphasis given to different parts of the curriculum at Key Stage 3 and 4. Also from a practical point of view using a common system is simpler.

10. **Formal procedures for moderating teachers' assessments of investigations should be set up.** This is necessary both to achieve public confidence in teachers' grades and for teacher development. Consideration should be given to moderation meetings across phase, particularly between Key Stages 2 and 3 in order to achieve smoother progression between the Key Stages.

Teacher Development and Resources

11. **Teacher development** and the production of appropriate support materials in relation to teaching using scientific investigations should be a priority, particularly in primary schools.

Explanation of the recommendations

The AKSIS study has carried out consultations with three focus groups, in different parts of England and Wales, involving 32 teachers. Each teacher came to a planning meeting with the AKSIS team, completed a detailed proforma about their planning and reflections on an investigation that each teacher did with one of his/her classes and then came to a weekend meeting to discuss their experiences of investigative work with the research team and the other teachers. This was followed by a national questionnaire survey which was sent to a stratified sample of 500 primary and 500 secondary schools. Each school received 2 questionnaires. The response rates were 46.3% at KS2 and 55.7% at KS3. The stratification of the respondents matched the stratification of the sample. These data are the source of our recommendations. More detailed reports of these two phases of the project are included in the list of AKSIS publications at the end of this report.

Programmes of Study

1. The emphasis on practical investigative work in Sc1 should be maintained. Investigations should encourage more decision-making by pupils. This requires changes in the way in which the statutory orders for the National Curriculum are written so that there is a shift in emphasis from investigations as products, often written products, to investigations as processes. This also requires changes in assessment and reporting procedures (see 8 and 9 below).

Although there have been difficulties in the implementation of investigational work the attitude of teachers to this kind of work remains positive (see table 1, q 25b and d). Teachers see investigations as motivating and as an important understanding something of the ways in which in which scientists work. Most teachers (about 60%) would like the quantity of whole investigations to remain the same (table 1, Q25b) and the quantity of part investigations to remain the same or be increased (table 1, Q25d).

Table 1: Q25. Please indicate what changes you would like to make with respect to investigational and practical work that you do at Key Stage 2/3

	KS2 n=463			KS3 n=557		
	less	same	more	less	same	more
	%	%	%	%	%	%
a. variety of investigations in lessons	2.1	54.3	43.6	2.1	40.1	57.8
b. quantity of investigational work in lessons	5.6	60.7	33.7	7.1	58.4	34.5
c. amount of decision-making by pupils	1.7	49.4	48.9	4.1	46.3	49.6
d. quantity of part investigations (e.g. focusing on a particular aspect of an investigation such as planning)	7.3	49.9	42.8	7.6	34.7	57.6
e. number of long investigations used	17.7	64.4	17.7	24.9	57.3	17.6

Teachers feel that pupil decision-making is important (Table 1, Q25c) but often feel constrained by the limitations imposed on them by assessment. They tend to make investigational activities more closed than they seem superficially in order to help students produce a product that matches against the highest level descriptor possible in the National Curriculum. This often involves structuring activities carefully to guide students to a particular product. An example of this is in the use of graphs. The most common reason for teachers to get students to use graphs is simply to get them to display their results. Particular kinds of graphs are imposed on investigations in order to match particular levels of the National Curriculum. It is less common for students to use graphs to make predictions or to look for anomalous results. An analysis of graphs constructed by students shows them using them in a rather mechanistic way without understanding their power (Goldsworthy et al., 1998c).

Planning or prompt sheets are often used (in 78% of investigations at KS2 and 75% at KS3) to help structure student work and support decision-making, but can turn into a straight jacket that confines students' thinking.

2. More emphasis should be placed on reflecting on results and evaluating. Pupils should be encouraged to interpolate, extrapolate and use patterns in data to identify anomalous data. Evaluation should be integrated as part of the investigative process rather than be seen as an 'add on' that can be done alone by pupils.

The lack of reflection on results and evaluation was identified as a serious weakness in the AKSIS work with focus groups. Often little lesson time was planned for this kind of thinking and even when it was planned, it was often squeezed out by other parts of the investigation taking longer than expected. It was rare for students to be given opportunities to use their reflections or evaluation to take their investigations further. In the free response question (Q26) significant numbers of teachers said they would like to see more emphasis on analysis and evaluation (12 at KS2, 26 at KS3), decision-making by pupils (35 at KS2 and 9 at KS3) and developing pupils' thinking (16 at KS2 and 13 at KS3).

3. The variety of investigations used in schools should be increased. Again this requires changes in both the way in which the statutory orders for the National Curriculum are written and the way in which investigative work is assessed. The AKSIS project has developed descriptions of six different kinds of investigations that should be considered for inclusion in the National Curriculum.

The changes to the orders made in 1995 allowed more kinds of investigations to take place but the impression given by the orders is that fair-testing is the norm. New orders should make it explicit that a variety of kinds of investigations is encouraged.

The work of the AKSIS project reveals a very impoverished set of investigations in use at KS2 and 3 (Goldsworthy et al., 1998a; Watson et al., 1998d). There is a heavy emphasis on fair-testing particularly at Key Stage 3. Other types of investigational work that are considered to be important are under-emphasised, for example ecological studies (usually classified in 'pattern seeking below') and chemical analysis ('identifying') are infrequently used as investigations. In addition the range of investigations used in fair testing is limited with dissolving in water being used as a context for fair testing by every child in the country an average of three times during key stage 2 and 3.

Table 2: Kinds of Investigations

	% @ KS2 (n=447)	% @ KS3 (n=540)
1. Fair test	50.4	82.6
2. classifying/identifying	8.7	2.0
3. pattern seeking	2.9	1.3
4. exploring	15.2	3.7
5. investigating models	0.4	0.2
6. making things	10.7	4.1
7. unclassifiable insufficient evidence	5.3	3.3
8. no investigation	6.3	2.8
Total	100.0	100.0

The responses to Q25a in table 1 indicate a strong desire by teachers, particularly at Key Stage 3 to widen the variety of investigations being done.

4. Better integration of theoretical and experimental aspects of science should be encouraged.
Teachers (particularly at KS3) would like to see better integration between Sc1 and the 'theory' work in Sc2, 3 and 4. This was the most frequently mentioned future development desired by KS3 teachers (Q26; 56 responses). The use of a greater variety of kinds of investigations may help to address this issue. For example, classification using the periodic table, or an ecological study, both demand some integration of theory with the investigational work being carried out.

5. Both whole investigations and part investigations should continue to be encouraged by the statutory orders. Part investigations allow for teaching focused on parts of investigational processes.

The vast majority of teachers think that the use of whole and part investigations has increased since the introduction of the National Curriculum for science and again after the new orders in 1995. Teachers think this change is desirable and should continue (Q25b and d, table 1).

6. The emphasis on the contents of Sc2, 3 and 4 should be decreased, in order to allow sufficient time for investigative work. The emphasis is currently given by both the quantity of content that is specified and by the way in which different parts of the National Curriculum are assessed.

Insufficient time for doing investigations is seen as a constraint by many teachers. In the free response question (Q26) the most frequently desired change (56 teachers at KS2 and 49 at KS3) was more time to do investigations. In addition significant numbers wanted the contents of Sc2, 3 and 4 to be reduced (26 at KS2 and 37 at KS3). At KS2, particularly in Y6, this shortage of time is compounded by the system of assessment biasing the emphasis of the curriculum (see 8 and 9 below).

7. **The use of terms used in orders for the National Curriculum for Science should be written in unambiguous language.** In investigative work in school science words are used that have come to acquire a technical meaning in that context and these words are used differently by different teachers, e.g. fair test. One question was included in the AKSIS questionnaire to address this issue. A summary of the responses is included in table 3. It is clear from the results that many teachers do not share a common understanding of the words 'fair test'.

Table 3: 'Fair Test' has a special meaning in school science investigations. Below are some examples of how pupils have used these words. Please indicate whether you think the use of these words is scientifically acceptable.

	KS2 (%)			KS3 (%)		
	Not acc.	Not sure	Acc.	Not acc.	Not sure	Acc.
a, To make it a **fair test**, I will make sure the force meter is in working order	63.6	17.4	19.0	83.3	10.7	6.2
b, To make a **fair test** of how good our pressure-pads are at detecting burglars, we must make the same person tread on each pad that we test	13.7	5.6	80.7	15.7	6.9	77.4
c, When we were testing whether light affected germination of seeds we made it **fair** by watering the seeds equally and putting them all on blotting paper to grow	15.0	8.9	75.7	7.7	11.2	81.1
d, We rolled a toy car down a ramp from different heights. We made it a **fair test** by always measuring from the bottom of the ramp to the nearest point of the car	16.8	15.4	65.7	21.9	18.8	59.2
We repeated the measures three times to make it more **fair**	34.0	24.0	42.0	72.0	10.6	17.2

Assessment, Moderation and Reporting

8. Assessment and reporting procedures must be made to match the desired emphasis in the curriculum. Current assessment and reporting procedures are leading to a investigations being seen as unimportant at Key Stage 2, in contrast to Key Stage 3 where GCSE assessment procedures are already acting to maintain an emphasis on investigations. Teachers' assessments of investigations work should be aggregated with the external assessments made by SATs in order to restore the prestige of investigative work. Teachers should submit their assessments of pupils investigative work before receiving information about grades awarded for other parts of the curriculum.

Evidence from the AKSIS focus groups and from Q26 of the questionnaire (34 comments at KS2 and 26 at KS3: codes 34 and 35) indicates that the balance of the curriculum is being distorted by the SATs, particularly at KS2. Teachers see preparation for SATs as more important than investigational work. Often fewer investigations are done to allow more time for preparation for SATs. Some teachers wait for SATs results to be released in order to match Sc1 levels to levels attained in the SATs. One aspect of the problem that needs to be addressed is the reporting of levels. Separate reporting of SAT levels and teacher assessed levels has led to the perception that teachers' assessments are not to be trusted. SAT levels and teacher assessed levels should therefore be aggregated to produce a final level for Science for reporting purposes.

9. The assessment procedures for GCSE and the National Curriculum should be made to match one another. Teachers see a discontinuity in the emphasis given to different parts of the curriculum at Key Stage 3 and 4. Also from a practical point of view using a common system is simpler.

The second most frequent comment made by KS3 teachers in Q26 (56 teachers) is that there should be better continuity and progression in the curriculum. Most of these comments focused on the discontinuity in assessment procedures between KS3 and 4. There is clear evidence that the procedures being used in KS3 are being influenced by GCSE assessment procedures (Q20). In addition teachers wanted the assessment procedures to be simplified and made less time-consuming (25 KS3 teachers, Q26).

10. Formal procedures for moderating teachers' assessments of investigations should be set up. This is necessary both to achieve public confidence in teachers' grades and for teacher development. Consideration should be given to moderation meetings across phase, particularly between Key Stages 2 and 3 in order to achieve smoother progression between the Key Stages.

There is a great deal of variability in moderation procedures used by teachers (table 4). The school having a portfolio to exemplify standards of work (c) and attendance at school meetings to discuss standards of work (d) are the most common forms of moderation.

A significant number of teachers (12% at KS2 and 14% at KS3) said that they did not moderate the assessment of pupils' Sc1 work. Interestingly about a third of these also ticket one of the moderation procedures indicated by (b), (c), (d) or (e), usually (d) or (c). Presumably they did not see these as serving a moderating function. This casts in to doubt whether (c) and (d) are effective ways of moderating and more research is needed to clarify this point. Of the 24% of KS2 teachers who have collected a portfolio of work to exemplify standards (b) only 2% also attend school (d) or LEA meetings (e) and so it is doubtful whether their portfolio of work serves a moderating function.

Table 4: Which of the following procedures do you use for moderating the assessment of pupils' Sc1 work?

	KS2 (n=463)	KS3 (n=557)
	%	%
a. I do not moderate pupils' work	11.9	14.4
b. I have collected a portfolio to exemplify the standards of work of my class	29.6	24.2
c. The school has collected a portfolio to exemplify standards of work	62.0	39.9
d. I attend school meetings to discuss standards of work	55.1	65.5
e. I am involved in an LEA or cluster group initiative to moderate Sc1 work	15.6	14.7

Teacher Development and Resources

11. Teacher development and the production of appropriate support materials in relation to teaching using scientific investigations should be a priority, particularly in primary schools.

Teaching using investigations is not easy and one message that comes through very clearly in the free responses in the questionnaire is that teachers would like more help, particularly at KS2. This alone is a good reason for strengthening moderation; to allow teachers to share good practice.

Teachers want more help and guidance in using investigations (Q26: 40 teachers at KS2, 6 at KS3), more moderation and sharing of examples of investigations (6 at KS2 and 19 at KS3) and published collections of investigations (34 at KS2 and 28 at KS3).

Resources in terms of books, equipment, technical support and the need for smaller classes and more technicians, support assistants and teachers were mentioned by many teachers, particularly KS2 teachers (Q26: 53 at KS2 and 30 KS3).

Publications arising from the AKSIS Project

1. Goldsworthy, A. and R. Watson, R. (1997) 'In the Know' *Times Educational Supplement, Science Extra* January 3rd pp. VII-IX.
2. Watson, R. (1997) ASE-King's Science Investigations in Schools project: Investigations at Key Stages 2 and 3 *Education in Science* No.171 pp. 22-23.
3. Watson, J.R., Goldsworthy, A. and Wood-Robinson, V. (1998a) Interim report to the QCA from the ASE/King's College Science Investigations in Schools (AKSIS) Project. London, King's College.
4. Watson, J.R., Goldsworthy, A. and Wood-Robinson, V. (1998b) Getting AKSIS to Investigations *Education in Science* 177, 20-21.
5. Goldsworthy, A., Watson, R. and Wood-Robinson, V. (1998a) Sometimes its not fair! *Primary Science Review* May/June pp. 15-17.
6. A. Goldsworthy (1998b)*Learning to Investigate* Chapter 3 in Section 2 of ASE Primary Teachers' Handbook for Science.
7. Watson, J.R. and Wood-Robinson, V. (1998c)*Learning to Investigate* Chapter 2,4 in ASE Guide to Secondary Science Education. Cheltenham, Stanley Thornes.
8. Goldsworthy, A., Watson, J.R. and Wood-Robinson, V. (1998c) *Getting to Grips with Graphs* Science Teacher Education
9. Watson, J.R., Goldsworthy, A and Wood-Robinson, V. (Dec. 1998d) What is not fair with investigations *School Science Review* xxx.