JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 40, NO. 2, PP. 219–233 (2003)

Home-School Learning of Science: The Culture of Homes, and Pupils' Difficult Border Crossing

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Abstract: A British project that explored the way parents and their children of elementary school age carried out simple science activities at home is described and illustrated. Previous research in this field has yielded ambiguous results when evaluated in terms of school science knowledge gained. The basis of the analysis carried out here is largely descriptive using some sociological theory to understand activities in the home. It is argued that home is a special place not only rich in supportive emotions, but also imbued with idiosyncratic attitudes toward science education, which often match with attitudes toward other matters. Schools create different and more uniform cultures for the same children. There has been a long history of calls for collaboration between the two constituencies; however, this article demonstrates that a number of these differences exist which cannot fail to affect children's learning in each situation. Extracts from the children's conversations with their parents during the investigations as well as parents' interpretations of what they are doing will be presented. These vignettes illustrate a wide variation in attitude which affects the children as they daily cross boundaries from one culture to another, trying to preserve what is precious in their home culture. At home the children's participation becomes far more relaxed and personal, just as discussion with their parents is more fluent than at school. © 2003 Wiley Periodicals, Inc. J Res Sci Teach 40: 219–233, 2003

Are homes the final frontier of educational research? No one would deny the influence of home and families on the education of our children, and there is little doubt that a large part of all early social learning happens there. However, it is private territory. General reflection on why this should be so brings only a sense of family closeness and affection from parents, and a predictable familiarity which must be preserved at all costs. It is the place from which our children's sorties into the cold strange world of school take place. At the start of the project reported in this article we did not know whether or how the learning of science might take place in the home with parents who might themselves know little science, but we were curious to find out about it. We did suspect from recent research into how the public received science knowledge that this might be much affected

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DOI 10.1002/tea.10073
Published online in Wiley InterScience (www.interscience.wiley.com).

by the context in which it was received. It was at least possible that this would be equally true of homes.

School–Home Investigations in Primary Science (SHIPS) Project

The SHIPS project was first launched as a modest U.K. venture in 1991, and several papers describing its operation were published at that time (e.g., Solomon, 1993, 1994). Since then, the project materials have been taken up in several other European countries (e.g., Cardoso & Solomon, 2002). This is a good time to reevaluate our findings.

The SHIPS project aimed to provide schools with banks of examples of simple activities which teachers could select as appropriate for their young pupils ages 5–10 years, to take home and carry out with their parents. This usually happened twice in each term, of which there are three in the British school year. The activity sheets were published in batches of 18 at three levels of difficulty (approximately 5–6 years, 7–8 years, and 9–10 years) with a complete waiving of copyright (Solomon & Lee, 1992). To ensure the activities would be appropriate for the school's own work scheme, all were devised in response to a simple inquiry to the class teachers: ''What topic is your class studying this half-term?'' (Satisfying teachers who answered ''Elephants'' or ''Space'' seemed near impossible at first, but in the end we could boast that we never failed to produce a suitable activity for teaching science!) After a week or two, when most of the pupils' investigations had been completed, results were taken back to school so that the children could explain to their teacher and friends what they had done and with whom, and what had happened. Several teachers used this opportunity to involve the one or two children whose parents had not found time to carry out investigations in a demonstration.

The equipment used was not like that in the kits often given to homes. It was composed of simple objects and materials found at home. The reason for this was not just convenience. Equipment used in a science activities would, in the sense of Latour's famous Actor Theory Network (Latour, 1997), be an ingredient (actant) of that science domain. For parents and children it would be an intruder from the domain of school. To understand science in the home, everything used should come from home and at best should be further extended to other objects chosen from the home domain. Familiar empty cereal boxes were sometimes used, and when one child had made magnifying drops, he asked his mother whether he could pick some of her herbs to observe them under his drops.

Because of the politics of its time, the outcomes of the project could be matched against science in the recently introduced science curriculum and to recent empirical work on how the lay public understood science. This SHIPS project followed hard on the heels of this Education Reform Act of 1989, so we were influenced by a wish to help primary teachers whose confidence in their ability to teach science was not high (Bennett, Wragg, Carré, & Carter, 1992) Some primary science had been taught before this (Solomon & Palaccio, 1987) but it had been optional and varied from class to class. An interesting feature of that early report was the frequency of comments from teachers that in science investigations there were no right answers. No doubt this formula reflected a defensive attitude on the part of teachers who were unsure of their own scientific knowledge. To do it justice, this comfortable precept may also have been understood in the context of simple practical observations such as ''What color are the leaves on your plant?'' and ''How many birds can you count on the bird table?'' Even in those cases, however, the use of this precept could be seen as unfortunate because it seemed to deny the value of careful observation. For the teachers it provided a defense from the imposition of well-known recipe experiments whose aim was to verify some scientific principle already known to be correct. In retrospect, we can see it as the end of a phase when the child-centered nature of elementary

education placed a high premium on creativity and originality. Thus, science investigations were recommended as much for these general pedagogic reasons as for any importance of the science knowledge which the children might gain. At first the SHIPS project simply fell into line with this teacher precept, but time was to show both its shortcomings and its benefits.

At about the same time there was a large-scale research project on the lay public's understanding of science (Bodmer & Wilkins, 1992; Ziman, 1991; Wynne, 1989). These empirical studies showed that that the context in which science information was received—sheep farming, medical risk, ecological activities, etc.—affected the nature of the understanding profoundly. Thus, two general questions confronted us: What messages about science would be conveyed by parents to children while carrying out simple practical activities? and How would the home situation affect the ways in which the children learned?

Previous Research

In his excellent analysis of the roles of parents in education, Macbeth (1993) outlined many ways in which parents might take part in the schooling of their children, ranging from being a traditional consumer—just choosing the school and encouraging the completion of homework—to being part of the school management or even helping in the classroom. Ever since the influential Plowden Report on the British primary school came out in 1967, along with its large-scale statistical analysis of over 3000 children and their parents (Bynner, 1972), there were new facts to be absorbed. For instance, it was clear that it was the aspirations of parents for their children, and not their socioeconomic position in society, which was significantly the most potent factor in their children's success at school. One difficult question our research had to explore was how these parental aspirations might be expressed in action.

The whole concept of parent–teacher partnership proved to be far more difficult than most of the encouraging official documents had suggested. The normal roles of parents and teachers were poles apart even though educational writers had long emphasized the importance of the home for the education of children (e.g., Wolfendale, 1983; Morgan, 1988; Macbeth, 1993). Some parents were unduly critical of teachers, probably a natural outcome of hopes and fears for their precious children. Politically left-wing educational sociologists such as Bernstein (1971), Bourdieu and Passeron (1977), and Willis (1977) reckoned that middle-class teachers, and indeed the whole school system, was heavily weighted against working-class children. On the other hand, it was not difficult to see that the age of respect for professional practitioners of all sorts, doctors and lawyers as well as teachers, was rapidly passing (Schon, 1983). Thus, there was also teachers' fear that overanxious and well-educated parents might be cross-examining their children when they returned from school, ready to complain about and root out any mistakes they might have learned from their teachers. [See Cardoso and Solomon (2002) for a description of the difficult situation in Portugal.] What used to be called a teacher's professional ethos was no longer a shield. This was particularly intimidating in the context of science in which few elementary school teachers at that time had either experience or knowledge. In Britain, inspectors issued more and more detailed instructions on what to teach and how to do it, sometimes calling upon parents' concern to help them root out too idiosyncratic an approach to teaching. Therefore, there was little reason to expect that the mutual trust which is essential to a real partnership would easily exist between lay parents and professional teachers, although everyone was careful not to mention this.

The research literature provides surprisingly ambiguous evidence about the effectiveness of science in the home. The summary by Dimmock et al. (1996) showed that students' work often improved after parental collaboration, although this could not be extrapolated either to younger children or to the doing of more conventional homework. The authors also drew attention to the

neglected area of communication between school and home. A study of take-home science kits used with primary-age pupils (Gennaro & Lawrence, 1992) gave positive results in terms of enjoyment and attitude but ambiguous results about achievement. More recent research (Baumert et al., 1998) has also failed to find a direct link between out-of-school science activities and in-school achievement.

Sociological studies of young children in their homes proved to be more interesting and encouraging for the SHIPS project. From research on neonates who would rather watch their mother's face than anything else, to youngsters at the moment of going off to school, the strength of home influences is huge. This is not only the place where children learn to speak and behave as their parents wish. It is also where they begin to learn what kinds of initiatives are prized by their parents. Piaget emphasized the difficulties children have in understanding others' perceptions and feelings, but modern studies of children at home tell a different story. Successful reading of the intentions of mothers is shown by infants from at least 14 months onward, although it varies from one home to another (Dunn & Munn, 1985). The same authors explored how such differences affect normal children, making them more or less sensitive to family approval. This provides a feedback mechanism of great power for learning in the home. No doubt this is what makes life-world knowledge so resistant to change (Schutz & Luckmann, 1973; Helldén, 1998) because it is so strongly tied in with affective bonds to the significant others in the family. When the children go off to playgroup or nursery school, they find themselves far less able to interpret the intentions of their teachers (Wood et al., 1980) and their self-image and learning suffer accordingly (Wood, 1983). In a well-known British study carried out by Tizard and Hughes (1984), the recorded chatter of 4-year-old children with their mothers contrasted sharply with the reluctant, often monosyllabic answers given by the same children to questions from their nursery teachers. The authors inferred that the everyday nature of the activities, combined with their meaning for the children (going shopping for real meals), was one aspect of the difference between home and school talk. The other was the close and loving relationship with the mother in contrast to the competition for adult attention at school. Macbeth cited the work of Tizard and Hughes and endorsed the effects of home learning with enthusiasm.

> It seems clear that home learning, reinforced by constancy of contact and natural bonding, has a powerful influence especially on attitudes which are learnt. Further, it is clear from research stretching back to the 1950s, that there is a linkage between the child's home background and in-school attainment, a process in which parental encouragement and home teaching play a marked part. (1993, p. 36)

If we go back to the time of Froebel, the founder of the kindergarten movement (1782–1852), we find teachers being urged to use mothers as role models and to become ''mothers made conscious''; but by the 1960s the situation had been reversed. Astonishingly few professionals in education were prepared to acknowledge that parents affected their children's learning. Even though 73% of parents of 6- to 7-year-olds reported that they regularly helped their children with reading, this kind of finding was not followed up. Hewison (1988) commented on this:

> As far as I can discover, reading professionals have exhibited no interest whatsoever in this finding—relating as it does to the activity of nearly three quarters of the parents—presumably because it was taken for granted, until very recently, that parental help had no beneficial effects. (p. 174)

By the 1970s and 1980s, research into parents' involvement in their children's reading was beginning to show effectiveness. However, by the mid-1990s the literature was full of recipes

for the training of mothers by teachers to make their homes more effective. Thus, it seemed that the professional teacher had finally, but perhaps sadly, triumphed over the untrained mother. In our project the mothers and the teachers continued to operate in their own domains and it was only the children who daily moved across frontiers from domain to the other and back again.

In Britain, as in the United States, there is continual comment about how little effect educational research has on actual teaching practice. However, whereas in Britain the usual conclusion is that most of the research was ill-conceived, seriously out of contact with the realities of teaching and learning, and probably of little worth (Hargreaves, 1996), in the United States there has been a more useful approach [see Rennie (1998) for a more detailed exploration]. For example, it has been strongly argued that the research should not only be carried out in collaboration with teachers, but also should be communicated in a more informal manner (Amabile, 1982). In the present case, where the practical activities were carried out in a range of different homes, there would be great problems with its quantitative interpretation. Therefore, we might claim that only the anecdotal presentation of such results which Amibile had recommended for better transmission to teachers could be valid.

Variety of Research Methods

To gain some idea as to how we should best carry out the project, we began with a simple playground questionnaire administered to a random sample of 100 parents before school from three of the local primary schools (Figure 1).

A primary teacher administered the questionnaire. She often added explanatory glosses to the short questions. In particular, she explained the connections between formal homework and the SHIPS activities. In addition, the teacher often commented privately to us about particular parents (such as those who held critical views about homework or those who added that they would help only if asked by the child rather than the teacher) by saying "she's pushy." This suggested that neither of the constituencies was as enthusiastic about collaboration as the official propaganda for home–school partnership was continuously suggesting they should be.

Six important points emerged from the questionnaire data.

The Parents' Questionnaire Results

	%
1. Did you take science at school to 16?	82
2. Did you enjoy it?	45
3. Does your child do science at school?	39 (correct)
4. If so what subject is s/he studying now?	35 (correct)
5. Do you help your child with reading?	89
6. Are you in favour of homework?	86
7. Would you help your child with homework if asked?	92
8. Would you help with homework in science?	71
9. Do you make things at home with your child?	75
10. Would you enjoy doing science activities at home with your child?	83

Figure 1. The parents' question results.

1. Less than half the parents had happy memories of learning science at school. This was worrisome for the success of the project. Would it affect parents' interest in their children's science learning? Investigation of the association between responses to Questions 2 and 3 showed that of the 55 who had no experience enjoying science, 44 (80%) did not know whether their child was doing science. By contrast, of those who had enjoyed science, 50% could answer Question 3 correctly. Therefore, we deduced that those who had not disliked science were signaling an unsurprising lack of interest in their children's learning of science.
2. Less than half of all parents knew whether their child was learning science, and if so what science. This might been owing to a lack of communication between school and home, but was more likely because of a reluctance to speak about school.
3. A small number of parents were not in favor of children of this age doing homework of any kind. They and some others added that they would help only if their child asked but not if the teacher asked them. This may have indicated antagonism between parent and teacher.
4. Large numbers of parents already helped their children with reading.
5. There was a large drop in affirmative answers from Question 5 (helping with reading) and Question 8 (helping with science). Comparing parents' answers to Questions 2 and 8, we found that only 17 of the 55 who had not had enjoyed science anticipated being able to help children with science (31%); 41 of the 45 who had themselves enjoyed science (91%) anticipated being able to help their children.
6. Making things with their children was enjoyed by the majority of parents, and so was the idea of doing science activities.

The findings of the questionnaire confirmed the willingness of most parents to carry out the SHIPS activities. We were also aware of a splendid example of a previous project in mathematics, the PACT project (Merrton & Vass, 1987), which was similar and had achieved considerable success. There, too, the activities were simple, using everyday objects to encourage children and parents to learn more about the properties of numbers.

The main data collection took place in the homes where the trials were carried out. Three schools collaborated in the first year, and a further three different ones in the second. Twelve different homes were involved in each of the 2 years. We asked teachers to suggest parents to us who had as wide a range as possible of interests, educational background, and enthusiasm. All of the parents we asked agreed to take part, except for some from non–English-speaking homes, where our attempts to find a friend who could translate were only intermittently successful. The activities took place twice in each of the three terms of the school year. In total, that meant nearly 144 transcripts were collected (about 115 when the missing Indian data and occasional absences were included). The schools varied in character from 2 small Oxfordshire village schools (1 in each year), 3 working-class inner Oxford schools (2 in the first year and 1 in the second), and 1 large primary school in a small railway junction town in the second year. The class teachers chose their activitities from the list in Figure 2.

Two different categories of data were collected in the homes. First, a researcher made tape recordings of the whole activity in each case. She tried to adopt a friendly but neutral attitude and asked no questions of either the parent or child, although she responded in as natural a way as possible. A different researcher previously unknown to the parents carried out final interviews with the parents without their children, in their own homes just once at the end of each year. In each school the teachers arranged sharing sessions, in which they asked to see what the children had made or drawn, and for accounts of how the activities were carried out. We were not able to record all those sessions directly but always asked the teachers for feedback.

Choices of units during the home based research.

Banging drums (vibrations of salt grains, and water in a plastic bottle)	**5-6years**
Egg balance (warmth from the top and balancing with 'wings')	
Floating food (pieces of apple and potato in water, separation)	
Measuring the fall of rain (collecting 'shower rain' over different areas)	
Wheel-barrow (length of handles and ease of lifting)	
Elephants Ears (Feeling the wet paper cool, 'ear' flapping. Elephants bathing)	
Weighing with rubber bands (measuring length and weight)	**7-8years**
Soft candle (candle in hot water, timing and softening)	
Soil and water (layering of soil settling in water. Bones and fossils)	
What does light go through? (floating foil, plastic, and paper, milk 'fog')	
Sun and Shadows (measuring shadows with a flash light, different angles)	
Rising drops (drips from melting butter going upwards in hot water)	
Flower stalks (Expedition. Own test for strength of strip and tube)	**9-10 years**
High-rise crane (Model from cardboard. Winding up and balancing)	
Magnifying drops (Drops of different sizes on plastic)	
Hunting mini-beasts (Hedge beating to get insects, count, draw and return.)	
The colour of bubbles (Soap films getting thinner and breaking)	

Figure 2. Choice of units during home-based research.

In the first year we included informal interviews with the head teachers (school principals) of the three project schools to obtain a school management perspective.

Parents with Their Children Doing the Activities

We found that organization of activities at home with the right jam jars, plastic bottles, cardboard boxes, and so forth at hand at the right moment within the allotted week could be arranged smoothly in most homes if advance warning were given. There is no space here to describe all the activities carried out, which totaled 52 by the end of the project. What is more interesting is the great variety of ways of talking, types of action, and even locations within the house where the activity took place. Below we give some contrasting examples of the ways parents talked with their children, the questions they asked, and how the children spoke to their parents about what they were doing. Other people—siblings, fathers, grandparents, and visitors—were also sometimes present.

Home A

One activity began by instructing the child to make a plasticine model of a little person and find out how long its shadow was when the flashlight was held low down, as in the morning, and nearly overhead, as at midday. Chris was 7 years old.

Mother: (Restraining Christopher) . . . Yes, just a moment. Just hold it up here sweetheart, 'cause it's [the light's] coming from here, from this side. 'Cause this is the morning, okay? Shine it on the little man.

Chris: There's the shadow!

Mother: Hold it up, sweetheart, so that it's. . .

Chris: I made the shadow!

Mother: Yes. I'll have to hold it up while you draw the line on the paper to show how long the little person's shadow is. Whereabouts did you have it—here?

Chris: Yes . . . there it is!

This mother helps whenever she sees need, holding the flashlight, making sure Chris stands where he can measure the whole length of the shadow, praising, helping with spelling, and checking on his explanation for shadows. At the end of the activity she supervises his report writing.

Mother: There's a question here. Could you tell me, tell me why there are shadows? Why do you think there are shadows, Chris?

Chris: Because sometimes when the sun comes down here, um, um, when the sun comes down. . .

Mother: Yes?

Chris: Um, when the sun comes down, um, the man's there and it blocks away the sun.

Mother: So, what do you think? So that's why there are shadows? That's what you think?

Chris: Yes.

Mother: It's something to do with the sun. And what does the sun give off, what does it bring?

Chris: Light, light, light.'

Mother: Good boy! Right.

The dialogue continued in this manner, always fun, loving, and helpful. When Chris finds it predictably difficult to put his idea about shadows into writing, his mother helps him find his own words by getting him to speak to her about it.

Home B

The following extract came from the poorest and most uncomfortable session. Twin girls 7 years of age carried out the Floating Food activity with their father, who managed to get through it in record time. Having found, to the girls' surprise, that pieces of apple however big and heavy always floated and pieces of potato however small and light always sank, he asked them the question on the sheet: ''If a silly cook mixed up pieces of apple and pieces of potato, how could she separate them using a bowl of water?'' The twins were silent for a minute, so he promptly told them what should be done. He finished by saying rather dismissively, ''That's how you would separate them. You didn't have any idea did you? You didn't know.''

Teachers and Children

Sharing times at school were different from home activities, not least because of the large number of children (usually about 34) and class management. These sessions began with a tally of who had done their homework and who had not, while the rest of the children were told to keep

quiet. Then the teachers managed to get quite a few of them answering questions and talking about what they had done, and with which members of their family. However, the teachers seemed less sure what their own responses should be. The experienced ones managed to place more emphasis on the children's talk and understanding than on the inevitable misadventures, often owing to the model breaking on the way to school. The teachers were always polite, saying ''Thank you'' when a child answered, even when it was only monosyllabic, and commenting, ''Lovely model,'' ''That was nice of Daddy to help,'' or ''Lovely pictures.'' It was much rarer to hear them try to explain the experiment or get the children to do it. Still, they seemed be confident that there was no right answer.

In their annual interviews in the first year, the head teachers expressed interest and even gratitude to the project's organizers. They had all taken up the official challenge of parent–teacher partnership, and so the SHIPS project was welcomed for that reason. They also seemed aware of teachers' lack of training in science and clearly hoped that this project might help to fill the vacuum. One remarked that she had been initially unsure whether the project could be carried out, but said that one of the advisers had reminded her that there was no right answer in science, so she had been reassured. Another head teacher remarked with great approval that she had heard gales of laughter from a classroom where one of her teachers had tried an activity in which globules of melted margarine had dripped upwards in a jar of warm water. The fear that teaching science might prove not only difficult for their teachers but also discouraging for the children was never far from their thoughts. In their managing capacity, the head teachers also spoke about the importance of good forward planning so that the activities could be incorporated into the schoolwork scheme. It was a credit to the project that these head teachers were so pleased with SHIPS that two of them began planning to include the home mathematics IMPACT project as well.

In response to requests, short notes were added at the end of the activity sheets for both parents and teachers during the second year of the project. Although the parents clearly had no obligation to look beyond the immediate activity in terms of learning, the teachers did need to fit the results into school plans.

Parents Alone

Interviews with parents were administered to a loosely structured schedule which included the following main questions: (a) How did the investigations go? (b) Did you feel you were teaching your child? (c) How was your own science education at school? (d) Did you talk about the science investigations after they were finished? The first question showed how parents judged the activities. Some saw them through the children's eyes as surprise and fun, and took the part of interested collaborators in the activity; some judged them as education and considered themselves as surrogate teachers organizing what it was that their child was supposed to learn; and for a few the activities were an imposition on the parents' busy lives. One mother, our only science graduate, denied that she was teaching her son. To her, it was a case of ''just helping him to learn,'' and occasionally learning alongside him as she encountered outcomes she had not expected. In other cases the situation was reversed. Another mother who had learned, by her own reckoning, no science at all at school, still answered firmly that she was teaching her child because she was the responsible adult. In this way, the parents told us about their concept of teaching and learning. Only a few of the parents admitted to talking about the investigations to their children on later occasions.

Although different homes were more or less encouraging toward school and science, most parents showed real enjoyment of at least some of the activities. Catching minibeasts by beating a portion of hedge, having placed a pillowcase trap underneath it, became a real wildlife hunt with

accompanying cries of ''Quick, quick, catch it!'' Using an elastic band to make a weighing machine was another great favorite among parents, as was the High-Rise Crane, which older children could make from cardboard and use to wind up a toy car. On the other hand, shaking earth, water, bone, and stones to get an idea where each layer would settle produced negative reactions from a few house-proud parents who did not relish having dirt in their house, even though it was confined within a screwtop jar. Others, including most of the children, enjoyed it all. Only one parent claimed she had not enjoyed the activities. She said she had hated science at school and that her son took after her. She had been interested only in sports, she said, and so was he. We interpreted this as a commitment to the home traditions just as strong as in the more positive examples of enjoyment [see Solomon (1993, 1994)]. Another aspect of parents' expectations made them feel distinctly uncomfortable; this was a fear that their children would ask questions they could not answer. As one mother put it.

> Like all children, they think Mummy and Daddy know everything, and that I should know whether this is the right way or the wrong way of doing it. And half the time I didn't know if it was supposed to happen or not . . . . I mean, things like the one where they collected all the bits and pieces and put them all in a jar. I think it was the bones, you know, and it said, ''Which things would float to the top?'' I would have said [the bones] would sink. Little things like that. You feel, you know [that by] looking at something you could tell what it would do. It wouldn't matter that a 7-year-old child wouldn't know, but you would know. And I was wrong.

Finally, some 50% of parents interviewed said that carrying out the SHIPS activities reminded them of science in their own schooling and reawakened their interest in science. Some parents bought science books or looked for their old science notebooks.

Discussion of Home Cultures

These four general points from the interview, together with visual impressions of the homes, were enough to generate a series of pictures about how parents allowed science to fit into their own homes. Just as people build a picture of their lives, which is part wish fulfilment and part reconstructed history, so it began to seem that some of the parents also had a consciousness of their family view of science: ''We would like her to think we were inclined toward science,'' ''We would like him to take science,'' or ''None of us is scientific.'' Such vignettes of family culture are reported in more detail in Solomon (1993, 1994). The claim made in those papers was that there was coherence in what the parents said in interviews, in how they interacted with the SHIPS activities, and sometimes even in the tidiness or clutter in the house itself, which seemed to show that science activities were becoming molded into what we might call the already existing culture of the home.

Thinking about homes in terms of a microculture is not a completely new approach. The term *home culture* was first used by Roger Silverstone (1994) in the context of how new technology appliances were used. Like our own research, this was the result of observations at home. Silverstone argued that television, for example, did not have uniform effects on all the families he studied. Some separated the children from it as completely as they could; others actually put the Moses basket on top of the set so that its noise could lull or stun the baby to sleep. He argued that the formation of this home culture had preceded the advent of television, so that the reception of this culture-shaping monster was itself shaped by the existing mores of the home. Television sets filled up preexisting semantic spaces in the home.

The same seemed true of the SHIPS activities. Some parents located them in the front room, having draped the table with a spotlessly clean cloth, as though they were trying to accord to science the respect due an important visitor. Others carried out the activities on a large and cluttered kitchen table in close proximity to all the other things that members of the family were doing, making a point perhaps about its familiarity and acceptance in their active lives. Some allowed other family members to join in, and others fetched books to ensure that the right answer was obtained.

The term ''culture'' has changed in focus a great deal during the past 50 years. Until the 1950s it was used to describe the behavior of alien tribes; later it came to be a study of word exchange and meanings (Wittgenstein, 1961; Geertz, 1973). More recently, most aspects of culture, large or small, have become associated with the construction of self-image or identity. To reverse our basic theme, we could say that our home culture, as a child defines it, is where we will feel at home in later years. Shweder and Le Vine (Shweder, 1984) wrote that the self can be a private personal representation, a collective cultural construction, or both. This idea was later expanded by Rom Harré (1998) into the construction of personal points of view. For Anthony Giddens (1990), who analyzed our modern times in terms of risk and expertise, trust is the stable circumstance from which the young child's self-identity evolves. The most significant of those whom children trust are certainly their parents. Thus, they slip, comforted and comfortably, into the culture of their home, with science if it is there at all, as they return daily from school to home.

The idea of home culture is presented as a coordinating feature in line with modern theories of culture as well as with the behavior and talk of the family. It is the whole home whose culture has nourished and created children's first self-image and their sense of identity which is still firmly anchored to their family. Even in school it is reinforced by the daily reading out of their name from the register. Otherwise, the school is at best strange, like a place in another land and another culture, and at worst threatening. Some children remain quiet and almost unidentifiable in school for many months or even years. In the end, however, they all build up a second identity for special use at school, one that marks them as good or clever or naughty. Therefore, any attempt to understand children's reactions to home–school learning in the SHIPS project, or any other, needs to take into account who they are at home, and who at school. A thoughtful analysis by David (1993) demonstrated serious gaps in our understanding of the perspectives of mothers and families which are bound to be important.

All but one of our sample performed the science activities happily and naturally at home. In at least 50% of investigations, the child had enough confidence to make some original contribution to the investigation. It might be the leaf of a herb that they rushed out to collect for magnification, a plastic toy to be compared with other plastics, a different colored candle to be softened in hot water, or some special stones to be added to the soil. In this way, they made the investigation at least partly their own, which rarely happens at school. They spoke easily with their parents and were encouraged, joked with, scolded, or ignored in a manner that clearly seemed familiar to them. In school some of the same children seemed eager to answer the teacher's questions, but because they were forced to wait with their hands straining and waving in the air, they often expended far more energy than their short answers seemed to merit. Back at home when the activity was being carried out, there was a different atmosphere, with both child and parent looking at the activity and commenting freely upon it. Only if the mother referred explicitly to work done at school—that remote domain—did the atmosphere get tense and the children's comments uneasy.

> Mother: When you were learning about that at school, did they talk about that? That's how they might keep cool, isn't it?

Child: [Rudely] How should I know?

Another couple carrying out the same activity about elephants' ears had a similar problem.

Mother: Think! This is your project to take back to school. You just said it keeps itself cool by flapping its ears, didn't you?

Child: [Sullenly]: I don't have any idea.

In one case, a child was heard to deny, without truth, that his class was learning about the Romans, to escape questioning which might have reminded him of school. This is clearly part of the lack of communication which showed up on the opening questionnaire and the frequent comment from parents about how little they were told about what went on in school. As one mother said, ''When I ask him what he did at school, he always says, 'Not a lot!' '' This response, so familiar to parents, suggests a distinct reluctance to recount experiences from school in the private location of the home.

Validation of Results

We argue that any numerical attempt to evaluate this work would be reductive. It is impossible to read the transcripts without seeing these science activities as both educational and cultural successes. We treasure the image of a scene in which an extended Pakistani family, many of whom spoke no English, gathered around the bowl where the pieces of apple floated and potato sank, with a mixture of excited language and delighted laughter. This was a first experience for all the women. Then, a Nigerian mother reported to us that her son had made his Rain-Measuring Jar in the bath with great enjoyment, and that she had taken the opportunity to tell him about the importance of rain in her part of Nigeria. Thus, wise parents tried to bridge the gap between school and home, leaving a thought corridor to connect the cultures of both.

For young children, the transition from one culture to another is a big step. As adults we are aware of adopting different identities in different situations, and learning how to do this is a valuable part of children's maturing experiences. Aikenhead (1996) analyzed familiar science classroom problems as border crossing into the subculture of science. In this home–school project we observed the challenge of another border crossing from home to school and back again encountered by even younger children. This important aspect was ignored by most earlier research, which concentrated only on the views of parents and of teachers, and on measurable cognitive outcomes.

Our approach was descriptive and sociological rather than judgmental or evaluative. Our evidence suggests that parents confer on science activities the perspective of their home culture, so that any numerical mean measurement of outcomes may be misleading. Some homes will transmit to the children the idea that science activities are important for explaining phenomena, some that they are about having fun, some about succeeding in life, and some about knowing more science than other children. We had examples of all of these. If the results of research in homes are evaluated exclusively in terms of the facts recalled correctly, they are likely to be ambiguous if not downright misleading.

A better way of validating the findings is to show their consistency with (a) results gained from the questionnaires, (b) other home investigations, such as those of Tizard and Hughes (1984) and Silverstone (1994) already mentioned, and (c) sociological findings such as those of Garfinkel (1967) in ethnomethodology and of Schutz and Luckmann (1973) in the sociology of life-world knowledge.

An even more convincing evaluation would be some explanation of the conflicting results from previous work in this field based on our present findings.

We learned from the questionnaires that the majority of parents, whether they were confident of knowing much about science, were willing to help their children with science activities at home. We saw this at work in our investigations. Most of the mothers were uncertain about their science knowledge and some searched for books to bolster what they knew. Only one mother was negligent in carrying out the activities. The rest thoroughly enjoyed them, just as they thought they might do according to the questionnaire answers.

We also found that the children behaved differently in home than at school in almost precisely the way that the work of Tizard and Hughes (1984) predicted. Children spoke far more at home and seemed to act so as to reinforce natural bonding. At the same time, we noted that even the placing of science activities in the rooms of the house varied in recognizable ways from one family culture to another as Silerstone's work (1994) described.

We found, moreover, that when parents asked what children did at school, the children were uncomfortable or dismissive, as ethnomethodologists (e.g., Garfinkel, 1967) predicted. Social interaction is constitutive of the relationships between people. Thus, when at home the children rejected mothers' behavior when they tried to turn home into school or take on the role of teacher.

Finally, we argue that our findings explained much of the work summarized in the review paper by Dimmock et al. (1996) described earlier. Although it was known that students' work often improved after parental collaboration, this did not apply to the doing of more conventional homework which was not experimental and needed conceptual knowledge. Our parents succeeded because it was a practical activity in which they could join. Again, we would expect positive results in terms of enjoyment and attitude with take-home science kits like those used by Gennaro and Lawrence (1992) but almost no link between out-of-school science activities and in-school achievement (Baumert et al., 1998). Going to a theme park or a museum has none of the warmth of carrying out activities with the family. We know that parents often lack confidence in their own science conceptual knowledge, and the doing of conventional homework could well reflect this uncertainty.

We saw a general connection between recent research into the how the public received science knowledge and the way it was received in homes. Just as farmers interpret science in terms of farming, so parents see science as something that they once learned and their children may now. Those who liked making models incorporated that into the SHIPS investigations, those who saw science as a way of explaining things, explained, and those who saw science as bookish bought encyclopedias for their children. Little of this could be converted into a crudely quantitative measures. A far greater reward from these activities with parents in their homes was the possibility of implanting the enjoyment of science into the home culture, and through this into the child's self-image and future.

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