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Collaboration in Primary Science Classrooms: Learning about Evaporation

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Abstract

We have been studying collaboration in the context of children conducting science investigations in British primary classrooms. The classroom is the site of action where learning occurs and it is the teacher who plays the key role in manipulating the learning environment and selecting and structuring tasks to achieve the best learning effect for all children. In this paper we describe our general approach and focus in particular on the data we collect to explore how children's conceptual understanding of evaporation progresses. The paper highlights some of the messages emerging about how collaboration can sometimes enhance learning, and sometimes thwart it.

Introduction

Collaboration is a key fact of school life for primary children (aged 5 - 12 years old) in the UK. We have been studying how such collaboration mediates the science learning of children of a range of ages working in groups in a variety of classes in a number of primary schools as part of the Collaborative Learning in Primary Science (CLAPS) project. Some other workers (e.g. Howe, 1992) use a laboratory setting and study children's performance on science tasks separate from specific topics being studied by the children in their normal class work. It is very important in our view that our research is based in the classroom. There are two reasons for this- one the influence of context on learning and the other that the complex phenomenon we wish to understand only occurs in the classroom. Artificial contexts only replicate aspects of this phenomenon divorced from the mediating influences of teachers' and childrens' agendas.

The core of this study involves videoing children and teachers at work in the classroom on investigative science tasks. To complement this observation, a range of interviews of teachers and children and probes of cognitive and affective outcomes of the group work were conducted. We have carried out studies in four schools. Children aged from 8 to 12 years have been observed. The situations observed range from a single group in one session, i.e. a snapshot of collaborative learning, to more extended observations of groups lasting a number of weeks. We used radio microphones with target groups of children identified by the teacher as collaborating well and developed and used some questionnaires and interview schedules with children and teachers which focus on their views of science learning, the role of group work and pupil attitudes to it. This paper concentrates on an account of certain features of a part of one case study of year 5 children (8 and 9 -year-olds), studying evaporation. This approach to studying knowledge aquisition in authentic contexts results in rich data and is similar to that advocated by Brown, 1992. Its distinctive feature lies in the approach required to capture the effects of the distinctive investigative curriculum involving children in practical science activities in UK schools.

The focus on investigative learning in science in the UK schools has its roots in the research of the influential Assessment of Performance Unit's science project which identified practical science investigative activity as the synthesis of scientific skills, processes, procedures and concepts (see e.g. Murphy & Scanlon, 1993). Variable-based practical investigations help children develop their scientific knowledge and understanding and engage them in authentic activity (see e.g. Brown et al, 1989) which leads to an understanding of scientific evidence. As children engage in investigative tasks, they use and develop both their conceptual and procedural understanding (Gott & Murphy, 1987), so it is necessary when examining children collaborating on the tasks described below to consider their procedural competency in order to fully understand their conceptual development. So, in what follows we describe both the outcomes in terms of conceptual understanding and the probes used to elicit procedural competency.

Learning about Evaporation

The work on evaporation occupied the middle two weeks of a seven week case study on the topic of water. In our first observations of this class, the teacher had switched the composition of the groups on a week by week basis. For the work on water, two groups were selected by the teacher to work together throughout the period, partly because of his concern that mixed gender groups should develop ways of working together, and partly because, having tried a variety of groupings the teacher felt confident in his knowledge of the individual children's strengths and weaknesses. The target groups were Group 1, a group of three children, two boys and one girl, and Group 2, a group of four children, two boys and girls.

Data Collected. The data collected about the teacher's and the children's views and attitudes is extensive. For this paper, we focus on the specific probes used to ascertain the teacher's approach and the children's conceptual understanding in relation to evaporation and views of group work. In collecting the data about children's understanding we adopt a specific approach. First, we use the teacher's sources of information-in this case children's annotated drawings and accompanying discussions of them - together with the dialogue between children as they plan their investigation of the phenomenon and carry it out, and teacher's and childrens' accounts of the outcomes of the investigations. Secondly, we collect information independently to elaborate the classroom based sources of data. These independent observations include a simple probe prior to the investigation involving a related activity which demonstrates the phenomenon. In this case we used a wet hand print on a paper towel which the children were asked to observe over a period of time as the towel dried (Russell and Watt, 1990). The children's explanations of the phenomenon were recorded and probed to see if they linked their initial understanding of evaporation to this new context. After the children had completed their investigation we probed in recorded interviews what their hypotheses were, what they found out and what they now understood about the process of evaporation. At this point we also returned to the children's annotated diagrams and questioned whether these now represented their thinking and discussed again the 'handprint' phenomenon. The final data collection occured several weeks after the completion of the overall work on water. In this delayed probe, we looked in particular at whether children can apply their understanding of evaporation to new contexts. For these reasons we supplied them with clothes which were wet as they had just been washed and asked for explanations of how clothes dry and and the factors that influence this. Evaporation is not mentioned at this point. After this, we asked children to write and draw about evaporation. Finally, we used a series of photographs of everyday phenomena where evaporation is involved to probe further children's thinking.

The Teacher's View of the Investigations. We interviewed the teacher about his approach to science generally, his approach to specific tasks, his views of what would be achieved by the children and how the work turned out. We also asked about his reasons for grouping children and his views on how the group's work had progressed. His tactic was to group children with similar ideas. When asked about why he did this he said:

> *because then they will be doing what scientists do really basically which is test their own ideas to see if they are valid rather than, say, give a general question to the whole class where everyone investigates the same thing regardless of their conceptual understanding.*

The Investigations. Group 1 investigated what happened when containers were put in hot and cold places. In the words of one girl in the group (1G):

> *We put a container into an incubator that was hot and one container of water into a fridge ... We thought the one on the fridge would evaporate the quickest but after we done the test and we were half way through it we thought oh no when puddles are out in the road and it's sunny they dry up and they evaporate quicker but we couldn't stop anything then because the test was carrying on ?*

The children's accounts of their expectations differ slightly, but all mention the fact that originally they intended to study the effect of moisture on the rate of evaporation. This extract from the conversation between interviewer and the girl quoted above shows the role played by moisture in her thinking about evaporation.

> Interviewer: *Can you remember your original ideas then about why the fridge would be quicker*
>
> 1G Em.. because it had less moisture in there and there was more room for it to go up into
>
> Int: *Less moisture in the fridge so more room for the water in*
>
> 1G And then we thought if there wasn't as much moisture in there and there wasn't any moisture going up then nothing was evaporating

This notion of the influence of moisture does reappear in their discussion of results.

In this classroom, a particular focus was made of children deciding for themselves what features to investigate. However the teacher made strong suggestions about the importance of the variable surface area which was taken up by one of the target groups (Group 2). They decided to find out which containers lost the most amount of water, comparing a number of round containers of varying heights and surface areas. As a boy from group 2, 2B describes

> *We expected that the biggest one would lose the most amount of water... Because it's got a bigger surface area.*

However, the experiment hit a snag because the containers were placed in a greenhouse, and another class watered the plants.

The teacher commented later:*I knew this would happen ... so I was going to let them track their result and see if they actually noticed something was wrong ... but the good thing about that was they decided to start again'.*

In fact he had switched his intentions for the activity hoping that these children were learning some useful lessons about scientific procedures. This provides interesting evidence about the potential of an investigation to progress children's conceptual understanding. To understand how surface area affects evaporation is a complex idea beyond most children of this age. At no point do the children in group 2 refer to surface area in their later accounts of evaporation. Furthermore, the teacher switches to a procedural focus which influences his later interactions with them.

Both groups of children planned their investigation and then carried it out over a number of sessions, producing a report of what they found out at a group feedback session.

Group Influences. There were a number of differences in the way that the two groups approached and reacted to the tasks. One key difference was the amount of agreement about what would be the outcome of their investigations. Group 1 shared the hypothesis that heat would alter the rate of evaporation. However, they had differing views about effects of humidity e.g. the boys felt low humidity would enable more water to evaporate, while the girl felt the opposite and they argued this through. In this case, the difference did not alter their ability to design together an investigation to help them explore the issue, they still shared a common task and had developed individual views of it. They did however refer in different ways to their original ideas about the role of moisture. In Group 2, in contrast, all the children shared the hypothesis that water from the wider container would evaporate more quickly but it was a hypothesis provided by the teacher. It is also unclear to what extent the children could understand the surface area as their original ideas and discussion did not take any account of it. In contrast, the 'sun' had featured strongly in most children's prior explanations.

Other differences between the groups was that group 1 in the past had experienced more conflict between group members. In fact, in a prior investigation, the group had experienced enormous difficulty due to differing perceptions of what the task set implied for the design of an activity (see Murphy et al., 1994 for an account). As a consequence they argued through their individual views of the task and were continually attempting to make explicit their thinking.

Outcomes. We used previous research into children's ideas about evaporation to inform our analysis (Russell and Watt, 1990). The categories used to classify children's responses included the vocabulary used (e.g. whether the word evaporated was used, or some other like disappeared, gone, dissolves, soaked in, pulled, dries up), the location of the water transfer (to air, to sky, to cloth,to clouds,to sun, to ground), the agent of change (e.g. heat, sun, wind, gravity), views about the reversibility of the process (as in rain, as in condensation), the physical state the water is said to have (e.g. whether it has disappeared, or turned into water vapour), and the nature of the transformation involved (e.g. no conservation, change of location, change of location plus physical change). Beveridge (1985) reports that children's prior conceptions of evaporation are resistant to change on instruction. Levins (1992) suggested that it is necessary to study the instructional and developmental sequence further to properly understand how children develop these concepts.We constructed learning trajectories for each child in terms of the information elicited at each stage of the case study. These show what progress each child had made at each stage.

We focus first on the views of one child from group 1 (1B) at each stage of the data collection, and Figure 1 shows his description of evaporation. Before the investigation, when discussing the hand print, he had the idea that the water would have gone both into the air and into the cloth. He then took part in the investigation looking at the influence of heat in the process of evaporation. By the delayed post experiment probe he was able to discuss evaporation in the following terms:*Well first it like gets so hot and it turns into water vapour.. yes it just like ... the sun makes it steam and the steam is like water vapour so then it goes up, rises into the clouds and then you get rain again.*

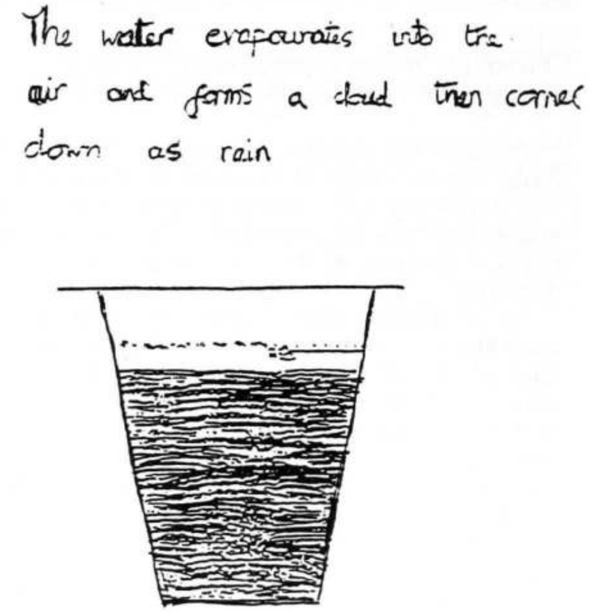

Figure 1 a: Drawings of evaporation made by a boy in group 1 before conducting the investigation (1B)

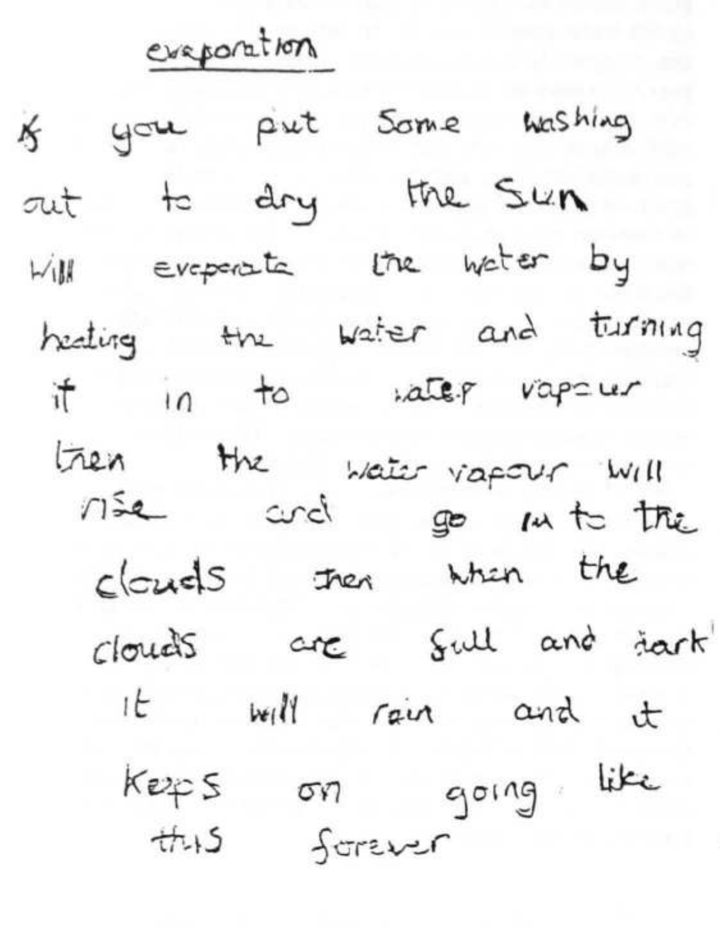

Figure 1 b: Writing on evaporation by a boy in group 1 after conducting the investigation (1B)

This child was also able to understand that evaporation could occur in a range of circumstances. For example, he was able to say that a person perspiring was a case of evaporation from the skin's surface. He also unprompted began to speculate on the link between evaporation and dissolving.

The construction of learning trajectories for each child made heavy use of data like the extract quoted above. The range of data collected is wide and interpretation of it, as it must always be, is subjective. However, we have the benefit of triangulation from information from more than one source to aid us in the interpretation. In these trajectories, we find some support for the Piagetian picture (1974) of 'the pathway which leads from the child's refusal to accept any 'passage of matter', to an intuitive change of state, and finally to the level in which children described steam as tiny "pieces of water" ' (Levins, 1992, p. 263) By constructing such learning trajectories for all the target pupils we begin to build up a picture of the overall result of the children's investigations of evaporation.

For a child in group 2, however, (2G) investigating surface area progress was limited. For this child the water in the paper hand towel dried up but had '*gone back onto the paper and then its just stayed there ... but its all dried up*.' When asked again about the water after her investigation of evaporation she repeated that '*it [the water] dries up inside the paper.*' This child's initial view of evaporation (shown in Figure 2a) was very similar to her final drawing of the process she provided in the delayed post probe (shown in Figure 2b).

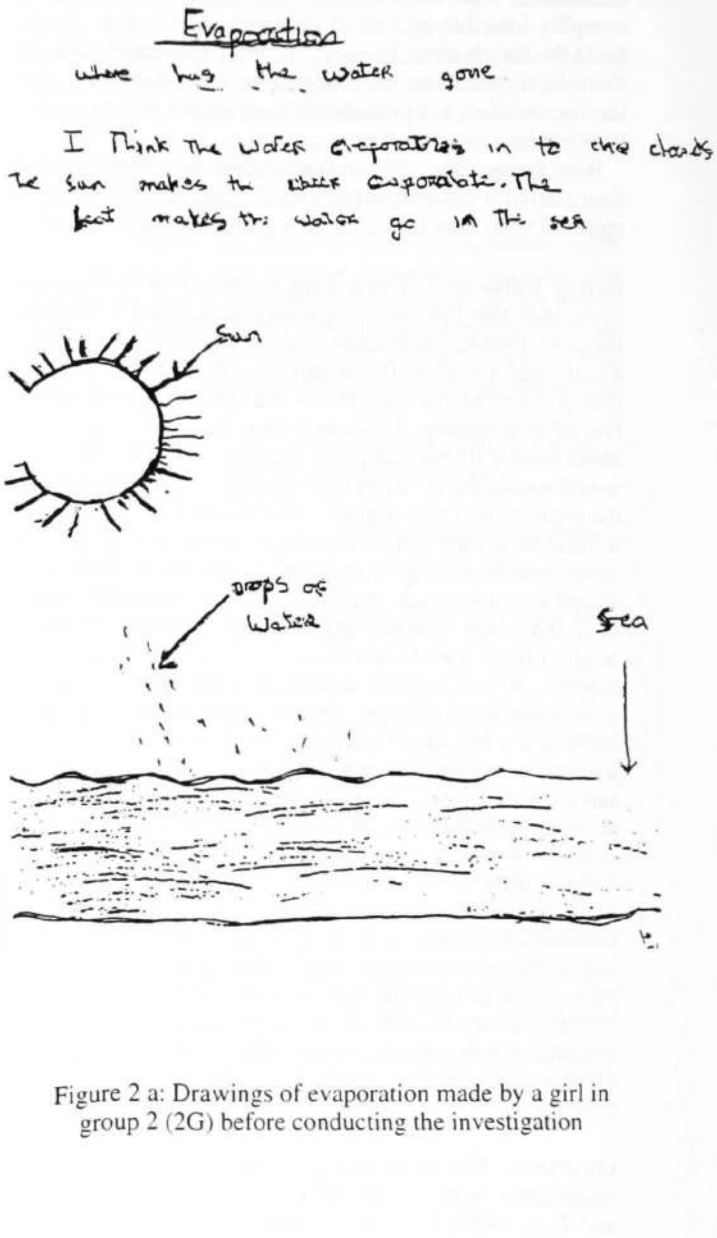

Figure 2 a: Drawings of evaporation made by a girl in group 2 (2G) before conducting the investigation

Figure 2 b: Drawings of evaporation made by a girl in group 2 (2G) after conducting the investigation

When asked about washing drying she replied.

Int: *So when the washing dries where do you think the water goes?*

2G Em, just think it will evaporate

Int: *You think it will evaporate, so when the water evaporates where do you think it goes*

2G It goes up into the sun and then into the sea

For others in this group, the investigations had produced more tangible outcomes.

It is not possible to conclude that it was the influence of the particular investigation performed by an individual child which changed their views on evaporation, because they will hear accounts of other children's results of their investigations and hear and see things outside the classroom which they try to interpret in terms of their current conceptual framework. However, our evidence suggests that most children made some progress (Scanlon et al., 1995). The most marked progress was for group 1 who explored their own perception of the task. Our initial analysis suggests that progress is affected by the level of task engagement which can be influenced by the group composition. In the case of group 1 the children had strong views which they argued through. It is also notable that marked progress was made between the post probe and the delayed post probe. This is in line with findings by Howe (1992) and Scanlon et al. (1993) which suggest that the results of collaborative activity in science often appear later.

Conclusion and Discussion

By combining observational data from the groups at work, interview data from children and teachers about their intentions and actions and probes of conceptual and procedural understanding we can build up rich pictures of how group composition influences the group process and how this in turn influences the learning of individual children. We have illustrated how data of a variety of types is necessary to come to an understanding of the way teacher intentions for the activities are developed and also the way in which investigations impact on children's developing ideas. It is our intention to refine such accounts as these to enable us to better understand the ways in which classroom conducted science investigations can aid learning, and the influence of group processes on this.

A key aspect of those group processes is the effect they have on the task children agree to pursue and their individual engagement with it. Our findings suggest that conflict plays a complex role in children's learning in groups. We have seen examples of children's behaviour which suggests that conflict, either between group members about what outcome is expected, or about how to plan or conduct an investigation can engender task engagement. In relation to the work on evaporation, one group disagreed about their expectations on the influence of heat because of conflicting views about the role of humidity in the process. In the post investigation interviews one child remembered the outcome and her surprise at it, yet another declared that all that had happened was what he expected. In this case the conflict in views seemed to be beneficial, enhancing children's engagement both with the task and the phenomenon of evaporation. Sometimes conceptual conflict can be less beneficial. We have seen occasions in other science lessons where disagreements in groups have compromised the conduct of the investigation. Also, perceptions of the tasks set can vary among members of groups so that progress is difficult (see Scanlon et al., 1994 and Murphy et al., 1994 for an account of this.)

Our observations confirm the enormous influence of the teacher in mediating investigative work in science. The way in which teachers select and resource tasks, monitor progress and facilitate children's collaboration is of key importance. We were interested in the way that the teacher in the evaporation case study shifted his focus towards procedural matters, and felt the need to import certain variables for the children to study, due to an unease in the the distance needed to travel towards the accepted scientific view. Teachers in general value group work. We are conscious that this is often for the development of social skills rather than the specific science outcomes.

The nature of collaboration on primary science investigations in classrooms is not clearly defined and subject to a number of influences. We have observed three aspects in particular that seem to matter. These are that participants (both pupils and teacher) have a shared task and have developed an explicit individual view of it in relation to their own thinking about the concepts involved; that participants have agreed plans for the investigation and are aware of the consequences of their decisions; and that they develop ways of managing conflict over how to proceed. We have seen in the evaporation case study that conflict can sometimes engender task engagement. Teachers need to be aware of the issue of how to ensure that pupils are engaged in the investigative task they work on. One of the dilemmas is that somehow they need to manage such conflict while protecting task engagement. We have seen examples of pupils themselves managing conflict about the nature of the task, by developing hybrid investigations whose results they cannot understand (Scanlon et al., 1994).

Our intention is to abstract further examples from our collection of rich data in order to explore further the way in which collaboration on investigations in primary science classrooms influences learning.

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