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AUTHOR Eraut, Michael
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ABSTRACT

In British primary schools, it is unusual to find more than one computer in a classroom. As a result, children are assigned to small groups to use the computer. This research reported here sought to explore the characteristics of groupwork with computers and to provide guidance to teachers on computer use issues. This paper summarizes work from the Sussex component of a three-year project involving London and Sussex Universities and 12 schools in six districts. The children observed in the study were between 8 and 12 years of age. The software used in the classrooms included LOGO (Mathematics), Lego LOGO (Control Technology), databases (for Social Studies Topics), and DEVELOPING TRAY (a language program using a cloze procedure format). Data ' - the case studies were gathered by observation, interviews, questionnaires, school records, and, in some cases, tests of pupil performance. This paper reports on the following selected topics from the research: group processes, including pupil roles, decision making, turn-taking, participation, fairness, conflict, and collaboration; ability factors; optimum size of group; personality factors; teacher approaches to group composition; and emerging policy issues. (Contains 23 references.) (JLB)

GROUPWORK WITH COMPUTERS IN BRITISH PRIMARY SCHOOLS

Michael Eraut, University of Sussex

Rationale

In British Primary Schools, it is still unusual to have more than one computer in a classroom. As a consequence children are normally assigned to the computer in small groups (2-4 and occasionally 5-6); though many positive arguments have also been advanced for a groupwork approach (Eraut and Hoyles, 1989; Valcke, 1989). There has been little previous study of such groupwork in naturalistic settings; and previous research by the author (Eraut and Petch 1989) indicated that the "computer zone" was usually regarded as an alternative working environment where teacher intervention was rare and informal peer–tutoring quite significant. There are also good theoretical reasons for expecting groupwork with computers to have a significantly different character from that in other classroom settings: different roles, turntaking at the keyboard, screen focus diminishing interpersonal eye–contact, high motivation raising the stakes, limited access to the main resource, etc. The reported research sought to explore the salient characteristics of groupwork with computers and to provide guidance to teachers on such issues as task design, group size and composition, gender equality, training in collaboration, appropriate monitoring and intervention, and the handling of children with a wide range of individual qualities and needs. The project was funded by the UK Economic and Social Sciences Research Council as one of four projects exploring developments in Information Technology in Education.

Methodology

The general approach to this three year project has already been reported (Eraut and Hoyles, 1989). The project involved London and Sussex Universities and 12 schools in 6 districts. This paper summarises work from the Sussex component drawing on 19 single-site case studies covering the work of 16 classes in 10 schools. The majority of these case studies were written by teacher–researchers observing in a colleague's classroom; and a minority, by a University–based research fellow, Rhiannon Petch, who also supported the teachers and assisted in their training. The children were aged between 8 and 12, and a quarter of the classes had a mixed age composition. Four main types of software were used: LOGO (Mathematics), Lego LOGO (Control Technology), databases (for Social Studies topics) and DEVELOPING TRAY (a language program using a cloze procedure format).

Most of the case studies were conducted over a school year (either Year 2 or Year 3 of the project) following groups of children at regular intervals. The teachers and authors concerned are listed in the Appendix and should be regarded as coauthors of this paper. They selected their own methods but addressed a common agenda of issues. All but one case study (which focussed on pupil opinions and feelings) involved extensive observation of groups of children working at the computer; a majority used interviews, questionnaires and school records; about a half used recordings and/or pupil diaries; several used tests of pupil performance.

Analysis of Data

Towards the end of the first group of case studies (Year 2 of the project) the initial agenda of issues (Eraut and Hoyles 1989) was adjusted by mutual discussion between the teachers and the researchers. During this discussion it became apparent that hypotheses oriented towards possible generalisations had a short half-life. While it is possible to use data from one school to support a plausible hypothesis, findings from another school will disconfirm it. Indeed we could support or challenge much of the published literature, which is almost entirely based on short experiments in single settings, by selecting data from the appropriate school, age-group and class. This is because

(a) The variations between classrooms are considerable, both in collaborative experience and ethos, and in the way teachers initiate and intervene; and

(b) Individual children's effects on groupwork cannot be reduced to commonly cited variables such as gender and ability, there are also personality factors and friendships to be considered.

This interpretation of the complexity of the phenomena being studied led us to redefine the role of generalisation within the programme as follows.

> Even if two or three schools find groups behaving in similar ways it does not follow that all groups in those schools will be similar. For each possible generalisation, we have to ask for which groups have we got evidence that suggests it is either true or untrue; and for which groups have we got insufficient evidence to be useful.
>
> Where we do arrive at generalisations they will be unlikely to be true for all groups; so we have to ask *under what circumstances* is it most likely to be true. We should not let occasional exceptions divert us from noticing general patterns, any more than we should avoid claiming general patterns on the basis of only two or three examples.

Thus although we agreed an agenda of issues and possible generalisations to serve as a focus for much of our subsequent research, our purpose was not so much to prove or disprove these generalisations as to ascertain *the conditions under which they were most likely to be true or untrue.* In retrospect, we feel that this is an excellent way of conceptualising and focussing research involving multiple case studies.

The main purpose of the project was to develop a conceptual framework for thinking about groupwork with computers, which fully accommodated our findings and also helped teachers to understand groups in their classrooms and make decisions appropriate for particular children in their own specific context. Hence the second stage of analysis involved combining some 700 pages of case studies into a single book. This was approached by developing a list of about fifty topics and issues, then indexing every page of each case study with the number(s) of the topics and issues it treated. All relevant entries were considered at every stage in the write-up, and the synthesis report sent back to all the researchers for comment and verification. The resultant book is almost complete and will include a presentation of the conceptual framework, an analysis of the implications of the research for practice and a large number of illustrative examples from the case studies. Most of the data is qualitative or semi-quantitative, but there is also a small amount of quantitative data. This paper reports on selected topics from the research : group processes, ability factors, optimum size of group, personality factors, teacher approaches to group composition, and emerging policy issues.

GROUP PROCESSES

Pupil Roles

Although pupils referred to the **keyboard operator** as the central role, typists often did little more than enter commands dictated by others. When programming expertise limited their ability to translate intentions into commands, another pupil would act as **translator** and often as a **screen monitor** as well. When typists were able to translate, the dual role often made such demands on their attention and concentration, that they contributed little to any discussion. Thus only a few, very able, pupils were able to dominate from the keyboard. This accords with Webb's (1984) finding that learning from computers does not depend on being a keyboard operator. Indeed it suggests that in some groups the typist will probably learn less, a problem avoided during our project by regular rotation of roles. The role of **scribe** or notemaker, introduced by teachers when saving work could not be relied upon, also tended to restrict participation. So pairs, and even some trios, often proceeded with little active discussion.

Tutoring arose when one pupils set out to explain to others what was being keyed-in and why. Often, however, an "expert" pupil just showed the other(s) what to do without providing any explanation, thus leaving them none the wiser. Other children were more reticent with their expertise and operated more like **consultants.** They offered opinions and answered questions but did not control the discussion.

Some groups benefitted from having a **group manager**, who sustained a dual concern for completing the task and monitoring participation. This did not entail imposing one's own ideas (the **dictator** role) nor making all the decisions oneself, but rather overseeing the progress of the task including the making of any necessary decisions, ensuring that there were fair and sensible arrangements for the allocation and sharing of roles, and encouraging participation by the group members. Often some aspects of this role were taken up by an individual while others were picked up by the whole group, or even ignored.

Decision-making

Decision-making in computer groups is different from that in non computer groups, because unilateral decisions can be made without any discussion, simply by pressing a key. The typist may act on his or her own behalf or in response to another member of the group acting as **dictator** (in both senses of the word). It is also quite common for decisions to be made in mid-discussion before any agreement has been reached. Discussions we observed were often ended by unilateral action by the typist either on their own initiative or in response to a dominant member of the group. This was not necessarily resented by the others: it kept things moving along and in due course they also took up the keyboard position. Only some of the time, and in some groups more than others, was there a clearly formulated agreement among all participants prior to keying-in. Another aspect of decision-making was the kind of decision under consideration. We identified three levels.

- The command level is concerned only with the next instruction to be typed into the computer.
- The tactical level is focussed on some short-term goal, normally a small part of the task being attempted. Work at this level is characterised by a piecemeal, trial and error, approach with little or no attempt to look ahead or consider the task as a whole.
- The strategic level is concerned with discussion about how the whole task, some very substantial part of it or some anticipated problem will be tackled.

Most groups reached the tactical level at some stage and for many it was the dominant mode of discourse. But discussions at the strategic level were rare, and attempts to raise strategic issues were often ignored. While individuals contributed to the discussion at different levels and in a variety of ways (suggestions, comments, questions), the attention given to their remarks depended partly on their status within the group but mainly on their timing. It was difficult for a group to change the level of its discourse or to change a particular line of thought in mid-stream. Groups vary in their capacity to pause, review and consider alternatives; and **the computer entices groups into constant interaction rather than reflection**. We found that discussion at the strategic level was most likely to occur when groups were working off-the-computer, reviewing their progress or preparing programmes for when their turn came.

Turn-taking and Participation

The most concrete manifestation of participation was turn-taking at the keyboard. Pupils used two methods for organising turns: piecework usually involved very short turns (eg one movement and RETURN in the case of

LOGO); length of turn was easier to adapt to more flexible work-patterns as groups got used to working together. As pupils gained more experience of groupwork, most pupils began to realise that being a typist was only one of many possible roles and not necessarily the most interesting or influential. However, few entirely abandoned their expectation of a reasonable share of time at the keyboard. Younger and less able pupils were more likely to remain keyboard-dependent.

Consideration of fairness was not confined to turn-taking at the keyboard. It also extended to oral participation and even to the take-up of suggestions and ideas. However, the criteria for assessing such participation are not at all clear. Silent decisions can be made at the keyboard, which do not figure in recorded conversation; and a higher proportion of verbal contributions are ignored when the screen is the dominant focus of attention. To define participation in terms of the number of suggestions accepted assumes that all suggestions should be given equal weight, and ignores contributions which comment on the state of play or evaluate ideas put forward by others. While quantitative data provide useful evidence, overall judgements about participation are perhaps best left to the interpretation of pupils and observers in each distinctive context.

Another aspect of participation must surely be comparative. Some contributions of 15% to groups of four were treated by teachers as highly encouraging because they came from quiet pupils of below average ability. The quietest pupil in one group was a shy newcomer, whose 6% of the conversation was acknowledged to need teacher action; yet even she made several useful suggestions. Several cases were reported of children whose general class participation was improved as a result of confidence acquired during groupwork with computers.

Taking this natural variation into account, we concluded that the majority of groups observed had reasonable levels of participation. But there was still a significant number of groups in which some members were unreasonably constrained, either by dominant pupils or by marginalisation.

The two descriptions of dominance most frequently used by children were "hogging the keyboard" and "bossing people around". Numerous examples of both are reported in our case studies. While usually this dominance was resented, collusion between partners was also quite common. Observers noted that it could be disfunctional to both mutual learning and the achievement of the task, when important ideas from the less dominant partner were increasingly ignored. Dominance was usually more pronounced in pairs than in larger groups, where its worst excesses could be more easily moderated. But even in larger groups there were a few individuals who were particularly difficult to contain.

Although dominance is commonly attributed to personality, our researchers also found links with ability and with gender. There were some examples of less able children attempting to dominate, and also of dominant girls; but in general dominant pupils were more likely to be of higher ability and more likely to be boys.

Marginalisation is not simply the converse of dominance: it refers to the process whereby a single child becomes a non-participant in a group of 3 or more pupils. The main causes of marginalisation were: reticence, a personality characteristic; lack of with-it-ness, a failure to follow what was going on, which was usually attributable to ability but could also result from having missed a previous session; and location, sitting on the edge of the group without a clear view of the screen. Often these factors were acting in combination.

Argument and Conflict

"Too much argument" was frequently cited by children as a negative aspect of groupwork. The converse was equally true: a typical answer to a query about the success of a group was "we were successful because we didn't argue". At first sight, this seems like a simple transfer from norms prevailing in contexts where adults monitor children. However, closer examination reveals a much more complex set of considerations: causing disruption, putting friendship at risk or, with some teachers, missing a turn.

Sometimes **disruption** meant not getting on with the task and frustration for those looking on; sometimes, particularly for boys, it meant "if we argue, we start fighting and then we might accidently wipe the work off the computer". Disruption soured the atmosphere, and made pupils want to work in a different group.

Staying friends was an important consideration for many children, who were concerned that arguments at the computer might lead to broken friendships on the playground; and for one or two children concern with retaining a particular friendship outweighed all other considerations.

Missing a turn, because the teacher intervened to break up a noisy argument, was also a significant threat for pupils who valued their turn at the computer and knew there was always a long wait between turns.

This anxiety to avoid argument was a major reason for the emphasis placed on turn-taking. For example, groups would often try out their ideas in some kind of rota rather than risk a discussion about their respective merits. This has serious consequences for those who advocate groupwork in order to promote cognitive conflict, because their aspirations will only be realised if (a) there is sufficient discussion and argument to create cognitive conflict and (b) the group is able to contain such conflict within the cognitive domain. If cognitive conflict spills over into social conflict, then group cohesion is destroyed and with it the capacity to engage in productive discussion. Many groups maintained their cohesion by avoiding any cognitive conflict, thus limiting their opportunity to learn from discussing alternative proposals.

In practice we found that some groups evolved more productive strategies for resolving disagreements: good leadership, mediation, humour and a generally collaborative group ethos all played a part in minimising conflict. Members of such groups did not refer to a disagreement as an "argument" unless and until it had already become disruptive or threatened the collaborative ethos of the group. Pryor (1993), a teacher-researcher with an interest in gender issues, suggested that there was also a gender dimension to children's views as to what actually counted as arguing. Some children are able to cope with disagreement leading to justified discussion and debate as a positive thing, others are not able to do so and see any disagreement as 'arguing' and thus to be avoided. The tendency is for the first group to be girls and the second to be boys. However, it was a boy from a highly collaborative group who said:

> "We usually don't have any arguments and the ones that are arguments end up being discussions. We haven't had a shouting argument. If you think about it we work perfectly."

Collaboration

The words "cooperative" and "collaborative" are frequently used to signify what is judged to be successful groupwork. However, their meaning is rarely discussed with pupils or even among teachers. Collaboration literally means working together, not just being an accepted member of a group nor working adjacently as neighbouring individuals. Hence one criterion for collaboration is **group ownership** of the outcome. At the same time, however, the teacher is rightly concerned with individual learning, which is particularly difficult to monitor during groupwork at the computer. Various arrangements were tried to promote individual learning in addition to group achievement, but some turned out to be counterproductive. For example, in the second year of the project one class was divided into pairs, given a common assignment and instructed to provide one product for each partner. There was little group ownership and the minimal assistance given was directed at getting one's partner a result rather than explaining what one was doing. We found several other examples to support the group ownership criterion; and our London colleagues arrived at a similar conclusion from their more experimentally-oriented work. This confirms that the findings of Johnson et al (1986) also extend to naturalistic settings.

Another criterion referred to by both pupils and teachers was that of **mutual help**. This was used to cover a very wide range of circumstances; but usually referred to help with understanding, programming or decision-making, not to the division of labour. With many groups the barriers to such help resulted from the way the group worked, as in the more limited kinds of turn-taking reported above or when one or two members dominated the others. This happened rather more often in groups of two than in groups of three or more, though with larger groups there was always some risk of an individual being marginalised. Most of these larger groups were characterised by mutual help in several directions and proceeded on the assumption that all members were positive contributors.

An interesting question arises when we consider situations, where the flow of assistance is mainly one-way. Most teachers would argue that one-way assistance does not preclude reciprocal benefit, but neither does it guarantee it. Both partners will gain when the tutor clarifies his or her thinking through having to explain and the tutee understands what is said. For the tutor, a genuine attempt at explanation will increase time on task and possibly improve retrieval from long term memory. For the tutee the individual attention is greater than that obtainable from the teacher, and the social integration is also important. We observed occasions where both partners learned, occasions where the tutor appeared to be the main beneficiary and occasions where neither seemed to gain anything from the experience. Both personality factors and the ability to tutor were important in such cases.

So far we have focussed on overt mutual help in learning, but some would challenge such separation of the academic and social agendas. We noted many cases where participation in groupwork increased children's confidence and some long-running groups provided some of the more emotionally disturbed children with reassurance and a sense of identity within their class and their peer - group. This increased their time on task and often spread its beneficial effect in countering alienation into classwork in general. None of these phenomena were universally observed and many groups manifestly failed to provide mutual help of this kind. But the more successful groups quite clearly provided emotional as well as academic support for even their strongest members.

The highest aspiration of groupwork for adults as well as for children is best described as synergy. Though etymologically the Greek equivalent of the Latin word 'collaboration', 'synergy' has more recently come to signify the bringing together of separate parts to make a whole of greater potential. In a group working with synergy the separate contributions support and enhance each other without the need for any formal etiquette. Members stimulate rather than inhibit each other's thinking, and interfering agenda are cast aside in favour of a joint attack on the problem in hand. The most successful groups all exhibited synergy. They had evolved intuitive ways of working in which attention to etiquette was replaced by mutual sensitivity and the excitement of a joint intellectual stimulus. Group members were fully aware of this common achievement and valued it highly.

Pryor (1993) attributes successful groupwork to a combination of classroom ethos, training and group composition. He hypothesised, as a result of a year's careful study of the contributions to groups of different children, that successful groups need both members who focus primarily on group processes and members whose main orientation is towards goal achievement. The more successful groups, he observed, were stronger on the process side but still needed a goal-oriented person. However, as they became more effective groupworkers, children were able to transcend these stereotypes.

Nastasi and Clements (1991) review of research on cooperative learning contrasts the cognitive conflict view of the benefits of cooperative learning with the neo-Vygotskian theory that group partners "may integrate their differing task conceptualisations into a mutual plan without overt conflict", thus "making it possible for them to solve problems together that neither could solve alone". Our evidence of groups working in naturalistic settings strongly supports Vygotsky's perspective.

ABILITY FACTORS

We studied pupils' experiences in developing proficiency in three main kinds of software; and in each case we were able to distinguish between different levels of work : using Direct Drive or Procedures with LOGO, using Printouts or Search Techniques with Databases, using literal, semantic or syntactic cues with TRAY. The most basic level required competence in using the computer, familiarity with basic software commands and accurate keyboarding (less problematic with TRAY). But not all the problems encountered at this basic level were simple. Many LOGO tasks required some knowledge of geometry, TRAY texts incorporated difficult vocabulary, database searches involved reasoning with category systems.

Our evidence suggests that under the conditions of limited time and access pertaining in the project classrooms, the progress after six months of children of varying ability could be approximated by Table 1.

Ability	Basic Level Simple Tasks	Basic Level Complex Tasks	Higher Level Simple Tasks	Higher Level Complex Tasks
Very Low	Understands	Lost	Lost	Lost
Below Average	Proficient	Understands	Understands	Lost
Average	Proficient	Some Proficiency	Some Proficiency	Understands
Above Average	Proficient	Proficient	Proficient	Some Proficiency
Very High	Proficient	Proficient	Proficient	Proficient

Table 1 : Approximate Pattern of Pupil Competence

Proficient = Able to perform task on one's own.
Understands = Able to follow what group working on task is doing, as revealed by contributions or by questioning.
Lost = Unable to follow what is going on.

This rough summary of findings has to be read with caution as **ability** is a slippery construct of variable interpretation and limited validity. Nevertheless we were able to show that progress to competence at higher levels of software use correlated quite strongly with available scores on standardised tests. Table 2 presents data from 3 classes in separate schools on the linkage between being able to write a LOGO procedure and performance on standardised Maths tests (a different Maths test was used in each school!)

	School B				School S		School W	
Writing Simple LOGO Procedure	Maths Concepts Stanines		Maths Problem-Solving		Maths Quotient		Quantitative Reasoning Stanines	
	6 - 9	1 - 5	6 - 9	1 - 5	≥ 105	≤ 105	6 - 9	1 - 5
Proficient	8	2	8	2	8	2	10	2
Not Proficient	2	13	3	11	3	3	2	11

Table 2 : Maths scores and LOGO achievements

Out of 66 children there were 12 exceptions*, five positive (top right quadrants) and seven negative (bottom left quadrants). These were subjected to individual scrutiny which revealed that:

(1) Their categorisation as "average" or "above average" was marginal.
(2) The positive examples appear to have taken maximum advantage of the opportunities afforded by groupwork; while negative examples failed to settle into collaborative groups.

Returning to Table 1, we should note that it is only in those four categories where pupils are described as **lost** that groupwork was observed to be unproductive for reasons linked with ability. Our observations also suggest that pupils described as **understanding** or having **some proficiency** benefit from being in groups with at least one **proficient** member.

More specifically, our evidence suggests that the main contributions to a group from having members of higher ability relate to:

(1) software management : editing, saving, trouble-shooting consume a lot of group time when no group members are sufficiently proficient to deal with them smoothly and without any teacher help (see Section 2.1).

(2) programming expertise : it could be argued that proficiency in the syntax of LOGO procedures and database search enables the group to concentrate on the task in hand (see Section 5.2).

(3) subject expertise : mathematics for LOGO, topic-based knowledge relevant to database enquiries, technical vocabulary for TRAY.

(4) generation of ideas relevant to the task in hand.

It is very clear from observation that expertise does not get passed on to others, simply by being used and explained. So does getting the group task completed more effectively help other members of the group to learn? Our observations suggest that unless the high ability pupil is over-dominant, the main advantages to the group are:

* This excludes three School B pupils whose stanines for the two Maths tests were (5, 7), (8, 5) and (5, 6).

- not losing too much time sorting out trivial problems
- maintaining progress, continuity and a sense of achievement
- getting a holistic feel for what it is like working at a level just beyond what they can manage on their own, i.e. working in their "zone of proximal development." (Vygotsky 1978)

Also it would be wrong to assume that other members of the group were not making significant contributions or that higher ability pupils did not need their help. This was rarely the case. Often they helped to provide a framework or 'scaffolding' which enabled others to contribute more rather than less.

These advantages were diminished when the 'expert' dominated discussion or failed to explain his or her actions/ideas; and increased when he or she was able to provide some tutoring or adopt a process management role. Trying to set too fast a pace could also be counterproductive, even when not accompanied by any overt dominance; because it lowered the confidence of other pupils and hence reduced their willingness to stay 'on task' and try to contribute.

The main advantages of a group having members of lower ability were:

- that it would make people explain things and therefore understand them better.
- that in some cases it improved the "chemistry" of the group : diminishing dominance, improving the gender balance, or providing a calming influence.

Disadvantages, which are sometimes significant and sometimes not, include:

(1) absence caused by withdrawal for work with a support teacher.
(2) slow readers or writers delaying the group.
(3) being totally lost and not following what was going on.
(4) groups composed entirely of pupils of very low ability being constantly in need of teacher attention.

A fifth problem, raised in one case and relating specifically to pairs, was the lack of stimulus provided for a more able partner.

Overall, it should be noted that there were very few cases in which low ability appeared to be the only significant factor in a pupil's relationship with their group. Personality factors were usually more salient. However, the two are often inter-related. At Wallands, 8 of 11 mixed ability pairs in the first research year involved dominant partners and only 1 of 3 matched ability pairs. Only 1 of the less able pupils was dominant and then only because their partner opted out. The same pattern of high ability dominance was noted among mixed ability pairs at Five Ashes. In larger groups such dominance is less common and not quite so highly correlated with ability. In the second research year at Wallands the emotional problems of many less able children seemed to swamp the ability factor, but perhaps it was the combined effect of the two which caused the main difficulty.

Optimum Size of Group

There were several factors affecting the optimum size of the group, whose importance varied according to the age, expertise, personalities and collaborative ethos of the groups concerned. These factors are briefly reviewed with some indication of those features of particular groups which made them more or less significant. The main sources of the evidence are pupil opinion (usually obtained through questionnaires) and observations of the groups at work. In general, we found pupils to be good informants about what happened in their groups, except for a tendency for them to exaggerate the importance of the keyboarding role.

The first factor is the simple **arithmetic of scarcity**.

> One other effect of working in pairs was that it took longer to 'get round' and therefore in effect gave each child less time at the computer. For this particular class it meant that they never got on to the more open-ended work. More generally, given the constraints of time, this could be a very significant factor in determining group size: there would have to be very strong reasons for recommending pairs against larger groups. (W1 : 67)

This was also important when the computer task was linked with other non-computer-based work which could be spoilt by too much delay, a common occurrence when using computers in topic work.

The converse of this **rotation** factor was that in larger groups, individual pupils had less **time at the keyboard** during any one turn. This could lessen the motivation of younger children and others who had not yet overcome their initial keyboard fixation. Even a Year 6 class with a long history of computer-based work expressed a majority preference for groups of two because "you get more goes at typing" On average, size of group should not affect an individual pupil's total time at the keyboard; but larger groups give them more time at the computer in non-keyboarding roles. Most pupils could reason this out for themselves, but the frustrating experience of being at the computer and getting only a short turn at the keyboard appears to have been a more powerful influence on the thinking of that particular class.

Another consideration is the **level of participation** for each member of the group. We have reported elsewhere that **dominance** is more easily contained in groups of three or four than in pairs. A few children continue to dominate in groups of four but most are brought into line by their companions. In pairs, however, dominance is both more common and less easily remedied. Often a reticent or less able child colludes with their partner in taking a more submissive role.

Marginalisation, where a pupil's participation was constrained by the rest of their group rather than a single dominant partner, was commonest in groups of four and five and only occurred very occasionally in groups of three.

In general, **layout** was particularly important for groups of four or more. While threes could always seat themselves comfortably round the computer, fours often sat in positions which make it difficult for all members of the group to see the screen or to scrutinise any notes, diagrams or printouts they sought to consult. Fours could be accommodated more easily when there was plenty of space around the computer, and when the screen was placed beside rather than above or behind the keyboard.

The third factor which sometimes affects the optimum size of group is the **distribution of expertise**. Effective software managers were particularly scarce, so editing and saving of LOGO work could depend on the availability of the teacher or an itinerant pupil 'expert'. Some researchers reported a scarcity of subject matter expertise; and in one school the retrieval of information from a teacher-compiled database was observed to depend on groups having a member with a high ability in computing.

> If the group contained a particularly high ability child, they were able to retrieve the answers with no subsequent teacher intervention. However, some groups with only average and below average children found it extremely difficult to build on previous experience. The teacher finally had to suggest that they make a complete print-out of all fields and file names. (S2 : 36)

Larger groups enable a higher proportion of groups to have the expertise they need to complete such tasks; but this may not necessarily lead to other pupils developing this expertise. The balance of advantage depends on particular situations and particular children.

Another argument for groups of at least four pupils relates to the introduction of cross-gender collaboration; because many children are worried about being the only representative of their gender in a mixed group.

> "With threes, two girls will freeze out the boy and two boys will freeze out the girls." (R1 : 15)

This becomes less important for most, though not all, pupils after they have got used to working in mixed groups.

Probably the most important factor to be considered is the relationship between group size and the kind of **collaboration** we discussed above. This significantly depends on age and ability. Few 8-9 year olds or less able 11-12 year olds are able to think about tactics when they are at the keyboard. So collaboration in pairs is frequently very limited.

> In some pairs being on the keyboard was seen as a position of power as it allowed the operator to edit or censor the instruction; sometimes only the person on the keyboard was actively involved in the task. In others keying in involved taking instructions from the thinker in the group. Having a very confident member of the

pair on the keyboard often did not work well as it sometimes allowed them to race ahead without the understanding of their partner. Had the groups been larger there is a possibility that children would have felt less threatened by a single dominant or more able child. With two children the computer is exclusively the focus of attention when they are on task and the child manipulating it generally has the most power. However in a larger group where a majority of the group is not touching the machine, there is inevitably a shift of attention away from it and the role of those not actually typing is given greater status. In this way the contribution of each member of the group is validated. (W1 : 67)

This may also apply to a group of three, if a second member of the group is largely concerned with recording commands or reading instructions (see section 2.2); but this only happened under certain conditions. Groups of four always had enough 'spare' people to engage in discussion about tactics and strategy. This was recognised by a large number of children, who contributed comments to the effect that you needed a larger group in order to have more ideas.

"I liked being in a group of five. You can discuss and debate more. The group I was in worked well together. I find it more interesting in a large group." (R1 : 5)

Finally, the optimum size of group also depends on the nature of software being used (Crook, 1987) and the nature of the task. To use a distinction first made by McLuhan, smaller groups are more appropriate for tasks involving **hot** interaction with the computer and larger groups for tasks involving **cool** interaction where a lot of discussion is needed between moves. Two pupils from Rocks Park noted this:

"I think it was best to do this in a group of four, but other things it is best to do it in smaller groups (things with more typing and things that have a lot of answers and you want to do your own ideas without arguing)." (Railway Drama dbase Feb) (R1 : 12)

"Three or two are good for LOGO and Tray, where typing is important but you need four or more for The Railway Drama". (R1 : 15)

This last comment probably referred more to the early stages when children were working in direct drive and needed keyboard practice to become competent in using the basic commands, than to more complex programming tasks for which most children appreciated the idea-generating capacity of larger groups. As another child in the same class commented:

"four for LOGO, because you need more ideas."

This distinction, based on task rather than software, was also recognised at St Nicolas where the teacher used pairs for database compilation but threes for the subsequent interrogation.

Another interesting example occurred at Rocks Park, where the researcher reported a rapid change of group size in response to early experience.

> The size of groups originally doing Fletcher's Castle were too big. In fours there were children who found the exercise frustrating and demotivating. When they were put into pairs the immediacy of the software experience was restored and motivation levels were uniformly high. (R4 : 21)

PERSONALITY FACTORS

The project did not attempt to give the term 'personality' a precise meaning. It was not set up to do that kind of research. Instead we adopted the rather loose cluster of meanings which pervade teacher discourse about children. This suited our philosophy because the very vagueness of this common usage serves an important function. It allows teachers to express and assert the individuality of each child in their own way. Rather than encourage stereotyping, it provides an antidote to it. Words like domineering, shy, confident, outgoing, disturbed, kind, considerate, assertive, etc. were used to support discussion and reflection about children's behaviour; and hence to help teachers think through how best to provide for and respond to individual children in their class.

What we shall loosely refer to as personality factors affected groupwork policies in two ways.

(1) When composing groups, pupils thought liable to pose difficulties were given special consideration, either by being the first to be put into groups or by being checked out in a draft grouping plan.

(2) When monitoring groups, participation and collaboration, or the lack of them, were frequently attributed to personality factors. This could refer not only to individuals but also to the unique "chemistry" or "blend" of each group. Such observations and reflections would then inform future grouping policy or, if persistent problems were noted, cause teachers to intervene. In extreme cases this could lead to the teacher changing the composition of the group.

Teachers views about children were normally based on their behaviour off the computer, both during classwork and during the many breaks and transitions which occur throughout the school day. While for most children behaviour at the computer resembled that at other times, these were some for whom the introduction of a computer significally affected their normal pattern of behaviour. For example, one boy described as normally "very gentle and charming" appeared to be transformed when at the computer:

> Michael went his own way, barely responding to others, obsessed with trying out his own ideas. Despite his own realisation that he must let others have a fair go, Michael did not manage to achieve this. Sandie's comment that he would often walk away from the group when his aims had been met, confirms this impression. (W2 : 86)

Another dominant boy was "contained" by being isolated for a few weeks, then later being allowed back into a group, a fairly effective strategy in the prevailing ethos of that particular classroom. But could the teacher afford to do the same with Michael, given the shortage of computers and the possibility of it being seen as a reward?

For several other pupils, however, the opportunity to engage in a small cohesive group or to have their skill recognised by peers had a positive effect on their self-esteem. One teacher made deliberate use of this:

> Darren was an average student who had become very uncomfortable and unhappy in himself. He was finding it difficult to get on with other children and to motivate himself towards his work. The class wanted to use a database, for a topic on houses, and Sue needed somebody to manage the information and pass on the knowledge on how to use the database to the rest of the class. Darren was briefed on his role. He worked with all the children showing them how to enter and recall their information. Sue noticed quite significant changes in Darren's character and was in no doubt that his high status peer-group tutoring role had contributed to raising his self-esteem. "It worked - he blossomed again." (G : 7-8)

Another teacher who developed peer-tutoring as a comprehensive strategy found that its effectiveness depended on both the competence and the personality of the tutor.

> The effective tutors had certain personal qualities in addition to a modicum of intelligence, which fitted them for their role. All were outgoing, articulate, self-confident and, as we have seen, worked with a vivid internalised teacher ever present and quotable. Susie and Anne were outstanding in this respect: it is perhaps significant that each of them reported working with eleven other people — far more than anyone else in the class. (C : 26)

The tutoring role sometimes developed within mixed ability groups without any teacher briefing or intervention. Its success depended on the tutor's willingness and ability both to listen and explain and to recognise the worth of other contributions. If this was lacking, withdrawal or dominance might result. Many observations were recorded of more able children showing or telling others things which enabled them to progress the task but not explaining them so that others could learn as well, thus perpetuating their dependency and lack of competence. Webb (1983, 1989) presents evidence that this has a negative effect on achievement.

Shy children of 'above average ability' usually thrived in the relatively small groups used for computer work, because they felt both more able to contribute and more valued when they did. Those of 'average or below average ability' were seen to benefit from pairs or trios which gave mutual support, achieved successful outcomes and excluded more dominant peers. But in some classes it was not easy for the teacher to provide support for all the shy children and contain all the dominant children. Attention had to be given not only to selecting appropriate groups for computer work but also to establishing a cooperative ethos for the class as a whole and explicitly developing pupils' capacity to engage in collaborative groupwork.

Yet further problems arose in finding constructive approaches to handling a variety of special needs. While some of these relate to ability, others were linked to personality factors. Most classes had children who were prone to withdraw from their group or to engage in disruptive, emotional behaviour that threatened its effectiveness, if not also its survival.

> The explosive nature of Diana's character made whole group identity for all members a very difficult proposition. The resultant difficulties Diana introduced into the group effectively alienated Lindsey from the work despite her credibility with the others, because Lindsey's relationship with the others was just not strong enough to stand the strain. (W2 : 68)

Sometimes these problems were attributed to immaturity, sometimes to home problems, sometimes to low ability. Often the causes were multiple.

> Alex's relationship with the group remained at the surface level of visiting for the duration of the task. He did not achieve a deeper level of mastery. This was often due to the emotional upsets of home but also to his being unable to relate for a significant time to another member of the group. He often wandered off, returning when he felt ready. Work with his twin lacked cognitive skills and engagement with the task, often ending in negative physical contact. (W2 : 30)

> Jason started the year as a member of this group. Within a short space of time he felt that the atmosphere within the group was stifling and dissociated himself during tasks both at the computer and away from it. The relationship was left for a trial period to see if the situation would resolve itself but Jason showed increasing signs of stress, i.e. reluctance to physically join the group for any activity, including absenting himself from the room when selected to go to the computer. When encouraged to sit in front of the keyboard he remained unengaged, leaving the group at the earliest possible moment. Some encounters involved arguments and

rejection of overtures made by other members of the group. One final session resulted in emotional breakdown which demanded intervention. (W2 : 29)

All these examples present problems which would tax any teacher's imagination and resourcefulness.

TEACHER APPROACHES TO GROUP COMPOSITION

Leaving children to choose their own groups is a popular policy with teachers but carries certain specific disadvantages. First, it results in single gender groups; and in this the context we should note that in all upper primary classrooms where mixed gender groupwork was carefully introduced and supported, a large majority of pupils expressed a preference for it by the end of the year. Second, it often leads to a leftover group of social isolates; and nearly all such groups were unsuccessful. Third, it sometimes leads to a sink group of less able pupils, which lacks the intellectual resources to make much progress on the computer based tasks being tackled by the rest of the class. The particular problems of pupils with special needs are further discussed below.

Most teachers' thinking about group composition was centred around four factors: gender, friendship, ability and personality. A particular problem in introducing mixed gender groups was the reluctance of pupils to become the only boy or girl in a group. Two strategies for overcoming this were (1) combining single gender friendship pairs into mixed gender fours, and (2) dividing the class into mixed groups of seven or eight, from which smaller groups could be chosen in a variety of combinations. This latter strategy worked particularly well with a teacher who consistently stressed equal opportunities, and also proved to be an excellent way of supporting children with special needs within a medium-sized group. Overall, our evidence clearly indicated that equal opportunities objectives are achievable in computer-based work in primary classrooms: equality of access, equality of participation, equality of esteem, equality of performance.

Teachers who used a sociogram were able to assign nearly all pupils to groups with which they were not dissatisfied, as were teachers who had constructed a mental sociogram on the basis of informal observation. Both our own work and that of our London colleagues indicates that children do not have to be friends to work well together, but they must not be enemies. Many teachers were able to use groupwork for the positive encouragement of friendship, both across the gender divide and as solace for isolates and emotionally disturbed children.

We have already discussed ability and personality factors, so we can now briefly address the issue of how teachers can convert all these different grouping factors into a single set of decisions. Empirically, we found that most teachers, when composing groups, were concerned with:

- the optimum size of the group
- getting groups that will work effectively together
- accommodating individual children whose participation was anticipated as possibly causing a problem

Some teachers, however went beyond the three issues listed above to express concerns about:

- social goals of cohesion and mixed ability and cross gender cooperation
- the implications of leftover groups, when pupils were asked to choose their own groups
- the sharing of relevant expertise amongst the groups

Our research, however, can offer only general guidance on such grouping decisions. The teacher still has to know the individual children and to find a solution to a unique set of multiple problems, such as:

- Who can I put with X to counteract her dominance?
- Who will stop P and Q from antagonising each other?
- Who will encourage M to participate more?
- Who will be able to look after T and explain things to him?
- Who will stop G from getting too upset and leaving the group?

Imaginative responses to these questions could make a significant difference to the way groups worked together and the extent to which individual members progress. But, although our case studies provide much testimony that is relevant to this almost impossible task, they also demonstrate very convincingly the limits to generalisation.

EMERGING POLICY ISSUES

British primary teachers are not well informed about collaborative groupwork either in theory or in practice. Their knowledge about groupwork with computers is limited to what they have acquired from a few random observations in their own classrooms. We noted that although cooperation was overtly espoused by teachers, their implementation of this aim tended to take the form of reprimanding argumentative or antisocial behaviour rather than praising positive examples or developing groupwork skills. However, formal groupwork training took place in two schools. At Wallands, an introductory programme centred on the class playing the Cooperative Square game, discussing it, taking it to an infants class, observing them and then discussing it again. A Spaceship Crew exercise was used halfway through the year. Both exercises were reinforced by the teacher's consistent expectation and promotion of collaborative behaviour. At Rocks Park, a member of the University team was invited to advise on groupwork training for a Year 6 class with an unusual amount of antisocial behaviour. This then led to a formal experiment in Year 5 using two parallel classes. This showed that Kutnick's (1988) social skills training was significantly more effective than a control (physical education) in increasing learning skills and cooperative skills, improving the group outcome on a computer-based task and decreasing the time taken to achieve it. (Kutnick and Marshall, 1993)

Much evidence was gathered during the main case studies concerning the importance of appropriate and timely interventions, both to promote group awareness and mutual responsibility and to challenge the group to tackle problems at a more strategic and demanding level. However, the frequency of such interventions remained very low in most classrooms, the teacher's role being largely that of work planner and trouble-shooter. Size of class is an important factor but so also is the teacher's knowledge base. We hope, therefore that our project will provide some impetus towards dealing with the latter. Our analysis and examples should provide a useful foundation for learning from experience in the classroom.

We are acutely conscious, however, of the lack of guidance reaching teachers about how children learn in particular software environments. Our searches have revealed few detailed and systematic studies of how whole classes of children develop their capabilities with LOGO and databases in ordinary classroom settings, and the nature of their problems and misunderstandings. This problem was noted by Hawkins and Sheingold (1986). It has been illuminated but not resolved by Mayer's excellent compendium (1988) and a recent thesis by Smith (1994). Accounts in general books about information technology in education have tended to imply a greater level of proficiency that we have observed in average or below average pupils, which we have attributed to either selective reporting or much greater time on task. Careful reading of Hoyles and Sutherland's (1988) very detailed account of LOGO work with lower secondary pupils, for example, revealed that the pupils observed had had over 40 hours work with LOGO before the research even began. Not one of the pupils we observed had that amount of time on a computer during a whole school year!

Two of our policy-related conclusions may not apply in the US where access to computers is generally greater; but they are sufficiently important to be worth reporting. One of the aims of using information technology in British schools is to learn subject matter in more challenging ways. But this requires integration into the curriculum of computer-based work. Teachers can design excellent learning sequences involving work on and off the computer only to find that very few pupils can follow the planned sequence. Limited access to computers, typically one per classroom, makes it impossible to guide a whole class through a computer-based task in a manner that synchronises with other classwork. We also found that with complex software like LOGO the time between periods of computer-based work was too long to retain any reasonable sense of continuity, especially for less able pupils. Our research was not designed to investigate this issue systematically, but it does suggest thinking very carefully about hardware allocation. We would hypothesise that having three computers in a class for one term might be more effective than one computer for three terms.

Another finding, already hinted at above, is the need to have long term school policies on the use of complex software like LOGO. It takes some children a very long time to reach a stage of proficiency when they can use LOGO in some of the more creative ways advocated in the literature. This may be a very worthwhile investment for those pupils, provided they continue to have opportunities to use the software and reap the dividends. Given the rates of progression we observed this would require continuity of software use for relevant, worthwhile tasks over at least 2-3 school years. A similar point is made by Valcke (1989).

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