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CROSS-AGE PEER TUTORING IN SCIENCE

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Cross-age peer tutoring in science

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Several 'learning by tutoring' projects were set up in an inner city comprehensive school in the North East of England. Year 9 or 10 pupils tutored Year 7 pupils in the topics of energy transfer and plant nutrition. Groups containing well-motivated tutors who formed good relationships with their tutees and developed high grade tutoring skills, scored better than control groups on end of topic tests.

INTRODUCTION

In science lessons, it has long been the custom for pupils to work in pairs or in small groups. In these situations, one pupil will often take the lead and tutor the others. The roles of tutor and tutee may of course be seen to be reversed on another occasion. This system has been formalized recently by Bland and Harrison in the Midlands [1, 2]. Fourteen-year-old mixed-ability chemistry classes worked on chemical formulae, equations and reactions of acids in a peer-tutoring mode where pairings had been arranged to give a significant difference in ability between the two partners. Although this way of working was maintained for just a few lessons, the teachers concerned enumerated many benefits [1]. Key observations were the greater proportion of time spent 'on task' and the 'blossoming of some reluctant pupils' [2].

The idea of cooperative (as opposed to competitive or individualistic) learning patterns promoting affective outcomes is not new. Furthermore, there are many examples of projects designed to foster cooperative learning [3]. Few reports are available on projects in science. Okebukola [4], however, analysed 33 science lessons with 1,500 eleven- and twelve-year-old pupils. His analyses suggested that cooperative learning encouraged attitudes such as objectivity, open mindedness, and respect for evidence, as well as a more favourable attitude to science.

Perhaps one of the greatest spurs to the wider use of peer-tutoring is an American analysis of no less than 65 school tutoring programmes [5]. Here the overall conclusion was that tutoring improved the academic performance not only of the tutee but also of the tutor. Unlike the previously mentioned science studies, half of these programmes involved *cross-age* tutoring. Almost all the programmes focussed on reading skills or mathematics. The overall impression from the literature is that peer tutoring, whether same- or cross-age, has been successful in improving competence in basic skills. The challenge in this project, was to see if the same success could be achieved with complex scientific concepts on a cross-age basis.

Science has been tutored in a large-scale, cross-age project involving undergraduates and secondary school children (see: *The Pimlico Connection* [6]). However, unlike *The Pimlico Connection*- which might be described as a 'tutorial service' project - our work was predicated upon the assumption that the tutors' own learning in science would be enhanced as a result of their involvement in the project, together with that of their tutees. In contrast to the undergraduates, the tutors involved in our project were 'new' to the subject matter that they were tutoring. Hence the use of the term 'learning by tutoring'. It should also be underlined that we were not solely interested in the impact of the project on tutors' and tutees' performance in science. We also hoped to see - in both parties - improvements in communication skills, social skills and attitudes to school [7]. This article, however, will concentrate on learning outcomes.

THE INTERVENTIONS

All the interventions described below took place between March and July 1990 in a multi-ethnic comprehensive school, with a roll of about 1400 pupils. (Phil Sanderson was based in the school as a teacher-researcher.) Table 1 summarizes some aspects of the five interventions. The difficulties involved in scheduling tutoring sessions in suitable laboratories cannot be exaggerated and confirmed a survey finding by Fitz-Gibbon [8] that scheduling is one of the major problems confronting efforts to implement cross-age tutoring projects. Access was granted to classes in Years 7, 9 and 10. Although every effort was made to ensure that any peer tutoring took place at the same time as the pupils' normal science lessons, this was not always possible. Thus, it was necessary to negotiate the release of some Year 10 pupils from their weekly, two-hour 'leisure' session, and the withdrawal of some Year 7 pupils from subjects other than science.

The difficulties were even more severe than usual because this was a research project and every effort was made to establish control groups so that the effectiveness of the interventions could be evaluated quantitatively. Not surprisingly, it was necessary to overcome various practical problems when scheduling the peer tutoring sessions and negotiating the release of Year 7 pupils. Year 9 pupils selected for the project acted as tutors for all three of their 1 hour science lessons each week. Whatever the total number of hours spent in an intervention, the remainder of the pupils in the tutors' class (the control group) spent that same amount of time on the topic and worked through the same lessons.

In contrast, the tutors selected for Intervention IV from Year 10, worked on the peer-tutoring programme outside their normal science lessons - during their two-hour timetabled 'leisure' session each week. Despite their initial interest, several pupils dropped out of the programme and returned to the leisure session. With the benefit of hindsight, we recognize that it

Table 1 The interventions

Intervention number	Tutor's year group	Total length (hours)	Topic	Dates (1990)
I	9	17	Plant Nutrition	March-June
II	9	12	Energy	May-June
III	9	7	Plant Nutrition	June-July
IV	10	12	Plant Nutrition	March-June
V	9	10	Energy	June-July

was not really a good idea to put peer tutoring into competition with such an attractive alternative!

Ethical considerations

In planning the interventions, the research team gave particular attention to a number of ethical issues, including those related to access, timetabling and scheduling. The purposes and scope of the project, together with the perceived benefits, were outlined in a letter to the parents (or legal guardians) of both the tutors and tutees. In addition, parents were invited to approach the research team for further information about the project and its likely consequences. Similar information was made available to the pupils themselves at the beginning of each intervention.

Materials

The topics selected for the project were drawn from the school's Year 9 science syllabus. This helped to ensure that tutors on the project covered the same ground in the subject as their classmates. The school was trialling *Salters' Science Units* (Science Education Group, University of York). The classes studying *Child's Play* and *Green Machine* in the Salters' scheme were chosen for peer tutoring as these units corresponded to the topics of *Energy Transfer* and *Plant Nutrition* respectively, both of which have been researched extensively by CLISP (*Children's Learning in Science Project*, University of Leeds). The *Energy* topic was designed to run for a maximum of 13 lessons and the *Plant Nutrition*, a maximum of 19. Thus, these peer-tutoring interventions differed substantially from most others, both in terms of their duration and, as we have already indicated, in terms of the complexity of their subject matter.

The first task was to create additional materials to assist the tutors with their teaching of the two topics. In each case, a set of tutor notes was prepared. These comprised: an outline of the structure of the lesson - the 'Tutor Lifeline' - and additional material, providing suggestions on presentation and timing. These notes were made available to the tutors in advance and each session. In addition to the sets of tutors' notes, video back-up material was used at the beginning of each tutoring session, before tutees were sent for. The video clip aimed to help tutors clarify their own understanding of the topic and to identify and discuss potential difficulties prior to meeting their tutees. These preparatory meetings with the tutors lasted between 10 and 20 minutes.

Selection of pupils

There were six tutor-tutee pairs in Interventions I, II, III and V, and eight pairs in Intervention IV. (Space restricted in the laboratory allocated to the project effectively prevented any increase in these numbers.) As the average Year 9 science class size was 18, the withdrawal of 6 pupils thus left the class teacher with about 12 pupils to teach, the same number as the *total* that normally worked with the teacher-researcher in the peer-tutoring laboratory. Except for the short introductory training session at the beginning of each tutoring lesson, the amount of available teacher time per pupil was about the same in both the experimental and control groups.

The following procedure was adopted when selecting both tutors and tutees: first, the pupils in each of the classes involved in the research were ranked on the basis of their science achievement levels (as determined by teacher-devised tests). Each class was then stratified into six achievement groupings; random numbers or dice were then used to create an experimental and control group from each. Tutors and tutees were matched on the basis of these rankings in order to avoid a low achieving tutor having a high achieving tutee, a situation which could undermine the tutoring role. (The only pupils excluded from the selection process were habitual absentees, or those perceived by the school staff as having major difficulties with reading.)

Practical problems

In addition to the practical problems which arose as a result of pupils arriving late for lessons (the school operated on a split site making this an endemic problem), other similar difficulties had to be surmounted. For example, it was usual for one tutor to be missing (through absence from school) in any given session. As well as presenting the absent pupil with subsequent problems relating to continuity, another tutor had to be persuaded to work with two tutees for that lesson. Fortunately, each group always contained at least one tutor who was willing to take on this task. In Interventions I and V, it was necessary to 'dissolve' two pairings: in one case, the tutor was persistently absent; in the other, the tutee took a long holiday within a week of embarking on the project.

Training tutors

The tutors were given a number of training sessions which aimed to enhance both their pedagogical and interpersonal skills. A one-hour initial session was provided before any contact had been established with their tutees; subsequent 'review' sessions were timetabled at regular intervals (every fifth lesson or thereabouts), once the peer tutoring was underway.

In the initial training session, the aims of the project were outlined and discussed. The tutors were then invited to identify any learning difficulties which they themselves had experienced in their own educational careers. To facilitate this activity, the pupils were asked to work in pairs and interview one another about their respective experiences. During the follow-up discussion, the group were then asked to consider how peer tutoring might help to overcome such learning difficulties. The 'Tutor Notes' were then introduced and their function explained. At the end of this initial training session, the tutors were introduced to their tutees.

Invariably, the 'review' sessions began with a brainstorming activity which was followed by a role-play exercise. In this, two pupils were invited to play the part of a tutor and his(or her) 'difficult' tutee. Other pupils (and, if pressed, the teacher-researcher), then took it in turns to try to find ways of managing the 'difficult' tutee more effectively. These sessions appeared to the teacher researcher to be successful in improving tutoring technique. He reported that the role plays were usually 'voted hugely enjoyable'.

Assessment

At the end of each intervention, all the tutors and tutees were set the same (teacher-devised) test as the members of the appropriate Year 9 science class. The tests were, for the most part, made up of *Salters' Science* items, although 30 per cent of the *Plant Nutrition* test comprised items based on the CLISP project.

Before the tutors sat the test, the teacher-researcher attempted to rate (on a 10 point scale) their teaching skills and the quality of the relationship that they had formed with their tutees. In both cases these

Table 2 Mean test scores for tutors and their controls (Standard errors are shown in brackets)

Intervention number	Pre-test		Post-test		Retention	
	Tutor	Control	Tutor	Control	Tutor	Control
I	54.9 (6.2)	52.6 (5.9)	63.6 (7.2)	58.0 (1.8)	51.2 (6.3)	46.0 (5.7)
II	56.8 (3.3)	49.7 (4.4)	62.3 (6.2)	52.3 (7.8)	61.0 (7.2)	52.7 (4.4)
III	49.0 (5.8)	47.3 (6.1)	49.0 (5.5)	50.0 (7.0)	45.3 (5.5)	57.2 (3.9)
V	70.7 (4.4)	67.5 (2.2)	55.5 (8.2)	58.5 (4.1)	56.4 (5.1)	55.6 (4.2)

Table 3 Effect sizes and other tutor data

Intervention number	Effect size		Number of lessons	
	Post test	Retention test	Total	Average missed per tutor
I	+0.47	+0.39	17	2.4
II	+0.58	+0.57	12	2.2
III	−0.07	−1.07	7	1.0
V	−0.23	+0.08	10	1.0

judgements were formed on the basis of unstructured classroom observations during the tutoring sessions. However, some account was also taken of comments made by both tutors and tutees on the questionnaires administered at the beginning, middle and end of each intervention.

RESULTS

Tutors

Table 2 shows the mean scores for the tutors and their controls for all the interventions except IV (where no control group was available).

Effect Sizes were computed for each intervention in which there was a control group. The *Effect Size* is a measure of the extent to which the experimental group's scores tended to exceed the scores of the control group. It is defined in this case as [9]:

$$\frac{[\text{Mean of tutor group}] - [\text{Mean of control group}]}{[\text{Pooled standard deviation}]}$$

The *Effect Sizes* are shown in Table 3 both for the immediate *post-tests* and for the retention tests given between 14 and 19 weeks after the intervention had finished. Interventions I and II showed *Effect Sizes* consistent with those reported in meta-analyses [5].

In view of the small number of pupils involved, it came as no surprise to find no pair of means proved to have a difference significant at the usually accepted level of p = 0.05. *Effect Sizes* for the *post-test* and *retention test* are displayed graphically with their 68 per cent of confidence limits in Figures 1 and 2.

According to Cohen [10], *Effect Sizes* of 0.2 should be considered small, 0.5 medium and 0.8, large. Thus, we have Interventions I and II giving medium effects and Interventions III and V giving zero or negative effects. The consistently large standard errors however, should not be forgotten when we are making deductions.

Clearly, Interventions I and II were much the more successful in producing enhanced tutor achievement. How can this have arisen? The same matching procedures were used in each intervention when selecting tutors and tutees. In addition, the teaching materials used were

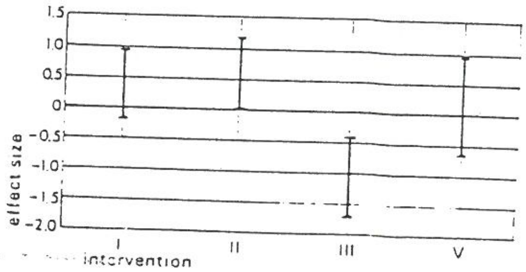

Figure 1 Effect sizes - retention test
(Bars indicate 68% confidence limits)

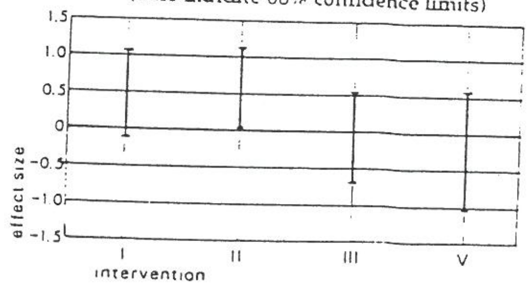

Figure 2 Effect sizes - post test
(Bars indicate 68% confidence limits)

comparable. Furthermore, the relationship between the research outcomes and the topics chosen for the interventions was not clear-cut: for example, one of the interventions dealing with *Plant Nutrition* was apparently successful, while the other was not (I and III); the same was true of the two interventions which focussed on *Energy* (II and IV). To try and answer the question, we listed some quantifiable factors alongside the interventions but there is no obvious dependence of *Effect Size* on total number of lessons tutored. In more than one case, it was noted that certain tutors who had been absent on several occasions had not gone on to register low test scores. The tutoring situation allowed pupils who had been absent to catch up, both by leaving the teacher-researcher relatively free to give extra help while tutoring was in progress and by the extensive use of resource materials. However, once the average number of lessons missed by tutors in each intervention had been calculated, it was seen that the *proportion* of lessons missed was approximately the same for all interventions. Thus, the problem of absenteeism among the tutors did not appear to account for the disparity in *Effect Size* values. It may not be possible to determine for sure the reason why the first two interventions were more successful than the others. To the teacher-researcher it seemed to depend upon the particular attitudes of the pupils involved.

Tutees

Statistical treatment of tutee test data was necessarily different as, although *pre-test* results had been used to ensure that each tutee had an equivalent pupil remaining in the normal class as a control, that class did not work on the same topic as the tutee. Thus, as far as assessing achievement in science is concerned, there was no control group.

The aim here was to find out how effective tutors had been in their tutoring and, if possible, answer the question: 'What makes an effective tutor?' The procedure adopted for each intervention is illustrated here using the data from Intervention II. First the *post-test* result for each tutee was plotted against their *pre-test* result, the regression equation calculated and the regression line drawn (Figure 3).

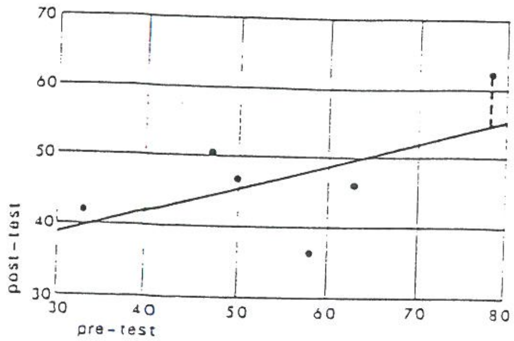

Figure 3 Regression analysis for *post-test* data on *pre-test* data for the tutees in intervention II
(The regression line is given by: Post = 0.35 Pre +28.5. The dashed line shows the residual score (+5.9) for the highest scoring tutee)

The residual score for each tutee was then computed. This is equivalent to the difference between the *obtained* score and the *predicted* score. For the highest scoring tutee in this particular intervention, it is shown by the dashed line in Figure 3 and it was *equal* to +5.9: that is, this tutee's *post-test* score of 62% was almost 6% *greater* than that based on the general pattern of results as denoted by the regression analysis.

DISCUSSION

What then makes good tutors? Do they have to be higher attainers? The link between tutor effectiveness and their general levels of academic achievement would appear to be at best tenuous. In the four main interventions in this study, the most skilful tutors were ranked, out of six pupils, first, third, fourth and fifth respectively in their groups on the *pre-test*. High achievement, it seemed, was a less important factor than an outgoing personality and a willingness to put into practice the teaching skills taught. A positive attitude to the project certainly helped. While some potentially difficult pupils responded favourably to the project, there were also disaffected pupils who remained disaffected.

Unstructured observations undertaken by the teacher-researcher helped to identify the more effective tutors. For example in Intervention II, Lesley, the tutor with the maximum teaching skill score of ten came across initially as a sullen individual, who, by her own admission, was often a disruptive influence in the classroom. However, she quickly showed herself to be a capable tutor who could always be relied upon to engage actively with her tutee throughout the session. In contrast, Sajid the least skilled tutor in the group never really got to grips with what was required. He repeatedly came to the teacher-researcher for advice and, frequently, he would be found to 'off task': that is, chatting to his tutee about things which had nothing to do with the lesson. And when 'on task', his exchanges with his tutee were generally restricted to comments such as: 'Do this' or 'Answer that'. It is possible that he felt ill at ease with Tim, his tutee, who was very big for his age and had a reputation as a bully. (In one of their early meetings, Tim was overheard making an apparently racist remark. Giggling in an unrestrained manner, he had taunted his tutor by asking: 'Is your name *really* Sajid?) Lesley, on the other hand, tutored Tasleem, a somewhat diffident girl; Martin's tutee Asma was also a little reticent. Yet Asma's residual score was almost as negative as Tasleem's was positive. Martin, while having a lot more confidence than Sajid, made no real effort to explain things to Asma; he gave instructions rather than assistance.

Like so many tutors and tutees involved in the project, the pupils referred to directly above expressed reservations about working with members of the opposite sex; we had deliberately chosen to make no allowance for this factor when creating pairings. Our decision was promoted by principle: gender apartheid should not be encouraged. Having said this, it appeared that a greater proportion of same-sex pairings were successful than the cross-sex ones.

CONCLUSIONS

Given that this was a controlled experiment to test the effectiveness of peer-tutoring in science (rather than a project designed to maximize success by a contrived choice of pupils and pairings), it can be judged a qualified success: three out of four tutor groups usually scored at least as well as their control groups, and where there were well-motivated tutors, definite gains were seen, in terms of both tutor and tutee achievement in science.

Arguably, our biggest stumbling block by far was the school timetable; the removal of pupils - both tutors and tutees - from lessons in areas of the curriculum other than science presented numerous practical difficulties. To enable cross-age peer tutoring in science to take place, the following minimal conditions have to be met: the school needs to have a timetable sufficiently flexible to allow the simultaneous scheduling of tutor's and tutee's science classes; and a science curriculum which allows for two year groups to choose to study a common topic.

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Videos and other teaching materials relating to the project can be obtained (at a small charge) from: The Curriculum Evaluation and Management Centre, School of Education, St Thomas Street, University of Newcastle-upon-Tyne NE1 7RU.

REFERENCES

1 Bland, M and G Harris, 'Peer tutoring as part of collaborative teaching in chemistry', *Support for Learning*, 1988, 3, 215-18.
2 Bland, M and G Harris, 'Peer tutoring', *SSR*, 1989, 71(255), 142-4.
3 Slavin, RE (ed), *Learning to Cooperate*: Cooperating to Learn, (New York, Plenum Press, 1985).

4 Okebukola, PA, 'Effect of student-student interactions on affective outcomes in science instruction', *Res Sci Tech Educ*, 1985, 3, 5-17.

5 Cohen, PA, JA Kulik and CC Kulik, 'Educational outcomes of tutoring: a meta-analysis of findings', *Amer Educ Res J*, 1982, **19**, 237-48.

6 Goodlad, S and B Hirst, *Peer Tutoring: a Guide to Learning by Teaching*, (Kogan Page, 1989).

7 Foot, HC, MJ Morgan, and RH Shute, *Children Helping Children*, (Wiley, 1990).

8 Fitz-Gibbon, CT, *A Survey of Tutoring Projects*, (Los Angeles, Centre for the Study of Evaluation, Report H118, 1978).

9 Glass, GV, B McGraw and ML Smith, *Meta-analysis in Scoial Research*, (Beverley Hills, Sage, 1981).

See also: Fitz-Gibbon, CT and LL Morris, *How to Analyse Data*, (Newbury Park, Sage, 1987).

10 Cohen, J, *Statistical Power Analysis for the Behavioural Sciences*, (New York, Academic Press, 1977).

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