SCRE Spotlights
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Peer- and Parent-Assisted Learning in Maths, Science and ICT

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The focus here is on learning by school-age children, assisted by the family and/ or peers, and supported and managed by professional teachers. Keith Topping, who specialises in researching paired learning, provides an outline of the essential concepts of peer-assisted and parent-assisted learning, followed by discussion of specific practical evidence of its use in maths, science and ICT.

In previous centuries, traditional conceptions of teaching emphasised direct instruction – the transmission of information from the professional teacher to the learner. However, recent years have seen a vast increase in both the quantity and accessibility of information within and without schools. Irrespective of class size, social interaction between individual pupils and professional teachers will always be scarce. Consequently, the professional teacher increasingly works indirectly as a manager of effective learning – an arrangement which may be supported by peer- or parent-assisted learning.

▶ *PEER- AND PARENT-ASSISTED LEARNING*

Peer- and parent-assisted learning have some similarities, and a number of differences.

Peer-assisted Learning (PAL) can be defined as the acquisition of knowledge and skill through active helping and supporting among companions who are matched or equal in status. It involves people from similar social groupings, who are not professional teachers, helping each other to learn and learning themselves by so doing. The most common form of PAL, peer tutoring, is characterised by specific role-taking as tutor or tutee, a high focus on curriculum content and, usually, specific procedures for interaction, in which participants are trained. By contrast, in more general 'cooperative learning', typically the group participants are working in parallel toward some common goal, rather than primarily, specifically and consciously helping each other's learning.

It is clear that PAL is not a diluted and inferior substitute for direct professional teaching – it has quite different strengths and weaknesses, and to deploy it to maximum effect teachers need to be aware of these (Topping, 2001).

Some of the benefits of peer-assisted learning are shared by **parent-assisted learning**, especially one-to-one attention, increasing time on task and engagement with task – and extra practice. It is also individualised and interactive, with immediate support, modelling, monitoring and feedback. However, especially in the early years, most parents might be expected to be more 'expert' than their children (for example in reading), and the social and emotional tone and content of the parent-child relationship is very different from that of a peer relationship – praise and other forms of reinforcement might be even more salient and powerful in motivational terms. However, as children move up the school, parents are less likely to be 'expert' with more advanced educational content. This must be reflected in the way they are asked to encourage and prompt, rather than model.

In recent years, the notion of 'parental involvement in children's reading' has been replaced by the term 'family literacy', which implies greater emphasis on practices which enhance the literacy levels of the whole family now and in the future, for their own purposes, within their own context. This implies respecting the home culture and not merely seeking to export the school culture while at the same time carefully considering the cost/ benefit aspects of involvement as they might be perceived by potential participants. The social inclusion agenda has also gained ground (at least in the rhetoric), so there is now more emphasis on equal opportunities for involvement by all families in their own homes, rather than an elite selected group of parents acting as teacher helpers in school (Wolfendale & Topping, 1996).

Parents are now involved in mediating the learning of their children in a great many ways, in many curriculum areas, at various levels of complexity, before and during the years of schooling and beyond into lifelong learning – and the benefits can be mutual and reciprocal for both members of the pair.[2]

What then are the implications for peer-assisted and parent-assisted work in different curriculum areas? This Spotlight (83) focuses on the areas of maths, science and ICT; the companion Spotlight (82) focuses on reading, writing, spelling and thinking skills.

▶ *MATHEMATICS*

Even in middle class areas, many parents see themselves as poor at mathematics. Thus, disliking maths can all too readily be construed as 'normal'. Gender stereotypes can also be transmitted within the home (as well as at school), possibly leading girls to abandon interest in maths even though they are no less capable. Consequently, 'parental involvement in maths' schemes which merely 'ship home the school curriculum' have been criticised as naively ignoring the affective and historical dimensions of parents' own reality. Mathematics is now understood to be a contextually and socially defined activity. 'School' mathematics can all too easily consist only of applications and purposes, methodologies and solutions which are socially approved within the context of the classroom. The result of the discontinuity between the classroom and 'real life' can be that the child's conception of what mathematics is narrows.

Because many mathematics learners lack self-confidence and are insecure in their understanding, they tend to rely on habit-learning, rather than developing generalisable concepts or models. Children are often too concerned with giving the right answers to a limited class of questions – 'tricks for ticks' – with very little encouragement to relate these to their concrete experience. More important is intelligent adaptability – being able to learn from encounters with the physical world, matching experience against expectation, communicating with and learning from others and comparing ideas with them, and being able to develop and build mathematical models which yield creative and testable predictions.

As with other curricular areas (eg science), information transfer and processing is heavily dependent upon language. Mathematics has much specialist vocabulary, including that applied to abstract and complex concepts, as well as using some 'everyday' vocabulary with more specific and restricted meanings. Concept formation is aided greatly by the ability to use accurately the related language, whilst the learning of new concepts is closely associated with the acquisition of new words which are meaningful. However, children might learn words without really understanding the associated concepts, while their understanding of some concepts might be underestimated because they do not use the 'official' terminology. 'Paired Maths' is designed to help deal with this. It involves the development of mathematical abilities through playing mathematical games.

Games have many advantages. The structured rules and materials of games provide strong support or scaffolding of the parent/child or peer tutor/tutee interaction, while avoiding any danger of a didactic 'top-down' ethos. Games also promote active involvement, are intrinsically motivating, exciting and challenging, are grounded in concrete meaningful experience and have a purpose in which the child is intimately engaged, promoting greater concentration and persistence as well as decision making and problem solving. Paired Maths games require children to think and do more mentally than they could possibly record on paper in the same time. They enable repetition for consolidation while avoiding tedium. Success or failure is self-evident, so they are self-correcting – no 'marking' is required. Games can be played at different levels and the element of chance enables children of all abilities to be included and all children to have an equal likelihood of success. The inherent enjoyment and success can foster positive attitudes to the self and to mathematics. Games also encourage turn-taking, cooperation, communication, and other interpersonal skills (Topping & Bamford, 1998a).

Many school mathematics schemes include some 'games' – but these are often brief, two-dimensional, insufficiently various and very tightly articulated to the taught curriculum, and are therefore unlikely to stimulate wide generalisation of skills. Paired Maths games are specially selected and collected to achieve the wider programme objectives outlined above. Specimen kits of Paired Maths games have been assembled at three different levels, for children aged 4 to 7, 7 to 11 and 11 to 13 years, with the expectation that older children would increasingly be likely to use these in peer-based projects in schools.

A number of small Parental Involvement in Maths projects in the UK have shown encouraging results, and three were controlled studies. In one study of 5-year-old reception pupils, all the parents for the new intake for that term were invited to take part, 12 of the 16 parents accepted. The children in the next term's intake, who were not offered any project involvement, were used as a comparison group. The Quest maths tests were used with all the experimental children pre- and post-project, and with the comparison children over the same eight week time interval. The project children showed a marked improvement, particularly in the areas of pattern, order and conservation. The children in the comparison group, although showing some improvement in their scores, gained significantly less than the project children, particularly in these same areas. Pre-project scores for project children were on average below those of the comparison children, but post project this situation was reversed.

A controlled evaluation of a same-age peer tutored Level 2 project was reported by Mallinson (see chapter 6 in Topping & Bamford, 1998b). The experimental group was a mixed ability class of 25 ten-year-old children. The comparison group was a parallel class of 20 children, who did not play the games but received normal mathematical instruction from their teacher. The children played the games only for two 30 minute sessions each week for 6 weeks. Pairs were organised so that there was one child who could read well in each pair. A criterion referenced test was devised which was appropriate for the age and ability range of the children. On the mathematics test, the

experimental group scores increased significantly while those of the comparison group did not. Boys improved much more than girls. At pre-test the comparison group had scored significantly higher than the experimental group, but by post-test the experimental group had caught them up. The experimental group had significantly higher self-esteem scores post-test than pre-test, while those of the comparison group were slightly lower.

However, many schools still wish to deploy peer and parent tutoring with mathematical activities more closely related to the school maths curriculum. Recently a framework of interactive tutoring behaviours which can be applied to any mathematical activity has been developed – akin to the way Paired Reading can be applied to any book. The approach, named Duolog Maths, emphasises: Tutor Listening, Reading, Questioning, Pausing for Think-Aloud, Making It Real, Checking, Praising & Encouraging, and Summarising & Generalising. In a recent controlled study of parents tutoring 17 pupils from 7 –12 years old using the Duolog method, scores on pre/post mathematics tests increased significantly for the experimental group but not for the controls, despite only a brief period of intervention (Topping, Kearney, McGee & Pugh, 2001).

▶ *SCIENCE*

Science involves planning, hypothesising and predicting, designing and carrying out investigations, interpreting results and findings, drawing inferences and communicating conclusions. Observation, identification, measuring, testing, questioning (how? why? what if?), description, collation, recording and analysis are all seen as key constituents. The emphasis in national curriculum guidelines is clearly on science as a transferable skill, not as a body of knowledge to be learnt by rote and regurgitated. Skills learning develops through hands-on experience – practice and application. Transferable skills learning necessitates practice and application with many different problems in many different contexts and settings. Actually delivering this learning experience is difficult, especially in the early years of the primary school.

Early years children involved in science investigations at home could and should relate scientific ideas and skills to their own real life situation in the company of mature and highly valued adults. They could have their own personal demonstrations of what to do if all else failed. They would have the opportunity to explore their nascent understanding through discussion, enjoying immediate feedback and possibly improving their general language development as well as their scientific vocabulary. Apart from the extra practice, generalisation and transferability would be developed, but even more importantly, this activity could serve to improve the child's motivation, confidence and self-image. Improved attitudes to science might have enduring effects later in the educational system and possibly even affect later higher education or career choices. This could prove particularly important for any groups more than usually at risk of especially poor self-image as a scientist. Additionally, parents who acted as science tutors might themselves reap attitudinal and self-confidence gains, as with other forms of 'learning by teaching'.

The Paired Science programme and materials (Topping, 1998, Topping & Bamford, 1998b) are designed for use with children (tutees) aged 5 to 8 years, helped at home by parents (or in school by older peer tutors, who might be up to 11 years old). The 45 Activity Sheets are divided into 7 different areas of science closely related to national curriculum programmes of study: Air, Magnets, Moving Things, Light, Heat, Myself and Water. The simplest of equipment is required, and each Activity Sheet starts with a list of What You Need.

In Paired Science, the pair are usually given a good deal of freedom in choice of activity. In an initial 7 week 'trial' period, pairs take any activity from a different area each week. If they wish to continue after the trial period, they then have free choice across areas. Each Activity Sheet tells the pair What To Do in simple, low readability terms. The helper is likely to read this to the child, then re-read it with discussion about meaning and implications. They can of course do Paired Reading if they wish! A further section of the Activity Sheet gives helpers a fail-safe brief scientific explanation – with the caution that this is not to be read to the child, but to be discussed with the child if he or she fails to work it out for themselves through the activity.

Throughout, the role of language is crucial, just as it is in the early stages of learning mathematics. To support the helper in this, each Activity Sheet has lots of questions, and the helpers are asked to raise these, then help the child to work out the answer for themselves. In addition, throughout the text of the Activity Sheet, some key words of scientific vocabulary are printed bold. Each Activity Sheet includes a final section encouraging some further elaborated response from the child.

Three studies of parent-tutored Paired Science are reported in Topping (1998). In one, all 26 children in a class of six-year-olds participated in a seven week project, and a feedback questionnaire was completed by every family. The results clearly indicated that the parents were extremely positive about their children's reaction to the Paired Science activities, almost all reporting seeing more interest in and enjoyment of science in their children. Almost as high a proportion of children appeared to show cognitive gains in understanding and communicating scientific ideas and applying scientific methods. In two thirds of cases the children seemed more confident about scientific matters and were generalising their curiosity to a wider range of issues beyond those in the pack.

In another study, the methodology was extended to 4-year-old children in a nursery school, and also yielded encouraging results. Many parents expressed surprise at the capabilities of their child and were pleased at the increased questioning. Some parents reported an impact

on reading, with children increasingly likely to seek out science books. The participating nursery children who had older siblings grandly called Paired Science 'homework' and thought it was very special. The coordinating teacher concluded: 'the science activities stimulate imagination and promote a feeling of awe and wonder, while allowing children to begin to control their own environment'.

▶ *ICT*

In more advantaged countries, Paired Reading is connecting with the development of electronic literacy. It can be used with material on the World Wide Web, or with a shared story loaded into an electronic book rather than on paper, for instance. More and more reading is being done on screen rather than on paper, and readers are increasingly handling the multi-dimensional hypertextual and hypermedia environments rather than traditional linear text. This leads to what might be termed 'family electronic literacy' – of especial importance given the need for the 'digitally dispossessed' to overcome the 'digital divide'.

Stemming from its reincarnation as Duolog Reading in the USA, Paired Reading is also linking to software for computerised self-assessment of reading comprehension of real books by children – an excellent additional form of motivation, monitoring and accountability for both members of a peer-tutoring pair (Vollands, Topping and Evans, 1999), and some parents have also participated. Studies using this software to gather data on child performance have demonstrated the importance of additional successful monitored reading practice in raising attainment (Topping & Paul, 1999), but have also indicated that the professional teacher's quality of implementation of the system, and their quality of response to the data generated by the learning information system software, are crucial (Topping & Sanders, 2000).

Another interesting study, in the planning stage, is the deployment of pupils as ICT tutors, not only to peers in school, but also to senior citizens and other interested adults in after-school study centres and community education facilities (many children are of course more competent with ICT than many adults). This will involve the development of a generic framework for the tutoring of ICT skills (perhaps akin to Duolog Maths), coupled with a developmental framework for curriculum content and skills to be mastered, and the devising of relevant, valid and reliable means for assessing progress.

▶ *CONCLUSION*

Structured forms of peer-assisted and parent-assisted learning have been applied to many core skills and areas of the curriculum with considerable effectiveness and relatively low cost in professional time and resources. These often also yield social, motivational, and self-esteem benefits for both the helpers and the helped. They offer an exciting and enhanced role for professional teachers. However, it is important that teachers have access to user-friendly, flexible, durable and evidence-based methods, and some of these have been outlined above.[1] If the positive results from research studies are to be replicated in everyday practice, teachers must plan carefully and implement the methods with maximum fidelity. There are still many productive avenues for further innovation and action research by practitioners and professional researchers in this area. An additional incentive is the considerable value of such methods in other countries where resources are much scarcer than in the UK.

The development of skill in communicating information obviously requires practice in a socially interactive context – but it is asserted here that social interaction can also be a powerful and differentiated learning context for information access, processing and self-management skills, when properly managed by professional teachers.

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Notes

1. A range of further resources, including practical materials, bibliographic information, and further details of the activities of the Centre for Paired Learning, are available online from: http://www.dundee.ac.uk/psychology/kjtopping/
2. A 'Parents in Education' website is under construction and will be available at: http://www.dundee.ac.uk/psychology/ParentsinEducation.

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