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Transforming education through evidence

Reciprocal Peer Tutoring in Irish Medium Schools

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Executive Summary

A study was undertaken to assess the impact of using reciprocal peer tutoring on mathematics attainment in 12 Irish Medium schools. Six schools undertook peer tutoring, and six schools acted as comparison and continued teaching as usual. Teachers implemented the peer tutoring technique during mathematics lessons, or used their usual teaching approaches, during a period of 16 weeks. Changes in attainment were measures with an Irish translation of the Scottish Survey of Achievement in Mathematics Test administered before and after the peer tutoring intervention. Classes that used peer tutoring improved their mathematics scores significantly more than the comparison group. The rate of maths development when using peer tutoring was nearly three times as fast as 'teaching as usual'. Results indicate that peer tutoring is an effective means of learning maths in Irish Medium schools.

The work was funded by a grant from CCEA.

Background

Theoretical Basis of Peer Tutoring

Piaget (1978) proposed that understanding developed in children through the processes of assimilation and accommodation, associated with the construction of internal schemas for understanding the world. Piagetian based peer tutoring can provide the right balance between the disequilibrium caused through cognitive challenge and social exchanges between peers for effective learning to take place (Palinscar, 1998). Piagetian tutoring involves cognitive challenge from peers and post-interactive reflection and restructuring. Both tutor and tutee have to fulfil their roles effectively. This creates a social interdependence between tutor and tutee. Their individual success is linked through common goals and mutual dependence on each other for gains in the tutoring process to accrue. Without both tutor and tutee performing their roles in accordance with prescribed patterns for interaction, neither can gain benefit from the interaction. Theories describing why social interdependence have been substantively developed and described by Social Interdependence Theory (Johnson, Johnson & Roseth, 2010; Johnson & Johnson 2012). For co-operative learning to be present during peer tutoring then social interdependence must be present in the form of:

- Goal structure (the pair work together with the aim of solving mathematics questions)
- Positive interdependence (in the tutoring process clear patterns for interaction are defined in the roles of tutor and tutee)
- Individual accountability (both the tutor and tutee have responsibilities, in the form of tutoring used each must reflect in their own performance and the performance of their peer partner)
- Interaction patterns (the tutoring process is structured to stimulate promotive interaction, group processing and enhance social skills)

Thurston and Topping (2006) developed a theoretical model of peer tutoring from De Lisi and Golbeck (1999). Students are set a problem. The tutor needs to examine the problem and think about what questions need to be asked during the interaction. The tutee needs to explain their thinking in solving a problem and answer questions posed by the tutor. Both of these processes require social interdependence (Johnson, Johnson & Roseth, 2010) and processing of prior knowledge using metacognitive strategy to link previous learning to the current problem. This also facilitates self-regulation should concomitantly result in enhanced metacognition as these two processes are interlinked (Eggen & Kauchak, 1997). This may facilitate assimilation of the learning and accommodation of new ideas. However, the accommodation does not imply long-term change at this point. Retaining the “correct” cognitive structure over time relies on the student gaining deeper understanding of the

new cognitive structures leading to equilibration as a result of post-interactive reflection.

Previous Studies and Research

Peer tutoring is a structured form of peer learning characterized by specific role taking as either tutor or tutee. It relies on constructivist approaches to learning and is based on the idea that knowledge acquisition occurs as a social activity (De Lisi & Golbeck, 1999). It is widely reported to have beneficial effects on learning (for example Ginsburgh-Block, Rohrbeck & Fantuzzo, 2006; Rohrbeck, Ginsburgh-Block, Fantuzzo & Miller, 2003; Topping, Kearney, McGee & Pugh, 2004). A meta-analytic review of peer learning reported large effect sizes for cognitive growth in mainstream elementary schools (Rohrbeck *et al*., 2003). One of the more recently established forms of peer tutoring is reciprocal role peer tutoring. This form of peer tutoring means that each member of a dyad alternates in a role as peer tutor and tutee and is usually done with same-ability and often same-age tutorial pairs. Reciprocal peer tutoring was originally designed for pairs of low-achieving, urban, elementary school students (Fantuzzo, King & Heller, 1992). It employs dyads of comparable ability with the objective of keeping both tutor and tutee actively engaged with the academic process. Students receive training before engaging in peer learning. Dyads set joint goals and time-limits for achieving these goals. Reciprocal role tutoring has the advantage that both/all students get to act both as tutors and tutees. This has been shown to result in increased attainment gains when compared to interventions where students acted in a fixed tutor/tutee role (Chapman, 1998). Significant gains in spatial ability were reported in a sample of 214 eleven to sixteen-year-old students in a three month reciprocal role peer learning intervention (Gyanani & Pahuja, 1995). Reciprocal peer tutoring in mathematics was reported to have a positive impact on mathematical ability and student self-reported levels of maths ability when compared to control groups in a randomised trial of 64, nine-year-old students (Fantuzzo, King & Heller, 1992). Significant gains in mathematics were reported for a sample of 175 six to ten-year-old children for socio-economically disadvantaged children compared to control children in a class wide peer tutoring initiative (Greenwood, Delquadri & Hall, 1989). Training for peer tutors is essential. Experienced tutors were reported to use tutoring behaviours that prompted explanations from tutees, rather than just giving explanations. Enhanced tutoring was possible because of deeper metacognitive awareness of the problem (Fuchs, Fuchs, Bentz, Phillips & Hamlett, 1994). Undertaking peer tutoring with strategic metacognition was reported to enhance outcomes in a sample of 158, nine-year-old students in science (Meloth & Deering, 1994). Similar findings were reported in a study involving 384, fourteen-year-old students in mathematics. Significant advantages were reported for students who undertook data handling activities

with peer learning and an emphasis on strategic metacognition as compared to a control group (Kramarski & Mevarech, 2003). Therefore, reciprocal peer tutoring, combined with strategic metacognitive questioning can provide a strong mechanism for cognitive development.

The current study was an extension of three previous studies. Two were undertaken in Scotland and supported by the Economic & Social Research Council. In one cross-age peer tutoring was used in a 129 school randomised trial in Fife Local Education Authority. Using PIPS mathematics tests (delivered independently by Durham University) then *Effect Sizes* of about 0.19 were reported for cross-age peer tutoring (Tymms, Merrell, Thurston *et al.,* 2011). The technique of peer tutoring was further developed in a study involving 20 schools in Stirlingshire, Falkirk and Dundee. In this study the tutoring method used in Fife was fine-tuned and adapted to a reciprocal role peer tutoring method. Using the Scottish Survey of Achievement in Mathematics Test the study reported greater *Effect Sizes* than had been observed in Fife of +0.46 (Thurston, Burns & Topping, 2011; 2012). The third study was a pilot to this work. It used the same peer tutoring technique in Irish Medium schools and developed Irish versions of curriculum and teaching materials. The study reported *Effect Sizes* approaching +1.0, but had no comparison group to determine whether using peer tutoring enhanced learning compared to teaching as usual (Thurston & Keenan, 2014).

Aims and Objective

The provenance of reciprocal role peer tutoring in English is well established. However, that does not mean that it is a pedagogy that will generate similar gains in mathematics development in Irish Medium mathematics lessons. The overall aim of this study was to ascertain whether similar patterns of gains in mathematics observed in previous research in Scotland would be replicated. In addition the intention was to build on the previous pilot study that created Irish Medium versions of materials and piloted their use. Specifically the intention was to recruit primary schools from the Irish Medium sector who would be happy to either undertake peer tutoring in their schools, or act as a comparison group and 'teach as usual' so that development in mathematics when not using peer tutoring could be assessed and compared to development when using the peer tutoring technique.

Research questions

What are the effects of peer tutoring on mathematics attainment in Irish Medium primary schools and how do these compare to changes in mathematics attainment observed in those classes that employed teaching as usual?

Method

Recruitment

Invitations were sent out by CCEA to all Irish Medium primary schools. The invitation stated that schools were required who would like to participate in a study that tested use of peer tutoring against teaching as usual. Teachers attended a one-day professional development event. After this teachers were asked to either volunteer to use the peer tutoring or teach as usual. Teachers were free to volunteer for either group. A total of 20 teachers expressed an interest and letters and pre-test were sent to 18 schools. Schools were asked to complete the pre-test if they wanted to take part. Subsequently 6 schools withdrew and 12 schools took part in the research. These schools completed pre and post test measures in mathematics. In total 14 teachers volunteered to take part in the study. Those who volunteered to take part in the peer tutoring were provided with the manuals, student handouts and videos developed as part of a pilot study on peer tutoring and Irish Medium education. Those who volunteered to provide the comparison group were asked to teach as usual.

Sample

Sample: The group who received the peer tutoring intervention included 8 classes. This included seven Primary 7 and one Primary 6 class based in 3 urban (with three classes being from the same urban location) and 3 rural locations. Mean class size was 15.25 students (SD 3.69). The comparison group included 6 classes from 6 schools. This included five Primary 6 classes and one Primary 7 class based in 3 urban and 3 rural locations. Mean class size was 14.33 students (SD 5.88). Differences in class size were not significantly different ($F(1, 12)=0.13$, $p=0.73$). In total 95 students served as a comparison group and 119 students served as the peer tutoring implementation group. Ethnicity of all students was Caucasian.

Research instruments

Mathematics attainment: Criterion referenced attainment tests in mathematics were developed from tests used in The Scottish Assessment & Achievement Programme Survey-2004. This was a nationally available, independently designed instrument with good reliability and validity (Cronbach alpha values 0.7-0.9 in a sample of 2345, ten to twelve year-old Scottish students, Scottish Government (2004). The Cronbach's alpha for the studies this test had been used on, with a total of 792 students in Primaries 5, 6 and 7, is 0.92). The final test contained 25 items. The instrument was scored out of 50 using a predefined marking template. One research assistant completed all coding and a subsample was checked for accuracy against the marking template. No

errors were observed. Scoring was undertaken blind to condition. The tests were translated into Irish for use in Irish medium classes by CCEA.

Continuing professional development: Teachers from volunteer schools attended a CPD day to train them in using peer tutoring techniques. Teachers were provided with a comprehensive manual, worksheets/handouts and a selection of videos to help them implement the technique in their classes. Students spent one hour per week, for sixteen weeks on structured maths peer tutoring activities. Students undertake the role of peer tutor in one topic and peer tutee in the other.

Implementation fidelity: Contact was made with schools at the end of the research period. Schools were asked to confirm whether classes had used peer tutoring or not. In addition they were asked to indicate how many sessions, and over how many weeks the classes had used peer tutoring for and for their anecdotal observations about implementation.

Technique of reciprocal peer tutoring used: The peer tutoring method used was one in which discussion between two students (tutor or teacher and tutee or learner) was used to solve maths questions. The role of the tutor was to provide support and mediate the learning processes for the tutee. In order to do this the tutor will ensured that the tutee attempted to answer maths questions using a structured approach. It was the job of the tutor to keep the tutee working within this structured framework. It was the job of the tutee to do the actual working out to arrive at an answer to a maths question. Students within one class were placed in a pair of broadly similar maths ability. They took turns being both tutor and tutee. The students worked together and solved maths questions in three main steps:

- Understanding the question: The pair read the question together. They identified exactly what the question was asking them to find out using talk, pictures and diagrams. They rephrased the question to clarify meaning. The tutor helped the tutee by talking through similar questions, or similar questions of a more similar nature. All the time the tutor had to listen carefully to what the tutee said. Finally the tutee formulated a plan to approach answering the question and explained this to the tutor.
- Finding an answer to the question: As the tutee answered the question the tutor asked open and leading questions. The tutor was instructed not to ‘tell’ the tutee the answer or simply show them what to do. They had to think of a way of leading them to the answer. On difficult parts the tutor was asked to break down the question into more simple parts. The tutee still had to do all the working out. During this process the tutor was asked to provide emotional support to the tutee, praising them when things went right and encouraging them during difficult

sections of work. During their working out the tutee had to 'think out loud' so that they were explaining each step to the tutor.

- Finishing the question: Pairs finished the question by asking themselves what had they done and how it linked to things they had done in the past. They were also asked to think about how this sort of maths might be used in the real world.

Results

Maths attainment

Data presented in Table 1 show mean pre and post test scores on the Scottish Survey of Achievement Mathematics Test. Scores are presented out of 50. ANCOVA showed that post test scores in mathematics were significantly higher for the group who had used peer tutoring than the comparison group ($F(1,214)=23.99$, $p<0.001$, with 98.8% power and an Effect Size of +0.39). ANCOVA used pre-test maths scores as a covariate to control for pre-test differences. ANOVA indicated that pre-test differences between the peer tutoring and comparison group did not reach significance ($F(1,214)=1.19$, $p=0.28$). However, post-test scores were adjusted for differences at pre-test in analysis as mean scores did differ by over one mark (albeit that this equates to less than one question in terms of score).

Table 1: Pre and post test scores in mathematics of peer tutoring and comparison groups

	Pre-test	Post-test
Comparison n=95	27.72 (8.43)	29.26 (9.72)
Peer tutoring n=119	29.16 (10.37)	33.97 (7.85)

Pre and post test were spaced out by 6 months. In that time the comparison group made an Effect Size gain of +0.18 and the peer tutoring group one of +0.46. If this is taken as the standard rate of maths development then the peer tutoring group made 15.33 months of maths development during the same time period, more than twice the rate.

Implementation fidelity

School using the peer tutoring technique reported that classes got a mean of 13.63 sessions (SD 3.29). Five classes got the full 16 sessions, two classes got 10 sessions and one class got nine sessions. Schools reported that they felt the use of peer tutoring was best used in Primary 6 and Primary 7. The

reason reported for this was that language capabilities presented a barrier to learning mathematics using the technique with younger age groups.

Discussion

Peer tutoring was demonstrated to be effective in the Irish medium setting. The experiment produced large *Effect Size* that was in line with those previously reported for the technique (Thurston *et al.,* 2012). Peer tutoring that combined a strategic approach to metacognition where learners gain mastery, and understanding, of their learning had previously been reported to promote gains in attainment (Higgins, Hall, Baumfield & Moseley, 2005). There was evidence in the pilot study that such metacognitive processes were driving the gains observed in maths attainment when using this peer tutoring technique. The pilot study analysed talk in 30 students in Irish Medium using the peer tutoring technique. The study found metacognitive talk such as identifying what a question was asking you to do, discussing how one was going to approach solving a maths question, asking questions and discussing answered and talking about how a question was related to previous work significantly predicted higher maths attainment (Thurston & Keenan, 2014). The *Effect Size* observed in this pilot was akin to the mathematics development that one may expect in 18 months of teaching as usual (Higgins, Kotosaki & Coe, 2011). As the project was conducted over a time period of 6 months then those using the peer tutoring technique showed enhanced maths development.

It must be noted that there is a risk of sampling bias. Schools listened to a presentation about the peer tutoring technique and then opted to act as comparison group or as peer tutoring group. There is a risk that there was a characteristic of the teachers who volunteered to undertake the new pedagogy that would predispose them to better maths teaching. There may be a risk of clustering effects caused by a characteristic of teachers who volunteered to undertake peer tutoring. The peer tutoring group had a higher proportion of Primary 7 classes and the comparison group a higher number of Primary 6 classes. There is a risk that this meant that changes in maths attainment could be biased by a factor to do with age and stage of students. However, maths attainment did not differ significantly at pre-test and so this lessens that risk of both of these factors. In addition findings regarding the use of peer tutoring were in line with larger studies undertaken in Scotland and there is nothing to suggest that the increased maths attainment in the peer tutoring group was atypical of previous research findings. The only way to definitively rule out sampling bias or clustering effects of schools would be to undertaken a randomized controlled trial as a new piece of future research with correctly powered sample size (likely to be about 40 schools).

Taken as a whole then the recommendations for teaching practice and policy are as follows. Peer tutoring appeared to drive similar gains in Irish Medium maths attainment that it had showed in English Medium education. It would appear that the technique is transferable across languages and culture. The project has developed resources to support the implementation of peer tutoring in Irish Medium maths. With evidence to support it, then it would appear appropriate to recommend the technique to teachers as one that would be an effective pedagogy through which to teach maths. Resources re available through CCEA and they are ready to use in school. Thought could be given to linking the technique to curriculum resources to help embed the process widely throughout the Irish Medium sector.

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