Structured collaborative problem-solving may improve performance more than unstructured collaboration and solitary learning – preliminary evidence from a randomised controlled trial

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PURPOSE OF THE RESEARCH

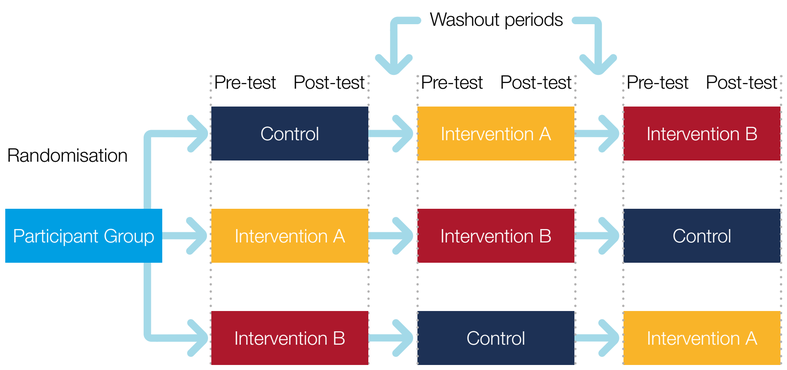
Social learning (learning by observing/imitating others) has often been seen as important (Bandura, 1977; Vygotsky, 1978). In evolutionary psychology, it is argued that humans may have evolved to imitate other humans (Sweller and Sweller, 2006). It is now also known that mirror neuron networks facilitate understanding between people (Fabbri-Destro and Rizzolatti, 2008). Relating this to classroom practice / the sustained use of working memory, that social interaction is associated with increased attention (Mundy and Newell, 2007) may help to explain why much education research has pointed to the importance of social processes. However, social interaction can be distracting and could affect a learner's ability to inhibit irrelevant stimuli during mathematical problem-solving (Cragg and Gilmore, 2014). This investigation, involving one school in Wiltshire, looked at the effects of two types of collaborative learning.

THE RESEARCH DESIGN

A pre- and post-test within-participant design was used (Figure 1). The independent variable (collaboration) was operationally defined by creating three counterbalanced conditions – with a washout period to help mitigate carryover effects (Churches and Dommett, 2016).

- IV Level 1 (Control): typical classroom practice – worksheet completed individually by children with no collaboration
- IV Level 2 (Intervention A): worksheet collaboration – worksheets completed with learning partner
- IV Level 3 (Intervention B): activity collaboration – activity completed with learning partner

Figure 1. Research design used in the present study



METHODS

Participants, sample size and randomisation

Three Year 2 classes took part in the research, a total of 86 children. The classes, which were predetermined by setting, were randomly allocated to the order in which they experienced the three conditions using the 'Excel Rand() function'. Data from 67 pupils was able to be analysed.

Procedures

Students were asked to attempt the tasks using varied pedagogical styles over a series of lessons. Firstly, the Control condition involved students being given the controlled input (same input for all activities) and then being given time to tackle the problem individually in a worksheet format. The second was the collaborative control condition, which involved the same input with the same worksheet but working collaboratively with a partner chosen at random. The third was the experimental activity condition where the students were given the controlled input and asked to perform activities, using related resources to problem-solve and explore their answers. Collaboration partners were chosen at random. Teachers taught the same group of students across the three sets of lessons.

Materials (and apparatus)

The same three inputs (using the same plan) were delivered for each set of lessons. Students were given the same worksheets. The first set of lessons involved fractions of shape and used Worksheets A consisting of '3 chilies'. The second set of lessons involved fractions of number (1/2, 1/4, 1/3) and used Worksheets B consisting of '3 chilies'. The third set of lessons involved fractions of number (1/2, 1/4, 1/3, 2/4, 3/4, 2/3) and used Worksheets C consisting of '3 chilies'. A test related to the learning was delivered at the beginning, and repeated at the end of each set of lessons.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The overall effect may have been caused by family-wise error and therefore the results may need to be interpreted with caution. Intervention A v Control had the largest significant effect size of 0.11. Intervention B v Control had a very small effect size of 0.04. In conclusion, the largest effect was seen from the use of collaborative worksheets rather than working independently or an activity completed with a learning partner. This surprised the researchers who expected a larger effect to be seen in the activity-based condition. This said, we know that certain forms of executive function are important for effective mathematical learning, such as the monitoring and manipulation of information in working memory; suppression of distracting information (inhibition); or flexible thinking (ability to shift from concept to concept) (Cragg and Gilmore, 2014). It may have been that the template-informed collaboration helped to guide and focus attention whilst the discussion supported the development of flexible thinking during the problem solving. Future research may wish to explore the combination of approaches in more detail.

RESULTS

Gain scores were first calculated from pre- and post-test scores in the graph below (Figure 2). An initial two-tailed Friedmann's ANOVA indicated that the effect across all three conditions was not significant ($W = 0.01$, $p < 0.435$) and therefore may have been affected by family-wise error. The ANOVA was followed by separate one-tailed Wilcoxon signed-rank tests and a Bonferroni adjusted alpha.

Figure 2. Pre- and post-test fraction test scores for worksheet (Control) compared to collaboration worksheet (Intervention A) and activity collaboration (Intervention B)

Table 1. Comparison between the present study conditions†

	Control v Intervention A	Control v Intervention B	Intervention A v Intervention B
Effect size (r)	0.11	0.04	-0.07
CI (95%)	-0.03 – 0.19	-0.05 – 0.13	-0.21 – 0.07
p-value	.005*	.399	.345

* Significant with alpha = .0167

† Test identification and analysis was conducted using StatsWizard©

LIMITATIONS

The initial sample size of 86 children was reduced to 67 due to attrition – a result of pupil absence. All children involved in the study were from three classrooms within the same school and year group serving similar socio-economic backgrounds which may not be representative of the whole population. A number of pupils obtained a maximum score in the pre-test, resulting in a ceiling effect. This said, some pupils had a lower post-test score. A future study may wish to use a test with a wider range of possible outcomes.

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