Evaluating Computer-Supported Collaboration for a Problem-Solving Task

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Abstract

Computer Science researchers are investigating systems that exploit the benefits of collaborative computing technology in learning. There is, however, little empirical evidence of the benefits and costs associated with different modes of computer support for collaborative learning.

We describe an experiment that compares how well 51 children (aged ten and eleven) learnt to solve a small puzzle in three different collaborative learning conditions. Results showed no significant difference in learning outcomes among the three conditions, but revealed that girls solved the puzzle more slowly when collaborating.

1. Introduction

"A computer in every classroom" is a common political statement throughout the world. The hardware to support visions of every school pupil having a computer connected to the Internet in the classroom is available now. However, the major computer technology issue facing schools is determining how hardware and software can be designed and configured to improve learning.

Computers are relatively scarce resources in schools. As a result, although primarily designed for a single-user (one keyboard, one mouse, and one screen), computers are often used as collaborative devices with multiple simultaneous users. Thus users contend for the input devices. To overcome this limitation, synchronous groupware technology allows multiple users to simultaneously work with a computer-supported artifact such as a puzzle, virtual world, or interactive story. As computers become more commonly available in the classroom, it is feasible that synchronous groupware applications can be used for new styles of collaboration among local and remote students. Although feasible, will these collaborative styles be beneficial?

We examined the effectiveness of computer support for collaborative learning, with a particular interest in the differences between shared use of single-user systems and shared use of synchronous groupware. Three questions are addressed in this paper. First, do children learn problem-solving tasks better when working alone or when collaborating? Second, which hardware and software configurations for synchronous collaboration best support learning? Third, are there differences in the ways that boys and girls interact with, and collaborate around, computer systems?

2. Experimental Design

Fifty-one children, aged ten or eleven, solved a puzzle ten times; five times in a learning phase and five times in a testing phase (see Figure 2). The puzzle (called the 8-puzzle and shown in Figure 1) consists of a three by three grid with eight numbered pieces and one empty slot. Users worked towards a particular target configuration (the one shown in the figure) by sliding pieces into the empty slot.

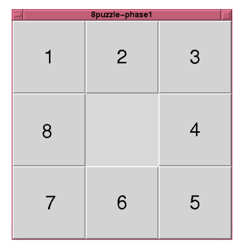

Figure 1. The eight-puzzle in its goal configuration.

In the first phase (the training phase) participants were separated into three groups. One-third of the participants solved the puzzle by themselves. Another third worked in pairs on one computer. The final third worked in pairs on two computers with WYSIWIS (What You See Is What I See, see [4] for details) mechanisms maintaining identical displays at all times. In the second phase (the testing phase) participants solved the puzzle by themselves. The experimental design is shown in Figure 2, and is based on an experiment conducted by O'Hara and Pane [3].

Switching from the training conditions to the solo testing condition allowed us to equitably compare how successfully the participants learnt the puzzle during training.

3. Results

All but two children were able to complete the ten trials within the maximum time allowed (one hour for the session). One was a female in the solo condition, and the other was a male in the contention condition. Their data were

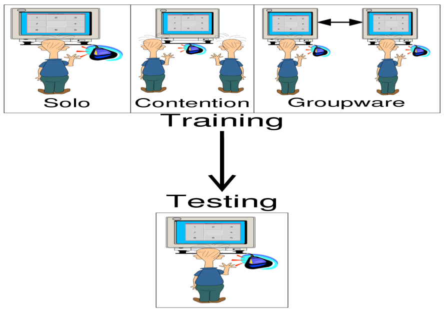

Figure 2. The participants were split into three groups for the training phase, but they all performed the testing phase individually. Participants solved the puzzle ten times: five times in each phase.

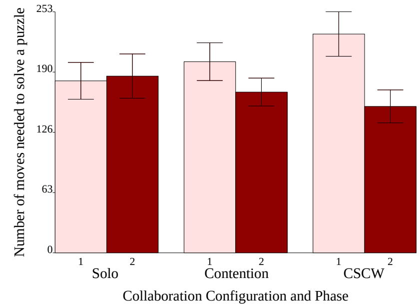

Figure 3. Number of moves needed to solve a puzzle in the first phase broken down by gender and collaboration. There is a reliable difference in phase one ($F(2,42)=4.70$, $p<0.05$), but not in phase two ($F(2,41)=1.620$, $p=0.21$).

discarded. The remaining 48 students succeeded in solving the puzzle relatively rapidly. Across all 480 trials, the mean time to solve each puzzle was 3m21s (σ3m12s) with a mean move-count of 186 (σ160). The minimum time to solve the puzzle was 0m15s using 21 moves by a male subject trained in the groupware condition and occurred in trial number eight. The maximum time to solve the puzzle was 24m29s using 1,129 moves by a male subject trained in the solo condition and occurred in the first trial. To reduce the effect of this skewed distribution, and to stabilise the variance for statistical analysis, we log-transformed the data [1].

We measured the number of moves required to solve each puzzle, the time taken for each puzzle, and the inter-move latency. An analysis of the number of moves taken in the first phase revealed a reliable effect of collaboration configuration ($F(2,42)=4.70$, $p<0.05$). Participants used the fewest moves in the solo configuration (180 σ19), and the most in the CSCW configuration (229 σ23). The contention configuration was the median with an average of 200 moves σ20). This difference appears to be a result of females feeling unsure of their planning when collaborating [5].

To equitably compare the effect of collaboration configuration on learning outcomes rather than on performance, we examined the second phase. Participants used on average 185 (σ19) moves to solve a puzzle in the solo configuration, 168 (σ15) in the contention configuration and 153 (σ17) in the CSCW configuration. These differences were not reliable ($F(2,41)=1.620$, $p=0.21$).

Like Inkpen et al [2], we noticed gender differences: the performance effects are more pronounced for females than for male. These effects are described in [5].

4. Concerns and Further Work

There are several limitations in our study. It is unclear how observations of learning in a small, bounded puzzle transfer to larger, unbounded learning tasks (like writing an essay on the history of Maori in New Zealand). Our metrics for 'learning' are crude measures of task performance, and there might have been important learning factors that we failed to measure. Examples of these learning factors could include development of social skills and practise at negotiation and compromise. Despite these limitations, we believe it is important to establish concrete empirical foundations that characterise and clarify the relative merits of different modes of Computer Support for Collaborative Learning. We will broaden our investigation in further work.

5. Conclusions

This experiment compared how well children learn to solve the 8-puzzle when trained on their own, when sharing access to a computer, and when collaborating through a WYSIWIS groupware system. Results showed that the collaborative configurations caused participants to make more moves when working together, but this did not reliably affect their learning outcomes.

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