## B. QUANTITATIVE ANALYSES OF CASE STUDIES AND THEIR IMPLICATIONS FOR CSCL

# Solo, Together, Apart: Evaluating Modes of CSCL for Learning a Problem Solving Task

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## ABSTRACT

This paper describes an experiment that examines how computer supported collaboration influences how children learn to solve a simple puzzle. We found that collaboration resulted in relatively poor performance during a 'training' period, but that it appeared to aid puzzle comprehension during a later 'testing' period. Results also showed that girls found it harder than boys to solve the puzzle when collaborating.

**Keywords:** Learning, educational technology, groupware, empirical studies.

## INTRODUCTION

Computers in schools remain, at present, a relatively scarce resource. Although primarily designed for single-user use (one keyboard, one mouse, and one screen), computers in schools are often used as collaborative devices with several simultaneous users. In this style of use, there is contention for input devices. To overcome the apparent limitations of contention for input devices, synchronous groupware technology can allow multiple users, each with their own computer, to simultaneously work with a shared computer-supported artifact such as a puzzle, virtual world, or interactive story. As computers in the classroom become more commonly available, it is feasible that synchronous groupware applications could be used to allow new styles of collaboration with local and remote students. Although feasible, will groupware be beneficial?

The precise questions addressed in this paper are as follows. 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? Our goal is to further the concrete empirical foundations of research in Computer Supported Collaborative Learning (CSCL).

## EXPERIMENTAL DESIGN

The experiment investigates the effectiveness of three different modes of computer supported collaborative learning in supporting children learning how to solve a particular puzzle[*]. The puzzle used is the 'eight-puzzle'which consists of a three by three grid with eight numbered pieces and one empty slot. Users work towards a particular target configuration (such as the one shown in the figure) by sliding pieces into the empty slot. In our user interface, mouse clicking any tile that is adjacent to the empty slot causes the tile to slide into the vacant position. The tile's movement is rapidly and fluidly animated, providing a clear indication of the direction of motion.

Each of the fifty participants, aged ten and eleven, was asked to solve the eight-puzzle a total of ten times, with five trials in a 'training' phase, and five trials in a 'testing' phase. Each participant was assigned to one of three collaboration conditions for the training phase, and in the testing phase all participants solved the puzzle alone using the single user version of the system. The first 'solo' training condition acts as a control, and involves using a single-user version of the puzzle. In the second 'contention' training condition, two participants shared access to the interface used in the 'solo' condition. In the third 'groupware' training condition, two participants, each with their own computer, screen and mouse, shared access to a strict-WYSIWIS (What You See Is What I See) implementation of the puzzle. The only visual difference between the groupware interface and the solo one was the addition of telepointers, which reveal the location of the other user's cursor in

[*] The experimental design is similar to that described by O'Hara and Payne (1998).

the display.

After solving the puzzle five times in the training condition, all of the subjects, regardless of their training condition, moved to the testing phase in which they solved the puzzle a further five times on their own. The interface used in the testing phase was identical to that used in the solo condition. Figure 1 summarises the difference between the three conditions used during the training phase and the one condition used during the testing phase.

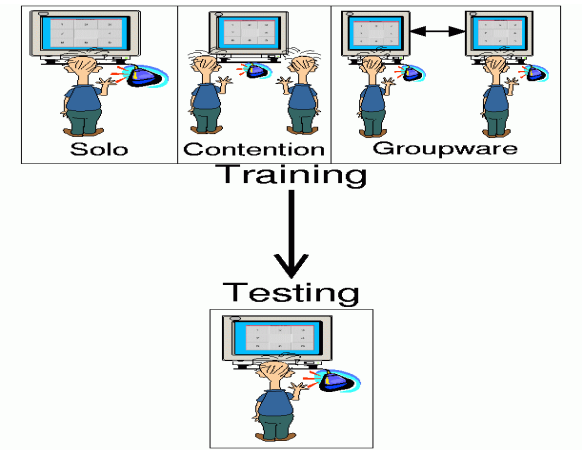


Figure 18: The participants were split into three groups for the training phase, but they all performed the testing phase individually.

## RESULTS

### Evidence of learning

Through the five trials in the training phase, the mean time to solve the puzzle was 235 seconds (σ 118), with a mean move count of 203 (σ 84), and an inter-move latency of 1.55 seconds (σ 0.22). During testing, these values all decreased, with means for solution time, move counts and inter-move latency of 167 (σ 78) seconds, 169 (σ 74) moves and 0.99 (σ 0.22) seconds. These are all reliable differences: $F(1,42)=16.23$, $p<.01$, $F(1, 42)=6.2$, $p<.05$, $F(1,42)=37.36$, $p<.01$. This reveals that the subjects successfully learned the puzzle.

### Learning as a factor of training condition

The main effects for the training condition were not significant for any of the three measures. The mean solution time for the solo, contention and groupware conditions were 194 (σ 95), 200 (σ 82), and 207 (σ 134) seconds ($F(2,42)=0.114$, $p=.89$). This is unsurprising given that the sampled data includes the highly variable performance of the subjects during their initial learning trials.

There is a marginally significant interaction between training configuration and phase (training or testing) for the move-count dependent variable: $F(2,42)=2.89$, $p=.067$. The solo subjects took slightly more moves to complete the puzzle in the testing phase than the training phase (increasing from 180 to 185). The subjects in the two collaborative training conditions (contention and groupware), however, showed a relatively dramatic improvement from training to testing.

To summarise the impact of the three different training conditions on learning, when tested the subjects trained in the collaboration conditions took fewer moves and solved the problems more quickly (on average), but this is not a reliable observation. However, during training, the collaboration subjects took more time and more moves to solve the puzzle (on average) than the solo subjects did, but again this is not a reliable observation.

An analysis of gender showed that girls took slightly longer than boys to complete the puzzle (on average, but not significant), but roughly the same number of moves. However, girls seemed to perform particularly poorly when being trained using a collaborative system. The girls' poor performance during training did not appear to influence their learning the puzzle.

## CONCLUSION

Results show that the children successfully learnt the puzzle. The three training configurations did not yield significant differences in the children's performance during testing, although the mean task completion times were lower for those that trained collaboratively. Girls in the collaborative training conditions took longer and more moves to solve the puzzle during training than those in the solo condition, but this had no obvious impact on their ability to solve the problem during testing. In essence, our results lend further support to prior studies indicating that collaboration neither hinders nor helps learning.

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