Playing together beats playing apart, especially for girls

Conference Paper · January 1995

DOI: 10.3115/222020.222164 · Source: DBLP

4 authors, including:

Kellogg Booth
University of British Columbia - Vancouver

Rena Upitis
Queen's University

Playing Together Beats Playing Apart, Especially for Girls

Kori Inkpen[1], Kellogg S. Booth[1], Maria Klawe[1], and Rena Upitis[2]

[1]*Deoartnent of Computer Science, University of British Columbia, Vancouver, British Columbia, Canada;*

[2]*Faculty of Education, Queen's University, Kingston, Ontario, Canada;*

Abstract

This paper describes follow-on studies focusing on how gender and grouping affects performance and attitudes of children playing a puzzle solving game called *The Incredible Machine* (TIM). We found that children playing together on one machine solved significantly more puzzles than children playing alone on one machine. Female/Female pairs playing together on one machine, on average, completed significantly more puzzles than Female/Female pairs playing side-by-side on two computers. In addition, the level of motivation to continue playing the game was affected by the opportunity to play with a partner, and success in the game.

This paper describes follow-on studies focusing on how gender and grouping affects performance and attitudes of children playing a puzzle solving game called *The Incredible Machine* (TIM). We found that children playing together on one machine solved significantly more puzzles than children playing alone on one machine. Female/Female pairs playing together on one machine, on average, completed significantly more puzzles than Female/Female pairs playing side-by-side on two computers. In addition, the level of motivation to continue playing the game was affected by the opportunity to play with a partner, and success in the game

Keywords — Human-Computer Interaction, Computer-Supported Collaborative Learning, Computer-Supported Cooperative Work, Children, Education, Gender, Games.

1. Introduction

Children naturally tend to gather in groups around computers and video games. This is obvious to the casual observer of arcades, living rooms, and classrooms, but was also overwhelmingly evident during a research study of children playing electronic games conducted at an interactive science museum, Science World, in 1993. This paper describes follow-on studies focusing on how gender and grouping affects performance and attitudes of children playing a puzzle solving game called *The Incredible Machine* (TIM). We found that children playing together on one machine solved significantly more puzzles than children playing alone on one machine. Female/Female pairs playing together on one machine, on average, completed significantly more puzzles than Female/Female pairs playing side-by-side on two computers. In addition, the level of motivation to continue playing the game was affected by the opportunity to play with a partner, and success in the game.

The Science World 1993 study was the first research undertaken by the Electronic Games for Education in Math and Science (E-GEMS) group. E-GEMS is an ongoing collaborative effort among scientists, mathematicians, educators, professional game developers, classroom teachers, and children. The goal of E-GEMS is to motivate children to learn and explore mathematical and scientific concepts through the use of electronic games. E-GEMS research includes focused studies on specific issues [7], long term qualitative investigations [10], development and evaluation of prototypes, and design of commercial products [3].

Science World is an interactive science museum where children and adults explore scientific concepts through a variety of hands-on activities. In July 1993 E-GEMS researchers set up an exhibit called the Electronic Games Research Lab to observe children as they interacted with video games and computer games. During the two months of this exhibit, over ten thousand children spent time in the exhibit and several hundred children were interviewed by researchers. Two strong themes that emerged from our observations at the exhibit were the popularity of collaborative play and differences in gender preferences and playing styles. Gender differences are reported in detail in [6, 11]. This paper presents the outcomes of a two-phase further investigation of collaborative play conducted in a school classroom in January 1994 and at Science World in the summer of 1994.

Many researchers have noted positive benefits from small group interactions around computers in the classroom [4, 12, 16]. Such studies include comparisons between individual, cooperative, and competitive groupings [9, 1, 2, 15]. In our study we chose to focus on the playing configuration rather than explicitly forcing children into competitive or collaborative playing modes. Children were placed in one of three physical set-ups:

Solo Play:	one child played alone at one machine
Parallel Play:	two children played side-by-side at two machines
Integrated Play:	two children played together at a single machine

The game chosen, *The Incredible Machine* (TIM), is a problem solving game in which players assemble Rube Goldberg style machines out of a collection of parts to solve challenges posed by the game. During the Science World 1993 study, researchers frequently observed collaboration on TIM by groups of children, including groups of children who had never previously met.

TIM involves solving a series of puzzles featuring a wide variety of parts used to construct machines to solve particular challenges. Typical challenges include building a machine to shoot a basketball into a hoop and trapping Mort the Mouse in his cage. The parts include many used in everyday life (e.g. gears, pulleys, ropes, ramps and levers) along with a host of characters and entertaining objects (e.g. cats, mice, balloons, various types of balls, scissors, and trampolines).

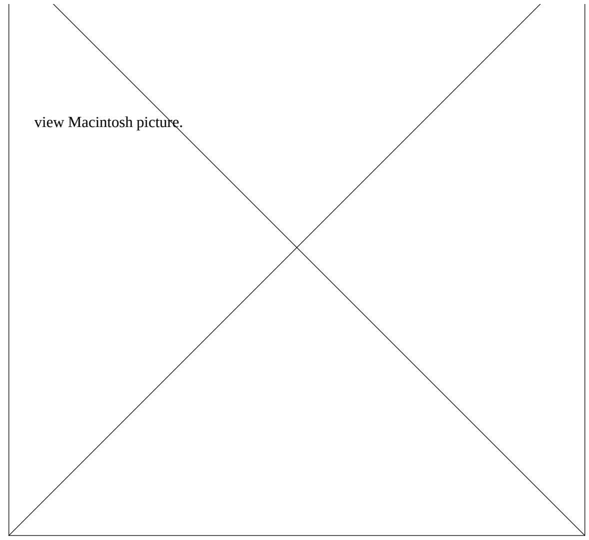


Figure 1: The Incredible Machine Playing Screen and Solution to Puzzle #1

In order to start solving puzzles in TIM, a puzzle is selected through the control panel. The puzzle screen contains three main areas: the playing area, a parts bin, and a start machine icon. In order to solve the puzzles, pieces must be selected from the parts bin and placed onto the playing area. Some pieces such as ropes or elastics must be connected to other parts such as conveyor belts, motors, and balloons. The player can try out the machine at any point and continue to modify it until the specified goal is achieved. The completed machine for the first puzzle is shown in Figure 1[1]. Many of the puzzles have more than one correct solution.

At Science World 1993, many groups of children played TIM for extended periods of time. Some groups passed control of the mouse back and forth while other groups had one person perform the group's suggestions. Often, the children in the group were active participants in terms of sharing ideas and directing actions within the game. The children who played TIM in groups appeared to play for longer periods of time and were better able to solve puzzles. These observations led us to hypothesize that children playing TIM in pairs would, on average, complete more puzzles during a fixed period of time, and would choose to play longer.

2. TIM Study

2.1. Phase I: Kerrisdale School

The first phase of the TIM study was conducted at Kerrisdale Elementary School, a public elementary school in an upper-middle class neighborhood of

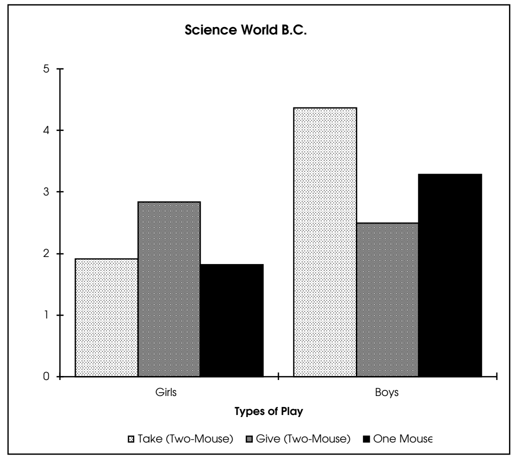
[1] When the machine is started, the bowling ball on the far left of the screen will drop onto the far left mouse cage. This will cause the mouse to run, turning its wheel, causing the far left conveyor belt to turn. The bowling ball on the far left conveyor belt will then roll onto the next mouse cage, causing this mouse to run. This process repeats until the top conveyor belt is moving, and the basketball to rolls down through the hoop structure.

Vancouver, British Columbia, Canada. The participants were 104 children (52 girls and 52 boys) between the ages of 9 and 12 who had not previously played TIM. Students were arbitrarily placed into one of the three experimental conditions described above, namely Solo Play, Parallel Play and Integrated Play. For the two-player conditions, the students were randomly assigned a partner corresponding to a particular sex-dyad. The gender groupings were: Female/Female, Male/Male, and Female/Male.

The setting was an empty classroom equipped with either one or two IBM-compatible computers, depending on the experimental condition. The total length of each session within the study was forty minutes. On entry to the room, the children were welcomed and given a brief introduction to the project and the environment. Next, the children were asked to try to complete the first three puzzles in the game and told that they were allowed to play for as long as they desired up to a maximum of thirty minutes. The children were given no directions on how to play to game; however, the game manual was placed on the table beside the computer and the children were told that it contained information about the game and that they could look at it if they wished. They were encouraged to try to work out any problems they might have amongs themselves. The children were also told that when they finished playing, they could come into another section of the room for a snack. The snack consisted of healthy foods (raisins, cheese and crackers, granola bars, etc.) and a drink of either milk or juice. Once in the snack room, the children completed a questionnaire and engaged in casual discussion until their forty minutes of research time was completed. Following this, the children returned to their classes.

The factors investigated in this study were achievement in the game, measured by the total number of puzzles completed by each student, and motivation to play the game, measured by whether or not the children played the game for the full thirty minute period allowed. Qualitative observations were also gathered concerning the cooperative play of the children and the group dynamics for the Parallel Play and Integrated Play conditions.

Table 1 and Figure 2(a) show the mean number of puzzles the children completed during each of the experimental conditions. Both females and males solved more puzzles in the Integrated Play condition than in the Solo Play condition, although the difference was not significant due to the small sample size.



The result for the Parallel Play condition was dependent on gender. Girls solved, on average, fewer puzzles in the Parallel Play condition than in the Solo condition. In addition, girls in the Integrated Play condition solved significantly more puzzles than girls in the Parallel Play condition, with p<???. Conversely, boys on average solved more puzzles in the Parallel Play condition than in the Solo Play condition and the Parallel Play results were similar to the results for the Integrated Play condition. Other than the Parallel Play condition, both girls and boys had similar results for the Solo Play and Integrated Play conditions.

These results indicate that children's success when playing with a partner may depend on whether girls or boys are playing and on their playing configuration. This supports other findings that girls and boys react differently to computers [wilder85,hall91]. We did not observe any effect on motivation since only five children left before the thirty minute session was over.

Phase II: Science World, 1994

Because of the intriguing differences observed in Phase I for achievement by girls in the Parallel Play and Integrated Play conditions, we decided to repeat the study with a larger sample size at Science World during the summer of 1994.

This phase of the research project used 331 children (247 girls and 84 boys) between the ages of 9 and 13; the disproportionate number of girls was deliberate because of the wide variation in results for girls observed during the first phase. The children who participated were visitors to Science World who volunteered to take part in the study. As before, none of the subjects had previously played the computer game TIM. Students were randomly chosen to play either alone or with a partner in one of the three experimental conditions. This time partners were chosen corresponding to one of two sex dyads: (a) Female/Female or (b) Male/Male. No mixed gender pairs were used.

The Research Lab at Science World contained four Macintosh LCIII computers set up so that four sessions could run simultaneously. The procedure for running each session was identical to that in Phase I, except that no snacks or questionnaires were involved. When the children finished playing, they left the exhibit and continued exploring Science World. The factors measured for this study were the same as in Phase I, namely achievement and motivation.

The average number of puzzles solved in each of the experimental conditions in Phase II are shown in Figure graphfig (b) and the statistical analysis for these results are given in Table ANOVA . In Phase II, gender (female and male) and experimental condition (Solo Play, Parallel Play, and Integrated Play) had a significant effect on the number of puzzles solved in the game, with and respectively.

Source	SS	df	MS	F	p
Gender	109.976	1	109.976	32.006	
Condition	25.322	2	12.661	3.685	
Gender x Condition	4.372	2	2.186	0.636	
Error	1116.726	325	3.436		

The results from this study validate the trend observed in Phase I that girls and boys solved more puzzles playing together on one machine in the Integrated Play condition than playing by themselves in the Solo Play condition, with . In addition, the discrepancies observed in the Parallel Play condition were also repeated, i.e. girls solved statistically fewer puzzles in the Parallel Play condition than girls playing in the Integrated Play condition, with. Also, as observed in Phase I, girls in the Parallel Play condition solved on average fewer puzzles than girls in the Solo Play condition. On the other hand, boys solved more puzzles on average in the Parallel Play condition than in the Solo Play condition but fewer puzzles than in the Integrated Play condition although these differences was not statistically significant.

These results support previous work in [8,2,14] demonstrating the advantages of small groups sharing a single computer. This seems especially true for girls, given that girls playing side-by-side on two machine solved significantly fewer puzzles than girls playing together on one machine.

The increased number of puzzles solved in the Integrated conditions for both girls and boys could be attributed to the necessary interaction that occurs while working together on one machine. This resulted in more verbal interaction in the Integrated Play condition than in the Parallel Play condition. This observation of increased verbal interaction during collaborative work on one machine is supported by another study [13] in which children playing together on one machine had more verbal interactions than children playing side-by-side on two machines. Elaboration, the discussion of and expanding on ideas, is recognized by many researchers as one of the underlying cognitive explanations of the benefits of cooperative learning [12].

Gender differences in achievement were significant in Phase II in contrast to Phase I. Girls solved significantly fewer puzzles in all conditions than boys, with $p < .001$. This result could be explained by many factors including differences in the environment, the selection process, and the type of platform and interaction style used. Phase I took place in an empty room in a school, during school hours. Phase II was in a science museum with many people wandering around the exhibit throughout the session. In addition, Phase II took place during summer break, leading to differences in the selection process. In Phase I almost all the children in eligible classes chose to participate since it was viewed as a desirable break from their regular school day. At Science World the children who took part gave up time that they could have spent at other highly attractive exhibits. The interface used in TIM also differed slightly between the phases because of the use of different computer platforms. The IBM-compatible implementation of TIM uses a point-and-click style of interface whereas the Macintosh implementation in Phase II uses a drag-and-drop style. A subsequent study of girls using both these interfaces showed a slight difference in the average number of puzzles solved [5]. In this study girls using the point-and-click interface on the IBM-compatible computer solved more puzzles than girls using the drag-and-drop interface on the Macintosh computer.

Phase II also demonstrated that playing configuration has a significant effect on motivation as measured by the number of children who stayed and played for the full thirty minute session. The percentage of children who left early are shown in Table time . All but one of the departures occurred more than five minutes before the end of the thirty minute playing period. A higher percentage of children left during the Solo Play condition than for the Parallel and Integrated Play condition. In addition, fewer girls left during the Integrated Play condition than in the Parallel Play condition. This result might be explained by two factors: success in the game and whether or not the child played with a partner. Success in the game seemed critical since of the 54 children who left early, all but three left before solving any puzzles. Of these three, two girls in the parallel play condition left after solving one puzzle; One child in the Solo Play condition left with one minute remaining because she had solved all three puzzles she was asked to solve. The presence of a partner may also have contributed to staying for the full thirty minute session, since a similar percentage of girls in the Solo Play and

Parallel Play conditions could not solve any puzzles, 58% and 58.7% respectively, but a higher percentage of girls in the Solo Play condition left early.

	Solo Play	Parallel Play	Integrated Play
Girls	21.3%	17.4%	4.3%
Boys	15.2%	11.0%	10.0%

3. Conclusions and Future Work

This study provides a basis for several directions of future research. Although much has been done in the area of computer-supported cooperative learning, further examination of the effect of technology is needed.

Previous literature of cooperative learning on computer tasks emphasizes how the teacher can structure cooperative tasks and group compositions to maximize academic and social benefits using existing technology. It is important to investigate whether some of the benefits of cooperative learning may be enhanced by changes in the computer hardware, the software, or the choice of user interfaces. Especially intriguing is the opportunity to adapt Computer-Supported Cooperative Work (CSCW) inspired multi-person interfaces to educational software. There is also a need for further research in multi-input systems and other shared-screen issues.

Although students in this study enjoyed to work with friends, they sometimes found it difficult to share the input device. Figure 5 shows two girls struggling for control over the mouse. In a later study, the addition of a second mouse to TIM was shown to have a positive effect on achievement for children collaborating on one machine [7]. A system that allows children to work together as well as maintaining the ability for individual exploration may be an important advance in cooperative learning with computers.

The results of this study suggest that grouping children around one computer does not negatively affect performance and in the case of Female/Female groupings, it can have a positive effect. This, combined with the extensively researched social benefits of cooperative learning, demonstrate a need to continue research and development in this direction.

References

1. Carol A. Carrier and Gregory C. Sales. Pair versus individual work on the acquisition of concepts in a computer-based instructional lesson. *Journal of Computer-Based Instruction*, 14(1):11-17, 1987.

2. David W. Dalton, Michael J. Hannafin, and Simon Hooper. Effects of individual and cooperative computer-assisted instruction on student performance and attitudes. *Educational Technology Research and Development*, 37(2):15-24, 1989.

3. Counting on Frank. EA*Kids, A Division of Electronic Arts. 1994.

4. Jan Hawkins, Karen Sheingold, Maryl Gearhart, and Chana Berger. Microcomputers in schools: Impact on the social life of elementary classrooms. *Journal of Applied Developmental Psychology*, 3(4):361-373, 1982.

5. Kori Inkpen, Kellogg S. Booth, and Maria Klawe. Interaction styles for educational computer environments: A comparison of drag-and-drop vs. point-and-click. Pre-Press.

6. Kori Inkpen, Kellogg S. Booth, Maria Klawe, and Rena Upitis. Cooperative learning in the classroom: The importance of a collaborative environment for computer-based education. Technical Report 94--5, Department of Computer Science, University of British Columbia, Vancouver, British Columbia, V6T 1Z4, 1994.

7. Kori Inkpen, Kellogg S. Booth, Steven~D. Gribble, and Maria Klawe. Give and take: Children collaborating on one computer. In *CHI '95: Human Factors in Computing Systems*, pages 258-259, Denver, CO, May 1995. Conference Companion.

8. Joel Cooper and Joan Hall. Gender, experience and attributions to the computer. *Journal of Educational Computing Research*, 7(1):51-60, 1991.

9. Roger T. Johnson, David W. Johnson, and Mary Beth Stanne. Comparison of computer-assisted cooperative, competitive, and individualistic learning. *American Educational Research Journal*, 23(3):382-392, 1986.

10. Maria Klawe and Eileen Phillips. Electronic games engage children as researchers. *CSCL '95*, Bloomington, IN, October 1995.

11. Joan Lawry, Rena Upitis, Maria Klawe, Ann Anderson, Kori Inkpen, Mutindi Ndunda, David Hsu, Steve Leroux, and Kamran Sedighian. Exploring common conceptions about boys and electronic games. *Journal of Computers in Math and Science Teaching*, In Press, 1994.

12. Bonnie K. Nastasi and Douglas H. Clements. Motivational and social outcomes of cooperative computer education environments. *Journal of Computing in Childhood Education*, 4(1):15-43, 1993.

13. Robert E. Slavin. *Cooperative Learning: Theory, Research, and Practice*. Prentice Hall, Englewood Cliffs, NJ, 1990.

14. Karl E. Steiner and Thomas G. Moher. A comparison of verbal interaction in literal and virtual shared learning environments. In *CHI '94: Human Factors in Computing Systems*, pages 97-98, Boston, MA, April 1994. Conference Companion.

15. Erik F. Strommen. “does yours eat leaves?'“ Cooperative learning in an educational software task. *Journal of Computing in Childhood Education*, 4(1):45-56, 1993.

16. Jim Watson. Cooperative learning and computers: One way to address student differences. *The Computing Teacher*, 18(4):9-15, 1990-91.

17. Gita Wilder, Diane Mackie, and Joel Cooper. Gender and computers: Two surveys of computer-related attitudes. *Sex Roles*, 13(3-4):215-228, 1985.

Authors Addresses

Kori Inkpen, Kellogg S. Booth and Maria Klawe: Department of Computer Science, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada. {inkpen, ksbooth, klawe} @cs.ubc.ca;

Rena Upitis: Faculty of Education, Queen’s University, Kingston, Ontario, K7L 3N6, Canada. upitis@?????;