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"Does Yours Eat Leaves?" Cooperative Learning in an Educational Software Task

ERIK F. STROMMEN
Children's Television Workshop
One Lincoln Plaza, New York, NY 10023, USA

Twenty-eight pairs of fourth grade children (mean age 10 years) were observed using an educational software game under two conditions. In the cooperative condition, two children played as a team against the computer. In the competitive condition, two children played against each other. No special instructions were given in either condition. Results indicated that the cooperative condition gave rise to more correct answers than did the competitive condition. An analysis of strategies used in both conditions indicated that the only strategies significantly related to obtaining the correct answer were those that involved the two children working together and that these strategies were significantly more frequent in the cooperative condition.

In recent years, educational researchers have documented the highly profitable learning effects of pairing interactive technologies such as computers with cooperative learning contexts. *Cooperative learning* is the name given to a varied set of instructional methods, all of which capitalize on the pedagogical power of the social interaction of children when working collectively on learning tasks. The relatively consistent experimental success of cooperative learning methods (D.W. Johnson, Maruyama, R.T. Johnson, Nelson, & Skon, 1981; Slavin, 1983) has been sufficiently strong that guidelines for teachers on how to optimally organize cooperative instructional contexts have been published in the educational literature (cf. Sharan & Sharan, 1989; Wizer, 1987).

Computers appear to have been joined to cooperative learning for primarily pragmatic reasons. Observations of school children using computers indicate that they spontaneously gather in social groups of two or more to use a computer, a phenomenon suggested to be analogous to the behavior of children grouping together around game machines in video arcades (D.W. Johnson & R.T. Johnson, 1986). This finding, combined with the fact that very few schools can provide a single machine for each student, has led to the adaptation of cooperative learning methods for teaching with technology, a marriage of convenience that has produced highly fruitful offspring.

Despite the proven success of cooperative methods in promoting achievement on a variety of measures, the precise processes responsible for the effectiveness of cooperative learning are not clear (Lambiotte et al., 1987; Slavin, 1987). Some researchers identify the metacognitive benefits of having to verbalize one's own reasoning as the source of gains in achievement in cooperative contexts (Fletcher, 1985; Lambiotte et al., 1987); others highlight the benefits of teaching another person as a force for learning (Webb, 1982, 1984), and still others identify the motivational value of group goals and shared rewards as the significant aspect of cooperative learning (R.T. Johnson, D.W. Johnson, & Stanne, 1986; Slavin, 1983). These studies typically involve comparing independent groups of students in cooperative, competitive, and individual motivation contexts and assessing differences in achievement among the groups after a specified length of time.

One shortcoming of studies comparing cooperative and other learning contexts as they interact with technology is that the experimental groups are often closely structured by explicitly providing incentives for cooperative and competitive behavior and even by giving instruction in specific cooperative methods to use (being instructed to take turns at the keyboard, for example) (cf. R.T. Johnson, D.W. Johnson et al., 1986; Wizer, 1987). The differential effects of these varied instructions have not been compared. The present study takes a different approach. The goal is to assess the differences and similarities in children's performance on a computer-based learning task under cooperative and competitive conditions and in the absence of any explicit instruction. Does cooperative performance spontaneously give rise to qualitatively distinct (and more effective) strategies than competitive performance? If children spontaneously adopt strategies in the cooperative and competitive contexts that are qualitatively distinct, this would suggest that the social processes invoked by cooperative contexts and competitive contexts naturally give rise to differential problem-solving strategies. If the strategies generated under both conditions are qualitatively similar, however, then the differentially effective strategies observed in recent studies of cooperative learning may be more the result of the experimental instructions than of the unique qualities of the different social contexts they are deployed in. Either result has important implications for instructional technology and methods for its use.

METHOD

Participants

A racially diverse sample of 56 fourth grade children, drawn from schools in the New York City metropolitan area, served as subjects (mean age = 122.53 months, or 10 years). Equal numbers of boys and girls were tested. All children were performing at grade level, and none were identified as having learning problems. All the students had previous computer experience in the form of a weekly computer class. The curriculum in this class was oriented toward touch-typing, word-processing, and drill-and-practice mathematical experience.

Materials

The software used in the present study was *3-2-1 Contact: Wild Things* (Children's Television Workshop, 1991), an educational computer game designed for use by third- through sixth-grade students. It is intended to promote learning in two areas: natural science knowledge and the accurate usage of reference materials. The program is organized along the lines of a simple board game, the goal of which is to be the first player to reach a predesignated space on the board. Movement distance is chosen by the player (up to three spaces at a time), but direction of movement is dependent upon correctly matching animals and plants on a variety of shared attributes. The children are presented with a target animal, a list of four alternative animals (one corresponding to each direction of movement), and a wild card that can move the player anywhere on the board. They are also presented with five unique comparative statements such as "Both inhabit boreal forests" and "Both are fierce predators." All five statements are true of the target animal, but one and only one is true of each one of the alternative animals or the wild card. To move in a given direction, the child must select the animal or plant associated with his or her desired direction of movement and then select the statement believed to be true for both the target animal and the animal associated with the desired direction of movement. An accompanying reference text, which includes a glossary of vocabulary words, provides an alphabetical listing of all the animals in the game and describs them in brief paragraphs that contain all the traits to be encountered in the attribute statements. If the child selects the correct matching attribute, the child's piece moves the selected number of spaces in the desired direction on the game screen. If the answer is incorrect and the correct answer is one of the animals associated with a direction, the child's piece moves in that direction. If the child is incorrect and the correct answer matches the mystery organism, the piece is moved to a random location on the board. In the two-player game, each player takes turns going through this sequence. In the one-player game, the computer simply moves toward the goal on its turn, and the children repeat the above sequence for each of their moves as a team.

Procedure

The children were tested in same-sex pairs in a room separate from their classrooms. Homogeneous same-sex pairs were chosen for this study because the literature on gender differences and cross-gender effects in cooperation is inconsistent (cf. Dalton, 1990; Engelhard & Monsaas, 1989), and cross-gender effects were not a focus of the present study. They were provided with two reference books so that each child could look up information on animals if he or she wanted. The children were randomly assigned to one of two conditions. In the collaborative condition, the children were simply told that they would "play together as a team" against the computer, and they played the one-player version of the game together. In this version, the children execute the sequence described above for their move, and on its turn, the computer simply moves toward the goal. In the competitive condition, the two children played against each other using the two-player version of the program. In this version, each player takes turns going through the sequence described above. At the completion of the sequence, control of the game goes to the other player.

The children were shown how the game worked through a step-by-step introduction during the first move. They were then left on their own to play as they liked, with an Experimenter available if they had questions about how to play. All sessions were videotaped for later scoring.

Scoring

Within each game, the children's performance on each move was scored for the presence of a variety of behaviors deployed to find the correct statement needed to move in the desired direction (see Table 1 for the definitions of the strategies observed). The list of strategies was identified based on pilot data observations and from careful assessment of the videotaped data in the present study and represents all the types of performance observed in the study. If a given strategy occurred during a move it was scored as being present on that move regardless of how much time was spent using the strategy or how many times the strategy was engaged in during the move. All the scores for each behavior were then summed across the total moves for each pair of children and divided by the total number of moves in the game, yielding a standardized score reflecting the proportion of total moves on which each behavior was demonstrated, expressed as a percentage. Two raters scored 50% of the sample, and average inter-rater reliability of the scoring system across two raters was found to be 92%, with disagreements resolved through discussion.

Table 1

Behaviors Deployed by Pairs of Children Working Collaboratively or Competitively on the Computer

Behavior	*Description*
Guesses answer	Children select answer for no apparent reason,or explicitly state they are just guessing.
Uses picture to find answer	Children use graphic images to determine accuracy of attribute (whether animal has eight legs, horns, etc.).
Uses process of elimination	Rather than using book, children use prior knowledge and strategy of eliminating unlikely options to find answer.
One child reads book	One child looks up information in the reference text while the other waits.
Both children read about the same animal	Both children look up the same animal and read about it simultaneously and then discuss the information.
Each child reads about a different animal	Each child in a pair looks up a different animal, and they discuss them.
Children compare personal ideas or information on animals.	The children verbally share information not read in the book about the animals on the screen.

RESULTS

For all the results described below, the unit of analysis was not individual children but the *pair* of children playing the game whether in the collaborative or competitive game; the average frequencies of each strategy for each condition are shown in Table 2. Unless otherwise noted, all analyses were conducted using 2 (Game Condition) × 2 (Sex of Pair) ANOVAs. The percent of trials on which correct answers to the game problems were found shows significant game effects, $F(1, 19) = 12.34$, $p < .002$, with more correct answers obtained in the collaborative than in the competitive game (76% correct vs. 56% correct).

Table 2
Mean Percent Corrent Answers and Mean Percent of Trials on which Observed Strategies were Used—for Each Condition

Strategy	*Condition* *Collaborative*	*Competitive*
Guesses answer	3% (5)	10% (10)
Uses picture to find answer	2% (3)	7% (9)
One child reads book	14% (14)	26% (19)
Both children read about same animal	38% (28)	20% (20)
Each child reads about a different animal	16% (20)	-- --
Children compare ideas or information on animals	31% (23)	8% (13)
Percent correct answers	76% (15)	56% (15)

Note: N = 28 pairs for each condition. Standard deviations are indicated in parenthesis. No means for the process of elimination are presented, due to too few pairs demonstrating this strategy (see text).

The lack of a strategy, or failure to use one, was manifested by guessing behavior, where an answer was chosen at random rather than actively selected. The percent of trials on which guessing occurred shows a significant effect for game type, $F(1, 19) = 6.81$, $p < .02$, $M = 3\%$ for the collaborative version and $M = 10\%$ for the competitive version, suggesting that the collaborative game leads to more strategic performance and less guessing overall.

A consideration of specific strategies observed in the present study suggests a pattern of differences favoring the collaborative condition. Relying on the graphics of the animals in the game to confirm animal traits is a rather low-level strategy and can only be effectively exploited for very concrete traits that can be assessed visually (number of legs, whether the animal is aquatic, etc.). There was no significant condition effect for the use of this strategy, but a trend toward its increased use in the competitive condition was noted, $F(1, 24) = 2.78$, $p < .10$, $M = 7\%$ of trials for the competitive game and $M = 2\%$ for the collaborative version. Another relatively low-level strategy involves using a process of elimination to find the answer. This strategy involves simply looking at the animals and the listed attributes and trying to find the desired answer by eliminating unlikely choices. While this was a very low-frequency strategy (80% of children in both conditions did not use it), an examination of the five pairs of children who did use it reveals that the three pairs of children in the competitive game used this strategy on 4%, 5%, and 7% of trials, respectively. However, the two pairs of children in the collaborative condition used a process of elimination on 13% and 25% of trials. While the number of observations is too small to allow clear conclusions, these results suggest that the process of elimination is promoted by having two children actively working on the strategy rather than one player or the other using it alone.

The books provided with the game are the chief source of the information for solving the game problems. How the books are used showed distinct influences of the competitive vs. collaborative contexts in the study. While not statistically significant, there is a notable difference between conditions for one child reading the book, $F(1, 24) = 4.07$, $p < .055$, $M = 26\%$ of trials for the competitive condition and $M = 14\%$ of trials for the cooperative condition. Typically, in the competitive condition, the child who was making the move would use the book, reading silently and even hiding the text from his/her opponent. Children in the collaborative condition, in contrast, tended to collectively decide who would use the book, sometimes taking turns but more often simply having one child take charge of looking up information and reading it aloud while the other read screen items and confirmed matches or mismatches between the screen items and the material read aloud from the book.

When both children read the books at the same time, there were two ways they could proceed. First, both children could look up the same information simultaneously. In the competitive condition, reading about the animals in the opponent's problem when it is not one's turn appears to have been done simply to find the correct answer to the problem before the opponent did in order to (a) tease him/her ("I know it and you don't!"), (b) determine if he/she is correct and try to dissuade him/her from the correct answer, or (c) determine the correct answer for one's own interest. In the cooperative condition, in contrast, reading about the same animal together allowed for sharing of read information, sharing of assistance with difficult passages, and collective consideration of whether the information being read matched that in the problem. The percentage of trials in which both children looked up the same information at the same time shows a condition effect that borders on significance, $F(1, 24) = 3.89$, $p < .06$, $M = 38\%$ of trials in the collaborative condition and $M = 20\%$ of trials in the competitive version; there is also a significant effect for sex, $F(1, 24) = 6.12$, $p < .02$. This effect is due to the fact that girls read about the same animal together more than twice as often as did boys, $M = 41\%$ of trials for girls, $M = 19\%$ of trials for boys.

The second strategy for both children reading simultaneously was unique to the collaborative condition: each child separately reading a different animal and then comparing the traits s/he read to those listed on the question-screen or to those read by his/her partner. For example, two children comparing animals in the book conducted exchanges such as "Does yours eat leaves?," "No. . .is yours main camouflage to hide?," "No . . .does yours live in a boreal forest?," and so on until commonalities were identified. Pairs of children in the collaborative condition used this strategy on an average of 16% of trials. In addition, while the effect is not significant, pairs of girls did use this strategy more than did pairs of boys, $M = 11\%$ of trials for girls but $M = 6\%$ of trials for boys.

The children also used a strategy of sharing and discussing their own knowledge of the animals, drawn from other sources, to find answers. Several children, for example, drew on popular movies or previous class lessons to find their answers. For example, one child knew that turtles had beaks because of a line from the *Teenage Mutant Ninja Turtles* movie: "Keep your beak out of other people's business." Another knew that scorpions were nocturnal because of an incident in the movie *Honey, I Shrunk the Kids*. Discussing previous knowledge in this way shows a significant main effect for game type, $F(1, 19) = 11.53$, $p < .003$, $M = 31\%$ of trials for the collaborative game and $M = 8\%$ of trials for the competitive game.

How effective are the above strategies, and does their effectiveness vary with the collaborative or competitive conditions under which they are deployed? To answer this question, the percentage of trials on which given strategies were used by children was correlated with the total number of correct answers they obtained during game play. The results, computed separately for each condition, are shown in Table 3. As the table indicates, the most valuable strategies for obtaining the correct answers are those that involve both children using the books or exchanging information.

Table 3
Correlations between Various Strategies and Obtaining the Correct Answer on Game Problems

Strategy	*Correlation with Finding Correct Answer*	
	Collaborative	*Competitive*
Guesses answer	-.25	.14
Uses picture to find answer	-.28	-.06
One child reads book	-.36	-.01
Both children read about same animal	.65*	.41
Each child reads about a different animal	.56*	
Children compare ideas or information on animals	.53*	.62*

Note: * = $p < .05$

Motivation During Game Play

Bored behaviors were defined as: (a) listless movement (tapping fingers, humming), (b) slouching in the seat, and (c) voicing impatience with the length of time the opponent was taking to make his or her move. Results indicate a main effect for game type $F(1, 19) = 24.77$, $p < .0001$, $M = 2\%$ of trials in the collaborative version and $M = 19\%$ of trials in the competitive version. The fact that almost one-fifth of trials in the competitive condition give rise to bored behavior appears to be related to the fact that in this game one player has to wait while the other makes his/her move, chooses an answer, or looks up information. In the competitive game, in fact, the waiting player not infrequently started helping the other or looking up information herself, as described above.

DISCUSSION

The purpose of the present study was to assess the unelicited and untutored strategies deployed by children when asked to use technology in cooperative and competitive contexts and to determine if these strategies are differentially effective across the two conditions. The results suggest that with little or no encouragement, children spontaneously combine their efforts in effective ways when asked to work together on an activity. Children worked together in a variety of ways in the cooperative condition, reading the books and exchanging information as they collectively tackled the game problems. There was significantly less guessing, less use of the rather shallow method of trying to use the pictures of the animals being compared to solve the problem, and less bored behavior as well. It is particularly notable that the strategy of each child reading about a different animal and both simultaneously comparing their traits, a strategy highly related to obtaining the correct answer, only appeared in the cooperative condition. The cooperative strategies were not simply motivational either: They showed notable correlations with obtaining the correct answer as well, giving substantive support to the overall impression that the cooperative condition produced a more efficient, deeper use of intellectual resources than the competitive condition.

Perhaps most striking, however, is that with the exception of each child reading about a different animal, the same strategies that are effective in the cooperative condition are also deployed in the competitive condition, but much less frequently. A minority of children in the competitive condition appeared to be unable to resist assisting their opponent in finding an answer even though the competitive context mitigated against such behavior. This finding suggests that children may have a tendency toward collaboration, one strong enough to override the desire for dominance and victory that is typically present in a competitive situation.

The present findings suggest two directions for future studies of cooperative learning and its effectiveness. First, given the finding that children with *no* specific training in cooperative strategies spontaneously produced strategies that increased their achievement, the actual efficacy of specific cooperative curricula needs to be more carefully scrutinized. In studies of cooperative versus other forms of learning, experimenters should consider adding a control group of students who do not receive the instructional intervention being studied but who are assigned to simply perform cooperatively together at the computer. This would allow the spontaneous effects of the cooperative context and those of the specific intervention to be assessed separately.

Second, the present results make it clear that more careful studies of children's spontaneous cooperation are in order. The methods children adopted for the present tasks of extracting reference information and discriminating among competing choices were based on the obtaining and sharing of information, the reflection on answers and their validity, and the creation of a consensus on which choices to select. Detailed consideration of the structure of such strategies and of how children distribute among themselves the subtasks that comprise them may lead to more effective instructional methods, ones that capitalize on and supplement the natural behaviors of children.

In conclusion, the results of the present study suggest that the cooperative use of a properly designed technology application produces positive and effective cognitive activity in children even in the absence of specific training in cooperative strategies and methods. The urge to work cooperatively is apparently strong enough that even children in a nominally competitive situation could not resist aiding their opponents every now and then, using the same methods as children in the cooperative condition. By exploring the ways in which children create their own collaborative efforts in more detail and by building on their seemingly spontaneous desire to work together to solve challenging problems, it should be possible to develop a rich variety of cooperative technology-based projects for children that capitalize on the best features of both the technology and children's reasoning ability to increase the effectiveness of classroom education.

References

Children's Television Workshop. (1991). *3-2-1 contact: Wild things* [Computer program]. Scotts Valley, CA: Wings for Learning.

Dalton, D.W. (1990). The effects of cooperative learning strategies on achievement and attitudes during interactive video. *Journal of Computer-Based Instruction, 17*(1), 8–16.

Engelhard, G., Jr., & Monsaas, J.A. (1989). Academic performance, gender, and the cooperative attitudes of third, fifth, seventh graders. *Journal of Research and Development in Education, 22*, 13–17.

Fletcher, B.C. (1985). Group and individual learning of junior school children on a microcomputer-based task: Social or cognitive facilitation? *Educational Review, 37*, 251–261.

Johnson, D.W., & Johnson, R.T. (1986, January). Computer-assisted cooperative learning. *Educational Technology*, pp. 12–18.

Johnson, R.T., Johnson, D.W., & Stanne, M.B. (1986). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. *Journal of Educational Psychology, 77*, 668–677.

Johnson, D.W., Maruyama, G., Johnson, R.T., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological Bulletin, 89*, 47–62.

Lambiotte, J.G., Danserau, D.F., Rocklin, T.R., Fletcher, B., Hythecker, V.I., Larson, C.O., & O'Donnell, A.M. (1987). Cooperative learning and test taking: Transfer of skills. *Contemporary Educational Psychology, 12*, 52–61.

Sharan, Y., & Sharan, S. (1989, December/January). Group investigation expands cooperative learning. *Educational Leadership*, pp. 17–21.

Slavin, R.E. (1983). When does cooperative learning increase student achievement? *Psychological Bulletin, 94*, 429–455.

Slavin, R.E. (1987). Developmental and motivational perspectives on cooperative learning: A reconciliation. *Child Development, 58*, 1161–1167.

Webb, N.M. (1982). Peer interaction and learning in cooperative small groups. *Journal of Educational Psychology, 74*, 642–655.

Webb, N.M.(1984). Microcomputer learning in small groups: Cognitive requirements and group processes. *Journal of Educational Psychology, 76*, 1076–1088.

Wizer, D.R. (1987). Cooperative learning with microcomputers. *The Pointer, 32*(1), 31–33.

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