Computers and Cooperative Learning: A Literature Review

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Abstract

This paper summarizes research from more than 100 studies examining aspects of computers and cooperative learning. Key aspects of researching these factors, such as gender, training, ability, group size, and ethnicity are identified. Calls for future research are identified in the areas of training and cooperative learning regarding computers in the schools.

Computers and Cooperative Learning: A Literature Review

For more than 100 years, educational, developmental, and social psychologists have researched and developed theoretical explanations for how students learn, remember, and, as a result, know. Several of the most important theories have originated from attempts to understand and explain child development.

Early cognitive theorists (e.g., Piaget, 1926) were interested in the ways cognition developed – the faculty of knowing. Piaget believed that young children's thoughts influenced their language and viewed children's thoughts as important to the outcome of the developmental process. Piaget focused his interest on how a child's interaction with the environment leads to the progressive development of cognitive abilities. He further acknowledged that interaction with other children or peers stimulates children to become more aware of the perspectives of others. Unfortunately, Piaget was not able to explain children's individual differences, factors that account for these differences, or ways to promote intellectual development.

Behaviorist theorists focused on learning as a function of items such as reinforcement and punishment but also strongly promoted the importance of the environment as the principal force shaping development. Early behaviorists (Pavlov, 1927; Skinner, 1953, 1957, 1961, 1968; Watson, 1925) focused on the child's immediate behavior and the environmental forces (conditioning – both classical and operant) that affect the behavior. Behaviorists contend development can be best understood through the analysis of specific behaviors, the circumstances leading to them, and their consequences. In addition, behaviorist theories are poorly suited to explain higher mental processes (e.g., thinking, feeling, analyzing, problem solving, evaluating, etc).

In order to overcome apparent deficiencies inherent in previous explanations of how humans learn, remember, and consequently know, many researchers have attempted to combine the best elements from various theories. A growing number of contemporary educational researchers as well as developmental psychologists are profoundly influenced by social cognitive theories. These theories of social cognitivism blend the best of the behaviorist tenets (recognizing that learning involves models of various kinds that act as social influences on the child) with the best of the cognitive tenets (recognizing the importance of a child's ability to reason, to uncover cause-and-effect relationships, and to anticipate the outcomes of behavior). Bandura's (1977, 1981, 1986) observational theory originally stemmed directly from a behavioristic orientation but has become progressively more cognitive and concerned with knowing, understanding, thinking and mental processes.

Bandura's theory is an application of operant conditioning based on the effects of imitation. He describes four processes involved in observational learning: (a) *attentional* processes in which the observer attends to important aspects of the model's behaviors; (b) *retentional* processes in which the observer mentally represents, in images or words, and stores in memory what has been observed; (c) *production* processes that make possible the performance of the observed behavior and; (d) *motivational* processes that lead to actual performance rather than acquiring behavior without performance. The three manifestations of observational learning are (1) the acquisition of novel responses (the modeling effect); (2) the inhibition or disinhibition of deviant responses (the inhibitory or disinhibitory effect), and (3) the encouragement of behaviors that are neither novel nor deviant but that are directly related to those of a model (the eliciting effect).

The question of how humans learn, remember, and know was being researched and investigated in 1902 and it is being researched and investigated in 2002. Research journals publish articles that investigate and produce evidence regarding new and potentially innovative instructional strategies (individualistic vs. collaborative; competitive vs. cooperative), the influence of new instructional technologies (computer-based instruction vs. face-to-face instruction) on the facilitation of knowledge, and the ability of students to learn without adequate training (a.k.a., in spite of their teachers).

The theory and research that educational, developmental, and social psychologists have developed over more than a century should not be abandoned. Instead, one should assimilate, extend, and test current applications of competing theoretical explanations for how humans learn, remember, and, consequently, know. For example, if one takes Vygotsky's (1962, 1978) proposal that social interaction through language and with adults and cognitively advanced children facilitates cognitive development and combines it with Bandura's (1971, 1981, 1986) observational (social) learning theory, then one is better able to compare individuals receiving computer-based instruction with trained cooperative learners who also receive computer-based instruction. This comparison allows a prediction about the potential benefits of trained social interaction to facilitate cognitive learning.

Social Interdependence Theory

Social interdependence exists when individuals share similar purposes for a task; success is also shared and relies on others' actions (Johnson & Johnson, 1996). Deutsch's (1949b) theory of cooperation and competition provided a focal point for the formulation of social interdependence theories in the mid- to late 1900s. Johnson and Johnson stated that Deutsch's theory of cooperation and competition, established on the work of Lewin, was the focal point of more recent studies of cooperative learning (1991).

Lewin

Johnson and Johnson (1996) credited social interdependence theory's origin to Kurt Lewin and the Gestalt school of psychology. Gestalt psychology studies how people view and comprehend the relation of the whole to the parts that make up that whole (Winn & Snyder, 1996). The ideas of the Gestalt school of psychology concerning the structure of social groups have influenced the use of cooperative learning. It is no longer necessary, as Lewin (1947) claimed it once was, for researchers to argue the very existence of a group within a societal structure.

Deutsch

Deutsch (1949a; 1949b) extended Lewin's theories and formed a theory of cooperation and competition. Deutsch recognized three types of social interdependence: positive, negative, and an absence of social interdependence. Under Deutsch's view, the type of interdependence within a situation determined an individual's interactions, which subsequently determined outcomes (Johnson & Johnson, 1996).

Positive interdependence is seen as promoting interaction among group members. Negative interdependence is seen as detracting from group interaction. The condition of no interdependence is the result of an absence of group interaction. The idea of interdependence among group members has influenced most of those investigating questions centered on cooperative learning, most notably, D. Johnson and R. Johnson as well as Slavin.

Cooperative Learning Theory

Three of the most prominent researchers of cooperative learning are Slavin and Johnson and Johnson. Analyzing their work lends a unique perspective to formal, structured cooperative learning. Slavin (1994) believed all cooperative learning methods had certain shared central ideas. In cooperative learning, students work together to learn and are responsible for one another's learning as well as individual learning. Johnson and Johnson (1996) defined cooperative learning as the pedagogical use of small groups of two or more students who work together to maximize their own and each other's learning.

Johnson and Johnson identify four types of cooperative learning. In formal cooperative learning, students work together to achieve shared learning goals and jointly complete educational tasks (Johnson & Johnson, 1996). Formal cooperative learning also proposes that teachers should tell the students the objectives for the lesson, make several preinstructional planning decisions, clearly explain the task to the students (as well as the need for positive interdependence), monitor student learning, intervene to provide assistance, and, finally, evaluate students' learning and help the students evaluate their own learning.

In the second type, informal cooperative learning, teachers assign students to work together to achieve a joint learning goal. The learning groups are temporary and meet for small periods of time (Johnson & Johnson, 1996).

The third type of cooperative learning is the cooperative base group which consists of stable membership over a long time period and group members of mixed ability (Johnson & Johnson, 1996). Base groups are established to support peer group members throughout the academic year with the goals of making academic progress along with positive cognitive and social development. Cooperative base groups typically are seen in formal cooperative learning settings.

The fourth type of cooperative learning is academic controversy, in which one student's thoughts, ideas, or other knowledge formulations are incompatible with those of a second student and the two seek to reach an agreement (Johnson & Johnson, 1996). Academic controversy also can consist of formal or informal cooperative learning.

Other significant cooperative learning methods articulated by Slavin (1994) include Student Teams-Achievement Divisions (STAD), Teams-Games-Tournament (TGT), Team Assisted Individualization (TAI), Jigsaw, and group investigation. STAD consists of five major components. These parts are class presentations, team activities, quizzes, individual improvement evaluations, and team recognition. TGT is similar to the STAD approach to cooperative learning with one significant instructional difference: TGT uses academic tournaments instead of quizzes and individual improvement scores. TAI is focused on the individualization of mathematics instruction and uses a specialized set of curriculum materials. Jigsaw is a form of instruction using cooperative learning techniques and is most appropriate when curriculum material is in written narrative form. Students working in Jigsaw, STAD, TAI, and TGT all work in heterogeneous teams.

Group investigation is a form of cooperative learning that dates back to John Dewey (1974). Student success using group investigation requires prior training in communication and social skills. For decades, many researchers have investigated the impact of students working together in instructional situations.

Reviews of Cooperative Learning Without Computers

The role of cooperative, competitive, and individual effort on achievement and performance has been investigated in the laboratory since the 1920s (Maller, 1929). Deutsch (1949b) presented an influential theory of cooperation and competition concerning their effects on small group functioning. The theory proposed an effect of strength of group membership and degree of unity for the functioning of small groups. In a subsequent article, Deutsch (1949a) reported the results of an experimental study generally supporting his theory of cooperation and competition. The study noted increased coordination of efforts between group members, greater diversity in amount of contributions per member, higher levels of subdivision of activity, and multiple levels of communication improvement between group members.

Slavin (1980) reviewed 28 cooperative learning field projects that compared the effectiveness of cooperative and traditional learning strategies. A primary conclusion drawn by Slavin was that cooperative learning techniques were no worse than traditional techniques for academic achievement. In most cases, they were significantly better. Johnson, Maryuama, Johnson, Nelson and Skon (1981) reviewed 122 studies comparing the relative effectiveness of cooperative groupings, competitive groupings, and individual goal structures. They drew the following conclusions from the statistical meta-analysis: (a) cooperation was considerably more effective than interpersonal competition and individualistic efforts, (b) cooperation with intergroup competition was also superior to interpersonal competition and individualistic efforts, and (c) no significant difference existed between interpersonal competitive and individualistic efforts. Slavin (1983) conducted another review of research on the achievement effects of cooperative learning strategies. Performance was higher in cooperative learning groups versus control groups for 29 of the 46 studies included in his review. Slavin concluded that enhancement of student achievement could occur when cooperative methods that used group study and group rewards for individual learning were incorporated into instruction.

The use of personal computers in classrooms to assist students in achieving cooperative learning goals has increased since the 1980s (Slavin, 1980). Initially, a concern existed that the introduction of computers would adversely affect the development of students' social and communication skills. This concern has not been realized as students often work together with computers. Increased communication and social activity has actually occurred in many instructional settings that use computers. In some cases the instructor planned for group work. In many instances using a group work strategy increased student access to the few computers available.

Reviews of Cooperative Learning With Computers

Webb (1987) reviewed the literature concerning peer interaction and learning with computers in groups. The goals of this review were to determine the following: (a) the pros and cons of group work for learning, (b) the types of verbal interactions that occur when small groups of students work at a computer, and (c) the types of interactions that were beneficial or detrimental to learning. She concluded that group work with computers was a feasible and capable way to learn. According to Webb, it was possible to design group-learning settings that benefited most students (Webb, 1987). Hooper and Hannafin (1991), Rysavy and Sales (1991), and Simpson (1986) also published literature reviews or discussions of cooperative learning and computer-based instruction. All three articles found numerous positive influences of computers and cooperative learning.

Summary Guide to the Literature: Cooperative Learning and Computer-Based Instruction

A comprehensive study of the literature revealed significant effects for more than 134 experimental comparisons. Appendix A contains a summary of these comparisons.

Computers and Cooperative Learning: Individual and Group Variables

In their writings on the processes of computer-assisted cooperative learning, D. Johnson and R. Johnson (1996) identify several key functions of group learning. These are positive interdependence, equality of participation, co-construction of ideas, giving and receiving help, promotive interaction, division of labor and conflict and controversy. Positive interdependence exists within a group when all members of a group believe that success is a joint endeavor. Group members are required to work together to achieve mutual, not individual, success. Equality of participation means that members of the group and the group as a whole are accountable. Group accountability exists when group performance is measured according to a particular criterion as opposed to individual accountability which exists when the performance of individuals is assessed, and results of that assessment are returned to the group for comparison against a measure of performance. Group members are held responsible for contributing an equitable share to the success of the group and the group typically reviews individual assessments. Promotive interaction occurs when members of a group encourage and facilitate other members' tasks in order to reach the goals of the group. Giving and receiving help occurs as group members aid each other in the pursuit of their mutual task. Division of labor is the process of dividing the group task into manageable sub-tasks for group members. Conflict and controversy, also a part of the cooperative process, occur as group members negotiate over the group task. Co-construction of ideas occurs as the learning occurs: Group members pursue a task and create a jointly constructed idea of their response to the instructional task.

Roschelle and Teasley (1995) examined the construction of shared knowledge in joint computerized problem-solving space. The computerized problem-solving space created for their research was viewed as essential to the completion of the cooperative task. The cooperative task was to view a graphical simulation of the concepts of velocity and acceleration. Researchers observed that the use of the computer created a space for clarifying discussions between group members. Cooperative computerized activities were seen as a means of resolving conflict or impasses. The specially designed interface was a device that both invited and constrained students' interpretations of dyad members' communications.

Rubtsov (1992) examined joint action at the computer. He constructed several principles following his research with a coordinated computerized task between dyad members. Several conclusions were derived from this research regarding the stages of joint action organization. During the initial stage of the research, participants were concerned with the immediate external consequences of their action. Gradually, students realized the way that their individual actions were distributed in relation to each another and the level of coordination between the two. Different levels of achievement were related to different levels of participant awareness regarding the relation between the structure of their coordinated action and the structure of the corresponding outcome.

Scardamalia, Bereiter, Mclean, Swallow and Woodruff (1989) examined several instances of joint construction of ideas in their investigation of *C*omputer *S*upported *I*ntentional *L*earning *E*nvironments (CSILE). Students who were using a CSILE were provided a means to build a collective networked database examining a particular educational idea. Scardamalia et al. (1989) maintained that the use of a networked CSILE aided in student construction of ideas through the use of direct contributions by students as they prepared for class contributions. Students were aided in the acquisition of higher-order executive control of the learning process. The CSILE endeavor was one of the most extensively researched projects (Oshima, 1989; Scardamalia, 1989; Scardamalia et al., 1989; Scardamalia & Bereitner, 1991; Scardamalia et al., 1992; Scardamalia et al., 1994; Oshima, Bereitner, & Scardamalia, 1995; Oshima, Scardamalia, & Bereitner, 1996; Scardamalia & Bereitner, 1996) in cooperative computer-based instruction in the recent decade.

Researchers have found the area of conflict and controversy among members of a cooperative group worthy of considerable attention. Howe, Tolmie, Anderson and Mackenzie (1992) examined the role of group interaction in computer-supported teaching. In their summary of multiple studies, Howe, Tolmie and Mackenzie (1995) maintained a general principle that software that supports computerized group work should require students to explicitly state and agree on their joint predictions. Agreement, as the Piagetian perspective provides, is only arrived at in a group situation by means of explored conflict. Joiner (1995) examined the dialog of students engaged in a cooperative group task. His research showed that modeled predictions of student interactions resolving conflict did exist. This research provided the basis for modeling conflict-generating situations.

Clements and Nastasi (1988) have examined the role of conflict and controversy in their program of research into Logo-based educational environments. Logo is a computer-based programming language originated by Papert of the Massachusetts Institute of Technology (1993). In one representative study, Clements and Nastasi (1988) found significant group differences among groups of students using Logo for conflict resolution, rule determination, and self-directed work. They did not find large differences between students using traditional computer-aided instruction and students using Logo-based instruction. These researchers did, however, find that both Logo- and computer-aided instructional environments encouraged interaction and decision-making skills among subjects.

Studies organized by D. Johnson and R. Johnson were extremely influential in the investigation of cooperative learning strategies. In an article summarizing several pieces of research (1993), they stated that cooperative learning promoted greater levels of oral discussion of curriculum material, higher achievement, and frequent use of higher-order reasoning strategies when compared with competitive and individualistic learning.

Group Processes

Numerous researchers have examined different aspects of group processes, both in the traditional study of cooperative learning situations and in the newer study of computer-based cooperative learning. Webb and Lewis (1988) examined several aspects of help-giving behavior during their program of research and discovered that several factors of student discussions reflected positive correlations. These correlated behaviors included giving explanations and input suggestions, receiving responses to questions, and receiving input suggestions in a group programming exercise.

Researchers did not find positive correlations in the verbalization of help-giving behavior. Jackson, Fletcher, and Messer (1992) found no significant effect of verbalization on performance. Their experimental findings, however, were tempered by a highly visual component of the experimental task. Laurillard (1992) found that non-canonical display diagrams, direct manipulation interfaces, and time-based constraints all serve to enhance reflective dialogue in a cooperative computerized instructional situation. These results reflect a realization few researchers have examined: The design of the interface for the cooperative computerized task was often as important as the design of the task itself.

Hooper (1992) extensively researched behaviors surrounding the cooperative behaviors of giving and receiving help while using a computer between higher- and lower-ability students. He found that high-ability students generated and received significantly more help in groups of similar ability levels than when placed in groups of mixed ability levels. Hooper's findings also suggested that, when grouped heterogeneously, high-ability students received lower amounts of stimulation in conversation with lower-ability students. Sherman (1994) examined help-giving behavior. He found that dyads using a cued HyperCard version of a treatment showed significantly more helping behaviors than those who used a noncued version of the same treatment. Several researchers noted that the use of prompting cues in programs has potentially beneficial effects in increasing helping behaviors.

Although several researchers examined behaviors surrounding the giving and receiving of help in cooperative computer use, a need for research still exists in this area. In a summary of past research and call for future studies, Light and Blaye (1990) emphasized the need for researchers to be able to specify the ways in which children solicit and gain help from those around them while working at the computer. This knowledge of socially mediated help should then be used to design help systems for computers. The research literature on computerized cooperative learning has focused primarily on helping behaviors. Equality of participation, social loafing, and division of labor are all areas that have been neglected in the literature.

Gender

More than 20 researchers have examined gender as an experimental factor. Underwood, McCaffrey and Underwood (1990) found that single gender pairs of elementary school children showed improvement in task performance when compared to the same children working individually. Mixed gender pairs showed no relative improvement. In a subsequent study, researchers found that girls tended to cooperate even when instructed not to organize or create roles for each other. Mixed pairs tended not to cooperate, even when instructed to share task work. Boys did not cooperate, unless so instructed specifically, after which their performance improved (Underwood, Jindal, & Underwood, 1994).

Tolmie and Howe (1993) also examined the question of gender differences between 82 twelve-to-fifteen-year-old members of cooperative computer-using pairs and found a convergence to the norms of the other gender in mixed groups. Males were observed to display more behaviors similar to those of females and females displayed more masculine behaviors, if the group members were aware of norms for each gender. Herschel (1994) examined group gender composition using a networked group support system environment. Herschel studied 61 groups consisting of 269 university students. In his study, Herschel found no significant differences between gender-based idea generation using the networked group environment. This study provided evidence of the leveling effect often seen within a networked environment. When groups interacted on an electronic basis using a networked environment, gender differences that typically occurred in a face-to-face setting were minimized. This finding contrasted with the Underwood studies cited earlier. The major difference between the findings of Herschel (1994) and Underwood et al. (1994) was the presence or absence of nonverbal communication factors. Age-related factors also accounted for differences between the two studies: Underwood (1994) examined children as research subjects and Herschel (1994) examined university students.

Yelland (1993) consistently examined gender as a variable in her research. In comparison of mixed and same gender pairs when performing Logo tasks, Yelland found minor differences between all boy and all girl pairs in examining the efficiency of tasks performed. Mixed gender pairs took twice as long to complete the task than did pairs of girls assigned to complete the same task (Yelland, 1994; Yelland, 1995).

Guntermann and Tovar (1987) found several significant results in their study examining the question of differences in social interaction behaviors while using computers. Male groups were observed to display more solidarity than were female or mixed groupings of students. Female group members were observed as much more likely to agree with peers than members of male groups. More questioning behaviors were observed in male groups than in female groups.

Research examining the interaction of cooperative learning and computing consistently uncovers positive effects when that research incorporates gender into research. Dalton, Hannafin and Hooper (1989) found significant gender interactions when examining attitude toward computer use. In Dalton's study, ratings for high-ability students on their attitudes regarding the computer-based instruction were largely unaffected by instructional method. Low-ability females had better attitudes regarding the cooperative computer-based treatment than did low-ability males (Dalton et al., 1989).

Ability

The consideration of ability has been a primary factor of investigation in researching computers and cooperative learning. Eraut (1995) reported several ability factors as experimentally significant during 19 different studies. When groups had members of higher academic ability there were positive correlations between ability and the areas of software management, programming experts, subject matter experts, and idea generation.

Groups have often been examined by high and low ability with regard to the experimental task. Researchers have found varying results when examining these factors. In looking at the use of ability as an experimental variable in eighth-grade students, Hooper and Hannafin (1988) found that grouping strategies appeared to have limited influence on high-ability students. Low-ability students grouped heterogeneously appeared to perform at higher levels than did their homogeneously grouped peers. Across several studies, Hooper (1992; 1993) found that instructional efficiency was not diminished when mixed ability members were grouped together.

Experiments (King, 1989) comparing cooperative computer use in groups of high and average ability found high-ability groups used significantly longer statements to describe the experimental task than did average ability groups. Sherman (1994) investigated the use of cued interaction and ability grouping during computer-based instruction (CBI). In his investigations, ability was viewed as a very strong performance predictor when students worked together during a CBI program. Students in lower ability dyads were reported to perform significantly worse on practice items than students in either mixed or higher ability dyads.

Group Size

Researchers have extensively studied differences between varying group size and individual learners. Amigues and Agostinelli (1992) found that students who worked alone on a computer used the computer more but did not necessarily show increased performance. In contrast, student pairs working together at the computer appeared to be more inclined to work on the solution inherent in the experimental situation and to give their answers more reflection.

Chernick (1990) examined students' performance under three conditions: interdependent, coactive, and individualized computer-based instruction. Significant main effects were found for condition across treatment effects that indicated subjects who worked in cooperative groups performed better than subjects who worked alone.

Eraut (1995) reported on a multi-year program that investigated group composition and group size as one of many research factors. These factors were listed as important for educators to consider when creating groups that will use computers. The first factor noted was the use of rotation, which detailed how often a student used the computer. A second consideration was the level of participation for group members. Group size apparently influenced the amount of dominant behavior by one member of the group. Groups of four seldom experienced one group member as a dominant member. Student marginalization, in which the group rather than one individual limited participation from an individual pupil, was reported to be more common in groups of four and five but occurred rarely in groups of three students. In pairs of subjects, dominance of one person was both more common and less easily remedied. Layout was observed to be a significant factor for groups of four or more students. Four or more students often sat in positions that made it difficult to see the computer screen or printed material. Hooper (1992) found consistently higher scores for students completing experimental tasks in groups when compared to individuals.

Ethnicity

Research examining race or ethnicity, as an experimental factor in cooperative computer-based instruction, does not exist within the studies identified. Race and ethnicity have been extensively studied in standard cooperative learning literature.

Training in Cooperative Learning Skills

Johnson, Johnson and Holubec (1993) describe three types of cooperative learning skills. The first, functioning skills, are needed to manage the group effort for task completion and to maintain effective interpersonal relationships. Formulating skills, the second set, provide the mental processes needed to build increased levels of understanding to stimulate the use of higher quality reasoning strategies, and to maximize mastery and retention of the assigned material. Finally, fermenting skills, allow students to participate in academic controversy.

Relatively few researchers have examined the use of training in cooperative learning skills as an experimental variable. Panitz (2001) has several writings promoting the need for training in cooperative and collaborative skills. Hooper, Temiyakarn, and Williams (1993) trained students on the use of cooperative learning techniques but did not measure the effects experimentally. Malouf, Wizer, Pilato and Grogan (1990) investigated the effect of training in cooperative learning techniques as an aid for special education students. Researchers documented an increase in cooperative learning interactions, which was the hypothesized experimental effect.

Repman (1993) compared three conditions in her experiments. Subjects were randomly placed in an unstructured setting, a structured setting, and a structured setting with training. Placing students in cooperative computer-based learning groups resulted in increased achievement in the content area. No differences were discovered regarding measures of critical thinking. Repman proposed that when students are provided with structure and training, then those techniques could be used to enhance instruction.

Theoretical Influences

The central emphasis of this study was to examine if computer-based instruction students, working in pairs and trained in cooperative learning skills, learn differently when compared to individual students completing similar computer-based instruction. The theoretical influences of this study examine an area of theory that contributes to the growth of cooperative learning theory. This study examined the effect of training on computer-based cooperative learning for students aged 18 or above. Researchers have examined the effect of training on fourth-grade and seventh-grade students. Other studies have not examined training on older students.

Relevant theoretical influences from the literature review are presented below. More than three hundred and fifty studies have examined the effect of training in cooperative learning situations. The ideas of D. Johnson and R. Johnson are the primary theoretical influences for this study. Relatively few other researchers have considered training in cooperative computer based instruction. Rocklin and O'Donnell considered the effects of training and cooperative learning on university students receiving computer-based instruction. They did not use Johnson and Johnson's cooperative learning strategies.

Carrier and Sales examined the differences between individual and cooperative computer-based instruction but did not train students in cooperative learning techniques. Clements and Nastasi completed a naturalistic comparison of students working together using two different types of computer-based instruction. Students were not trained in cooperative learning strategies but students were trained in Logo and a computer-assisted instructional program. Training in Logo consisted of training in the Logo programming language. The training in computer-assisted instructional programming consisted of instruction regarding five coordinate concepts creating shapes on the computer screen.

Hooper and Temiyakarn considered the question of training in a total of 175 fourth-grade students who were classified as being of high or average ability and randomly assigned to paired or individual treatments stratified by ability. Students completed training to enhance small-group interaction before completing a computer-based tutorial and a posttest. Following cooperative learning, students demonstrated increased achievement and efficiency as well as better attitudes toward both the computer lesson and grouping. Students completed more practice items and examples in program-control treatments than in learner-control treatments. However, the form of the lesson control did not affect students' achievement or attitudes.

Repman examined the kinds of elaborated verbal interactions that take place during group processing. In examinations of verbal interactions during group exchanges, most spontaneous student-student verbal interactions appeared to be limited to low level informational exchanges. In this study, the effect of methodology incorporating structure and training (designed to increase the level of elaborated interactions) was investigated. The students participating in the study were a sample of regular and at-risk seventh-grade social studies students engaged in a nine-week program of collaborative computer-based learning. Training led to increased rates of giving explanations and higher self-esteem, while structure (with or without training) resulted in improved content area achievement.

Based on the studies described above, it can be concluded that significant differences exist between individual computer-based learning learners and cooperative computer-based learning. There was no examination of a similar nature that included learners above the age group of 18 years or higher. No study examined the effect of training with cooperative learning and computer-based instruction on college-aged students and adults. Only Hooper and Temiyakarn considered the cooperative learning strategies elaborated by D. Johnson and R. Johnson within the area of cooperative computer based instruction.

Summary

Researchers investigating the use of cooperative learning as an instructional strategy have examined several variations of this form of learning. Studies examined many individual and group variables: such as gender, ability, training in cooperative learning skills, group size, and other ability factors. With the increased use of computers in classrooms, researchers who found questions surrounding cooperative learning of interest carried these questions into this new research area. Many of these questions have been answered substantially in the area of cooperative computer-based instruction. However, a significant gap remains in the literature regarding the use of training in cooperative computer-based learning. The need for further research into the areas of cooperative learning and computer-based instruction is well established.

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Bueno & Nelson, 1993)	Evaluation/ Microethnography Study of the Impact of a Contextualized Computer Environment on a Group of Learners Studying Spanish in an Elementary School Setting.	Students Worked on a HyperCard Stack Simulating a Spanish Language Educational Setting	Collaborative CAI	17 Fifth and 17 Sixth Grade Students	Students Were Observed Using a Microethnography Format While Using the Collaborative HyperCard Stack.	Students engaged in cooperative efforts that involved completing their peers' unfinished sentences, encouraging others to continue, inviting others to contribute, modifying another's statements and offering evidence for these modifications
(Burns & Coon, 1990) Experiment 1	1. Paired Students Using Logo 2. Paired Students Using Delta Drawing	Software Containing a Variety of Types of Analogical Reasoning Problems	Collaborative CAI	20 Third Grade Students	1. Previous Type of Computer Experience 2. Repetition	NSD For Previous Computer Experience on Performance. SD for Repetition on Performance
(Burns & Coon, 1990) Experiment 2	1. Paired Students Using Logo 2. Paired Students Using Delta Drawing	Software Containing a Variety of Types of Analogical Reasoning Problems	Collaborative CAI	18 Third Grade Students	1. Logo Programming Usage 2. Control Programming Usage	Verbalizations During Logo Programming Yield a Different Pattern of Collaboration Characterized by more Process Oriented Statements and Fewer Product Oriented Statements, as Compared to a Control Programming Task

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(Carrier & Sales, 1987)	1. Paired Students 2. Individual Students	Five Levels of Intellectual Skills, Based on Gagne's Taxonomy of Human Capabilities	Cooperative CBI	36 Undergraduate Students	1. Feedback Level 2. Learner Control	NSD For Grouping, Achievement. SD For Type of Feedback Selected by Treatment
(Chang & Smith, 1991)	1. Paired Students 2. Individual Students	A Computer Assisted Instruction Task in Beginning Spanish	Cooperative CAI	113 Students at the U.S. Air Force Academy	Post-test achievement scores	NSD Between Groups For Achievement Scores
(Chernick, 1990)	1. Interdependent trio 2. Coactive Trio 3. Individualized	Two commercial Apple IIe Computer Programs of Varying Complexity and Difficulty Levels	Cooperative CBI	80 Third and Fourth Grade Students	Complexity of Program	SD For Condition By Treatment Trials, Condition by complexity
(Clements & Nastasi, 1988)	1. LOGO Grouping 2. CAI Grouping	A Sequence of 28 Training Sessions in Either LOGO Programming or Drill and Practice CAI Software	Collaborative CAI	48 First and Third Grade Students	1. Social Interaction 2. Cognitive Interaction	SD For LOGO Groups' Social Behaviors in Resolution of Conflict, Rule Determination, and Self-Directed Work. NSD Between Groups For Time Working Cooperatively

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(Clements & Nastasi, 1985)	1. LOGO Grouping 2. CAI Grouping	Students Were Evaluated Working With On-Computer and Off-Computer Tasks	Collaborative CAI	48 White First and Third Grade Students	1. Treatment Group 2. Grade Level 3. Instructional Situation	SD For First Grade CAI Information Seeking Behavior, LOGO Group Problem Solving Behavior, Third Grade Helping Behaviors
(Cohen & Riel, 1989)	1. Teacher Evaluation 2. Peer Communication	Students Composed for Two Conditions - Teacher Evaluation and Distant Audience Evaluation.	Cooperative NBI	88 Elementary Students	1. Content 2. Organization 3. Vocabulary 4. Language Use 5. Mechanics	SD For Papers Written to Communicate With Peers
(Cousins & Ross, 1993)	1. Whole Class Instruction 2. Cooperative Group Learning 3. Computer Task Specific 4. Computer General Purpose	A Computer Software Package Developed Specifically for Solving Correctional Problems	Cooperative CBI	A Convenience Sample of 483 Students in Grades 9 and 10	1. Organizing Skill 2. Locating Skill 3. Synthesizing Skill 4. Concluding Skill 5. Teacher Characteristics	SD for Average Treatment Group, Teacher Characteristics by Student Residual Gain Scores

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Cox & Berger, 1985)	Group Size	Three Interactive Problem-Solving Microcomputer Programs Using Topics From Life Science, Social Studies, and Environmental Education	Collaborative CAI	66 Seventh and Eighth Grade Students Enrolled in Four Junior High Schools	1. Achievement of Correct Solution 2. Time Needed to Reach Solution	SD For Problem Solving Success Related To Group Size, NSD For Time To Solve Problems
(Crooks, Klein, Jones, & Dwyer, 1995)	1. Instructional Method 2. Learner Control	Computer program that either provided a full program with the option to bypass instruction or a lean program with the option to request additional instruction.	Cooperative CBI	128 Education Majors	1. Enroute performance 2. Posttest Performance 3. Attitude 4. Option Use 5. Student Interaction	SD For Learner Control, Instructional Method, Option Use
(Cummings, 1985)	A Microanalysis of Conversations Occurring Between Groups of Four Pupils Sharing Use of a Computer	Computer Simulation Program	Collaborative CAI	40 Boys and Girls From Two Primary and Three Secondary Classes	A Microanalysis of Conversations Occurring Between Groups of Four Pupils Sharing Use of a Computer	The Microcomputer Can Be An Effective Motivator In Group Work

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Dalton, Hannafin & Hooper., 1989)	1. Instructional Method 2. Gender 3. Ability	Parallel Forms of a Computer Based Lesson on the Anatomy and Physiology of the Human Reproductive and Urinary Systems	Cooperative CAI	60 Eighth Grade Students	1. Posttest score 2. Attitude	SD For Cooperative Group, Instructional Method by Gender, Instructional Method by Gender and Ability
(Dubrovsky, Kiesler, & Sethna, 1991)	1. Communication Condition 2. Decision Task	A Comparison Of Face-To-Face Communication With Electronic Mail in Decision Making Groups Whose Members Differed In Social Status	Collaborative NBI	24 Graduate University Students and 72 Freshmen Students	1. Gender Of Group 2. Status Of Group Member 3. Credibility Of Group Members	Participation Inequality Reduced In Computer-Mediated Discussions, High-Status Members Were More Often First Advocates than Low Status Members. Communicating Electronically Reduced Status Effects on Participation
(Ehman, Glenn, Johnson, & White, 1992)	Case Studies of Eight Social Studies Teachers and Their Students to Describe Teacher Used Computer Databases	Use of Computer Databases in the Classroom and Applications Of A Problem Solving Model	Cooperative CAI	Eight Classrooms in Four States	Combined Case Study	Teachers & Students Endorsed Working in Cooperative Groups, Experienced Time Constraints, and Discovered Many Students Did Not Have Adequate Prior Knowledge

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Fletcher, 1985)	1. Individual 2. Group	A Spaceships Game Presented on an Apple II Computer.	Collaborative CBI	29 Boys and 26 Girls Aged Between 9 and 11 Years Old	1. Verbal Knowledge Gained From Task 2. Problem Solving Ability During Task 3. Time Per Decision in Problem Solving Task	SD For Group Problem Solving Performance
(Galegher & Kraut, 1990)	1. Project Divisibility 2. Communication Modality	Students Were Randomly Assigned to Three Person Groups Which Were Then Assigned to Projects Manipulated on terms of Project Divisibility and Mode of Communication	Collaborative NBI	117 First Year MBA Students	1. Time Series Data 2. Retrospective Data 3. Process Data 4. Performance Data	Computer Mediated Groups had to work harder and communicate for longer periods of time and had greater difficulties in coordinating their work than groups who met face to face

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Guntermann & Tovar, 1987)	1. Group Size 2. Gender Composition	Students Were Assigned Graphic Tasks to Complete In LOGO	Collaborative CAI	36 Fourth Grade Children	1. Number of Minutes Using Program 2. Number of Commands Used 3. Final Score Given To Each Graphic 4. Process Data (Bales Categories)	NSD For Groups vs. Individual for Number Of Commands, Time to Complete Task, Final Graphic Score, Social Behavior, SD Between Dyads and Triad Groups For Dyad Opinion Giving Behavior, For Male Group Member Solidarity, Female Group Member Agreement.
(Harasim, 1993)	Case Study	Graduate and Undergraduate Courses Taught On-line or in Mixed Mode	Collaborative NBI	407 Graduate and Undergraduate Students in Twelve Classes	1. Active Participation 2. Interactive Learning 3. Creating An Environment 4. Group Tasks & Intellectual Activity 5. Problems	1. Thousands of Messages Were Generated in the Conferences over the On-Line Period 2. Student Messaging Made Up 90 Percent of Contributions 3. Students Had Problems Organizing the Message Flow 4. Students Found Decision-Making Difficult On-Line

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Herschel, 1994)	1. Skewed Female Groups 2. Balanced Groups 3. Skewed Male Groups 4. Uniform Male Groups 5. Uniform Female Groups	Brainstorming activity performed by groups using a Group Support System	Cooperative NBI	61 Groups Consisting of 269 People	Number of Ideas Generated By Group	NSD For Group Brainstorming Activity Due To Gender Controlling For Group Size
(Hine, Goldman, & Cosden, 1990)	1. Paired Group 2. Individual	Learning Handicapped Students Generated Text At Microcomputers	Collaborative CBI	11 Learning Handicapped Students	1. Error Rates 2. Error Prone	SD Between Dyad & Single Conditions for Error
(Hooper, Temiyakarn, & Williams, 1993)	1. Paired group 2. Individual	Activity designed to teach unique symbol system based upon the four basic mathematics operations	Cooperative CBI	175 Fourth Grade Students	1. Achievement 2. Attitude 3. Efficiency	SD For Grouping, Ability, Source of Control
(Hooper, 1992)	1. Paired group 2. Individual	Activity designed to teach unique symbol system based upon the four basic mathematics operations	Cooperative CBI	115 Elementary Students	1. Achievement 2. Instructional Efficiency 3. Intragroup Interaction Rate	SD For High Ability Students, Assignment, Group Completion, Ability vs. Group Composition, Helping Behavior

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Hooper & Hannafin, 1991)	1. Homogenous dyads 2. Heterogenous dyads	Activity designed to teach unique symbol system based upon the four basic mathematics operations	Cooperative CBI	125 Sixth and Seventh Grade Students	1. Achievement 2. Rate of Cooperative Interaction 3. Number of Embedded Quizzes Completed	SD For Ability, Level of Questioning, Level of Questioning vs. Ability, Instructional Group, Posttest Achievement vs. Interaction
(Hooper et al., 1989) Experiment 1.0	1. Heterogenous High Ability 2. Heterogenous Low Ability 3. Homogenous High Ability 4. Homogenous Low Ability	Activity designed to teach unique symbol system based upon the four basic mathematics operations	Cooperative CBI	73 Undergraduate	1. Aptitude level 2. Grouping level 3. Level of questioning	SD For High Aptitude vs. low aptitude, levels of questioning
(Hooper et al., 1989) Experiment 2.0	1. Heterogenous High Ability 2. Heterogenous Low Ability 3. Homogenous High Ability 4. Homogenous Low Ability	Activity designed to teach unique symbol system based upon the four basic mathematics operations	Cooperative CBI	70 University Undergraduate Students	1. Aptitude level 2. Grouping level 3. Level of questioning	SD For High Aptitude vs. Low Aptitude, Aptitude vs. Levels of Questioning

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Hooper & Hannafin, 1988)	1. Homogenous High Ability 2. Homogenous Low Ability 3. Heterogenous Ability	Activity designed to teach unique symbol system based upon the four basic mathematics operations	Cooperative CBI	40 Eighth Grade Students	1. Grouping 2. Ability 3. Types Of Learning	SD For Levels of Questioning, Ability vs. Levels of Questioning
(Howe et al., 1992)	1. Intragroup similarity on judgments 2. Intragroup similarity on strategies 3. Intragroup similarity on Principles	Eight Animated Physics Problems	Cooperative CBI	108 First Year Undergraduate Students	1. Outcomes 2. Initial Conditions 3. Interactions 4. Group Outcomes	SD For Strategy Score, Principle Score
(Hoyles, Healy, & Pozzi, 1992)	Case Study	Three Research Tasks Involving Mathematical Ideas and Incorporating Work With Computers	Cooperative CBI	48 Students Aged Nine to Twelve Years Old	1. Analysis of Group Process 2. Case Studies Constructed For Each Group 3. Studies Analyzed To Determine Cross Task Stable Activities 4. Comparisons made across groups 5. Evaluation & Refinement of Hypotheses	Findings: Consistent Group Organization, Pattern of Group Processes Across Tasks and Software, Software Influences Were Not Identified, Mix of Pupil Interdependence and Autonomy Identified as Essential, Emergence of at least 1 Pupil-Teacher Within Group, Group Negotiation Not Seen as a Factor

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Huang, 1995)	1. High amounts of prior subject knowledge 2. Low amounts of prior subject knowledge	An Instructional Module Designed to Help Beginners Strengthen Their Basic Cognitive Foundation in Weight Training	Cooperative CBI	120 University Students	1. Feedback Type 2. Retention of Knowledge 3. Attitude	Significant Effects for Retention Posttest Scores, Feedback Type, Significant Interaction Between Feedback Type and Ability.
(Jackson et al., 1992) Experiment 1.0	1. Grouping 2. Verbalization	Ten Mathematical Problems	Cooperative CBI	108 Ten and Eleven Year Old British Children	1. Moves 2. Time on Task 3. Time Per Move 4. Pre-/Post Test Comparison	NSD For Verbalization, SD For Group Number of Moves
(Jackson et al., 1992) Experiment 2.0	1. Groups 2. Individual Student	Ten Mathematical Problems	Cooperative CBI	108 Ten and Eleven Year Old British Children	1. Moves 2. Time on Task 3. Time Per Move 4. Pre-/Posttest Comparison	SD For Group Number of Moves
(Jegede, Okebukola, & Ajewole, 1991)	1. Individual Use of Computers 2. Triad Use of Computers 3. Individual Working Alone	Software Reinforcing Several Biological Concepts	Cooperative CBI	64 Students Enrolled For A Course Preparatory To A National Biology Exam	1. Attitude Toward Computer Use 2. Attitude Change 3. Learning	SD For Group, But Not For Gender. NSD For Achievement Level.

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Johnson, Johnson, & Stanne, 1985)	1. Cooperative Groups of Four 2. Competitive Groups of Four 3. Individualistic 4. Sex	Instructional unit that paired a computer simulation with written materials on the fundamentals of map reading and navigation	Cooperative CAI	71 Eighth Grade Students	1. Daily Worksheets 2. Posttest 3. Student's Success Level 4. Attitude	SD For Cooperative Worksheet Items Completed, Cooperative Posttest Questions, Cooperative Success Level
(Johnson & Johnson, 1986)	1. Cooperative Groups of Four 2. Competitive Groups of Four 3. Individualistic 4. Sex	Instructional unit that paired a computer simulation with written materials on the fundamentals of map reading and navigation	Cooperative CAI	75 Eighth-Grade Students	1. Daily Worksheets 2. Posttest 3. Student's Success Level 4. Attitude	SD For Correct Cooperative Worksheet Items, Cooperative Posttest Score, Cooperative Interpersonal Interaction Level
(Johnson, Johnson, & Stanne, 1986)	1. Cooperative Learning Groups 2. Competitive Learning Groups 3. Individualistic Learning 4. Male Students 5. Female Students	A 10 Day Instructional Unit That Paired a Computer Simulation with Written Materials on Map Reading and Navigation	Cooperative CAI	74 Eighth Grade Students	1. Cooperative Groups 2. Competitive Groups 3. Individualized Learning	SD For Cooperative Achievement, Cooperative Interpersonal Interaction

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Justen, Waldrop, & Adams, 1990)	1. Type of CAI Delivery 2. Type of Feedback 3. Individual CAI 4. Paired CAI	Six Lessons Designed To Teach and Reinforce Basic Concepts Related To Hypothesis Testing Research	Cooperative CAI	68 Undergraduate Students	1. Paired/Minimal Feedback 2. Paired/Extended Feedback 3. Individual /Minimal Feedback 4. Individual/ Extended Feedback	SD For Minimal Feedback Conditions
(Keeler & Anson, 1995)	1. Individual Learning Grouping of Students 2. Cooperative Learning Grouping of Students	Two Sections of Students Were Given the Same Content Instruction, With One Section Working Individually and the Other Working Cooperatively.	Cooperative CAI	62 Undergraduate Students	1. Computer Experience 2. Computer Anxiety 3. Learning Performance	A Higher Percentage of Students Received A's in the Cooperative Learning Section than in Individual Learning. SD For Age X Computer Anxiety, Anxiety X Work Experience With Computers
(King, 1989)	1. High Ability Level 2. Average Ability Level	A Nonprogramming version of Logo Turtle Graphics to Reproduce a Given Line Design	Cooperative CAI	36 Fourth Grade Students	1. Verbal Interaction 2. Problem Solving Strategy	SD For High Ability Groupings, Longer Task Statements, Asking of More Task Related Questions

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Light, Foot, Colbourn, & McClelland, 1987) Experiment 1.0	1. Pairs 2. Individuals 3. Structured Interaction 4. Unstructured Interaction	A Specially Written Computer Program Representing the Game, "Towers of Hanoi"	Collaborative CBI	68 British Middle School Students	Numbers of Moves	SD For Number of Trials
(Light et al., 1987) Experiment 2.0	1. Self Selecting Trio 2. Investigator Selected Trio 3. Sex	A Database Program	Collaborative CBI	24 British Eleven Year Old Students	1. Worksheet References 2. Peer Support	SD For Girls Worksheet References, Self Selection and Peer Support

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Mabrito, 1992)	1. Collaborative Writing Students Meeting face-to-face 2. Collaborative Writing Students Meeting Via A real-time Computer Network	Case Study Observations of Collaborative Writing Students Interactions Via face-to-face and Network Communication	Collaborative NBI	15 Senior and Junior University Students Who Participated In Both Network and Face-to-Face Discussions	1. Amount of Response 2. Linguistic Function and Focus of These Responses 3. Attitudes Regarding Participation in Each Mode	NSD For Amount of Discourse By Group Types, Distribution Of Discourse Units Among Individual Group Members Was Less Equal During Face-To-Face Sessions than During Network Sessions. Face-To-Face Groups Felt It Necessary To Spend More Time Establishing Discussion Order and Procedure For Task Completion Than Did Network Groups. Network Groups Spent Higher Proportion Of Time-on-Task. Network Groups Were Rated To Have Higher Productivity Than Face-To-Face.
(Makuch, Robillard, & Yoder, 1991-1992)	1. Paired/ Cooperative CAI 2. Individual CAI	A Tutorial on Proper Water Well Location and Construction	Cooperative CAT	27 Cooperative Extension Agents	1. CAI Experience 2. No CAI Experience 3. High Topic Familiarity 4. Low Topic Familiarity 5. Time on Lesson	SD For Time By Cooperative Learning Method, NSD For Instructional Method by Previous CAI Experience, Instructional Method by Topic Familiarity

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Mevarech, 1994)	1. Individual CAI 2. Cooperative CAI 3. Achievement Level	Drill and Practice with an Integrated Instructional system on mathematics curriculum	Collaborative NBI	623 Israeli Third and Sixth Grade Students	1. Overall Mean Achievement 2. Mathematics Achievement	SD For Third Grade Student Progression, Third Grade Aptitude by Treatment, Sixth Grade Cooperative Group, Treatment, Aptitude
(Mevarech, 1993)	1. Cooperative CAI 2. Individualistic CAI 3. Aptitude	Drill and Practice with an Integrated Instructional system on mathematics curriculum	Cooperative CAI	110 Israeli Third Grade Students	1. Time 2. Attitude 3. Invested Mental Effort 4. Academic Recognition 5. Social Acceptance	SD For Aptitude by Treatment, Time by Treatment, Academic Recognition, Time by Aptitude
(Mevarech & Kramarski, 1992)	1. Problem Solving Based Logo 2. Guided Logo 3. Control	Mathematics lessons with the LOGO program	Cooperative CAI	212 Israeli Seventh Grade Students	1. Aptitude 2. Creativity 3. Interpersonal relationships	SD For Figurative Originality for PS Logo, Verbal Flexibility, Verbal Originality
(Mevarech, Silber, & Fine, 1991)	1. Cooperative CAI 2. Individualized CAI 3. Ability Groups	Drill and Practice with an Integrated Instructional system on mathematics curriculum	Cooperative CAI	149 Israeli Sixth Grade Students	1. Achievement 2. Self-Concept 3. Anxiety 4. Math Self Concept 5. Math Anxiety	SD For Treatment, Ability, Treatment by Ability Interaction on Math Anxiety NSD For Treatment by Ability

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Mevarech, Stern, & Levita, 1987)	1. Individual 2. Homogenous Group	CAI Course in Language (Hebrew)	Cooperative CAI	115 Israeli Junior High Students	1. Social Behavior 2. Attitude 3. Achievement Scores	SD For Cooperative CAI Learning, Attitudes toward teammates, Attitudes Toward Cooperative Learning
(Nastasi & Clements, 1994)	1. Logo CBI 2. Word Processing CBI	Comparison of two computer programs to determine cognitive and social effects of CBI	Cooperative CBI	48 Third Grade Students	1. Pleasure Re: Task Mastery 2. Statements about Work 3. Statements about Cognitive Competence 4. Statements about the child/pair by the teacher 5. Approval statements from the teacher 6. Seeking assistance statements 7. Blame Statements 8. Higher order thinking skills	SD For Positive Statements about Work, Logo Positive Statements About Work Quality, Logo Group Experiencing More Failure, NSD For Negative Statements About Work, Mediation of Higher Order Thinking Skills

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Nastasi & Clements, 1992)	1. Logo CBI 2. Word Processing CBI	Comparison of two computer programs to determine cognitive and social effects of CBI	Cooperative CBI	48 Third Grade Students	Social-Cognitive Behaviors	SD For Group Differences For Negotiation of Social Conflicts, NSD For Group Differences in Conflict Resolution, NSD For Amount of Collaborative Interaction
(Nastasi, Clements, & Battista, 1990)	1. Logo Programming 2. CAI Problem Solving	Comparison of children working in Logo and CAI to see if they exhibit differing amounts of behaviors indicative of effectance motivation and cognitive conflict and resolution	Cooperative CAI	40 Volunteer Fourth and Sixth Grade Students	1. Social-Cognitive Behaviors 2. Cognitive Resolution 3. Social-Cognitive Resolution	SD For Logo Test Scores, Cognitive Conflict, Attempt at Resolution of Cognitive Conflict, Attempt at Resolution of Cognitive Conflict Ratio, Successful Resolution of Cognitive Conflict, Rule Making, Pleasure at Discovery, Seeking Approval and Positive Self-Statements
(Newman, Goldman, Brienne, Jackson, & Magzamen, 1989)	A Formative Experiment Using a LAN System to Allow Children to Use Computers as Scientists Do.	A LAN Based System Designed to Investigate Earth Science	Collaborative NBI	25 Classrooms of Elementary Students	Formative Experiment	SD For School Wide Network and Promotion of Cooperative Learning Groups, and Group Coordination

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(O'Brien & Peters, 1994)	1. Cooperative Learning With Microcomputer 2. Cooperative Learning Without Microcomputer 3. Microcomputer Experiences without Cooperative Learning 4. No Cooperative Learning or Microcomputer	Lesson on acquiring integrated science process skills and enhancing formal thinking abilities	Cooperative CBI	165 Undergraduate Students	1. Logical thinking skills 2. Process thinking skills	SD For Cooperative Learning and Microcomputer based Learning
(O'Malley & Scanlon, 1990)	1. Physics Students 2. Mathematics Students	Survey Of Students Receiving Distance Education Regarding the Extent Students Participated In Collaborative Work to plan Design of Future Systems	Cooperative/ Collaborative CBI/NBI	150 Open University Students	1. Students' preference for Group/Individual Work 2. Frequency of Group Meetings	Findings: Students Value Group Activity, Appropriateness of Group Activity Varies With the Nature of the Course Being Studied
(Okey & Majer, 1976)	1. Individual 2. Pairs 3. Groups of Three or Four	A PLATO IV Instructional Module on Bloom's Mastery Learning Strategy	Cooperative CAI	60 Undergraduate Elementary Students	1. Cognitive Test 2. Study time in minutes 3. Attitude Questionnaire	SD For Study Time, NSD For Cognitive Achievement, Attitude

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Paoletti, 1995)	1. Cooperative Computer Based Editing 2. Cooperative Paper Based Editing	Standard DOS Based Programs Used in Producing A Student Newspaper	Cooperative CBI	84 Fourth and Fifth Grade Students	1. Paper Based Editing 2. Computer Based Editing 3. Grade Level 4. Time	SD For Grade Level, For Treatment By Time.
(Pozzi, Hoyles, & Healy, 1992)	Case Study	An Attempt to Identify Factors Influencing Effective Computer-Based Groupwork	Collaborative CBI	48 Elementary Students	1. Task Management Types 2. Global Targets 3. Local Targets	Findings: Distinction in Form of Individual Involvement in Group tasks, Child-Child Interaction, Child-Computer Interaction
(Reglin, 1990)	1. Individualized CAI 2. Cooperative CAI	Highly Rated CAI Mathematics-Based Software that Paralleled the five domains of a national entrance examination.	Cooperative CAI	53 Prospective Minority Teachers Enrolled In A Mathematics Remediation Seminar	1. Achievement Test Scores 2. Math Anxiety Test Scores	SD For Cooperative CAI, NSD For Posttest Anxiety Scores

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Repman, 1993)	1. Unstructured Use of Collaborative Computer Based Instruction 2. Structured Use of Collaborative Computer Based Instruction 3. Structured Use of Collaborative Computer Based Instruction with Training	Several Pieces of Commercially Available Software Designed To Supplement and Enhance Current Curriculum	Collaborative CBI	Nine Intact Classes of Seventh Grade Students - Total Number of Students = 190	1. Critical Thinking Ability 2. Content Area Achievement 3. Self Esteem 4. Observational Data	NSD For Critical Thinking Ability. Students In the Unstructured Group Outperformed Both the Structured and Training Group. Training Group had Higher Measures of Self Esteem Than Other Two Groups. NSD For Cognitive Skills.
(Rubtsov, 1992)	A Computerized Display and recording device which allowed participants to control a light spot on a screen using two handles - one for each participant	Subjects were to move a light spot along a trajectory defined by a light on a screen	Cooperative CBI	44 Third and Seventh Grade Students In Moscow	1. How well the line approximated a smooth rectilinear form 2. That the line reached a desired end point	Findings The organization of joint action goes through a number of discernable stages. The results of the study focus attention on two types of relation between the target pattern and the joint actions required for achieving it. These correspond to direct and mediated forms of relation between action and solution

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Sabin & Sabin, 1994)	1. Cooperative Learning During College Instruction 2. Individual Learning During College Instruction	Students in an Introductory Computer Science Course Received Comparable Content & Instruction	Cooperative CAI	Two Classes Consisting of 31 Undergraduate Students	1. Achievement Comparison Effects 2. Attitude Effects	SD For Effects of Cooperative Learning on Instruction
(Salomon et al., 1989)	1. Text With Guidance 2. Text With Multiple Choice Questions 3. Text With No Guidance	Three Versions of A Program Designed To Reinforce Reading Skills On the Apple II e	Collaborative CBI	74 Israeli Seventh Grade Students	1. Pretests 2. Process Measures 3. Posttests	NSD Between Groups For Metacognitive Content, SD For Metacognitive Time On Task, Metacognitive Group Reported Invested Mental Effort, Metacognitive Group Posttest Scores.
(Scardamalia et al., 1992)	Case Study 1. ICON Configuration 2. Macintosh Configuration	A Case Study of a Networked Communal Database For All Student Productions	Collaborative NBI	Four Canadian Multigrade Classrooms	1. Prior Achievement 2. Productivity 3. Exploring 4. Collaborating 5. Thinking-type use 6. Constructive Activity 7. Knowledge Quality	Educational Outcomes: Graphical Literacy, Knowledge Quality, Level of Constructive Activity

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Seymour, 1994)	1. Cooperative Task and Reward 2. Individualistic Task and Reward 3. Combination of Cooperative and Individualistic Task and Reward	Students were all Instructed In Computer Aided Design Software Techniques. The Method of Instruction Varied With The Section.	Cooperative CAI	Three Sections of an Introductory Computer Aided Design Course Consisting of 57 Students	1. Student Post Test Scores 2. Student Drawing Scores 3. Student Quiz Scores 4. Student Attitude	NSD In Achievement Levels Between Cooperative Learning Structures and Individualistic Structures. NSD In Achievement Between Cooperative Learning Structures Combined With Individualistic Structures and Individualistic Structures Alone. NSD Between Treatment Types For Attitude.
(Sherman, 1994)	1. Homogenous Lower Ability Pairs 2. Heterogenous Lower Ability Pairs 3. Homogenous Higher Ability Pairs 4. Heterogenous Lower Ability Pairs	A CBI Science Program written in HyperCard	CBI	231 Junior High Students	1. Cued Feedback 2. Non-cued Feedback	SD For Ability Grouping, Cued Feedback

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Shlechter, 1990) Experiment 1.0	1. Group condition 2. Individual condition	A CBT Unit Designed To Train Subjects on Electronics and Communication Equipment	Cooperative CBT	24 U.S. Army Subjects	1. Frequency of Responses 2. Frequency of Helping Behavior 3. Time 4. Frequency of Proctor Assistance	SD For Instructional Efficiency, NSD For Achievement
(Shlechter, 1990) Experiment 2.0	1. Group condition 2. Individual condition	A CBT Unit Designed To Train Subjects on Electronics and Communication Equipment	Cooperative CBT	16 U.S. Army Subjects	1. Frequency of Responses 2. Frequency of Helping Behavior 3. Time 4. Frequency of Proctor Assistance	SD For Instructional Efficiency, NSD For Achievement
(Shlechter, 1990) Experiment 3.0	1. Group condition 2. Individual condition	A CBT Unit Designed To Train Subjects on Electronics and Communication Equipment	Cooperative CBT	24 U.S. Army Subjects	1. Frequency of Responses 2. Frequency of Helping Behavior 3. Time 4. Frequency of Proctor Assistance	SD For Instructional Efficiency, NSD For Achievement

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Simsek & Hooper, 1992)	1. Cooperative Learning 2. Individualized Learning 3. High Ability 4. Low Ability	Students Completed A Level II Interactive Videodisc Lesson About Whales	Cooperative CBI	30 Fifth and Sixth Grade Students	1. Achievement 2. Time on Task 3. Attitude	Students Working In Cooperative Groups Scored Higher on the Posttest than Individuals. High Ability Students Outperformed Lower Ability Students. Both High and Low Ability Students Demonstrated Higher Achievement In Groups than Individual Treatment. Students Working In Groups Consistently Took Longer Time To Complete Instruction Than Students Working Alone. Students Working In Cooperative Groups Demonstrated Higher Attitude Scores Than Did Students Working Alone.
(Stephenson, 1992-1993)	Instructor Initiated Interaction	A Spreadsheet Tutorial Which was Part of A Larger Commercial Integrated Software Program	Cooperative CBT	41 Undergraduate Students	1. Individual Subject Performance 2. Software commands	SD For Spreadsheet Experience Level, NSD For Experimental Group, Sex Differences, Interaction Effects

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Strommen, 1993)	1. Game Condition (Cooperative or Competitive) 2. Gender	An Educational Computer Game Designed to Promote Learning In Natural Science Knowledge and Accurate Usage of Reference Materials	Cooperative CAI	56 Fourth Grade Students	1. Percentage of Correct Answers 2. Percentage of Guesses Made	More correct answers were obtained in the Cooperative Game than Competitive. Cooperative Game Leads To More Strategic Performance and Less Guessing Overall.
(Sutter & Reid, 1969)	1. Paired Grouping 2. Individual 3. Control	Six Problems Designed to Illustrate a Heuristic Approach to Problem Solving	Cooperative CAI	100 Undergraduate Students	1. Achievement Change 2. Attitude Change 3. Test Anxiety 4. Sociability 5. Dominance	SD For Experimental Group, Interpersonal Conditions

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Tolmie & Howe, 1993)	1. Male Pairs 2. Female Pairs 3. Mixed Sex Pairs	A Computer Based Task Which Required Students to Predict Trajectories of Falling Objects	Collaborative CBI	82 12 to 15 Year Old Students	1. Differences Between Paper and Computer Predictions 2. Number of Disagreements Over Explanatory Factors 3. Number of References of Explanatory Factors 4. References to Explanatory Factors 5. Number of References to Explanatory Factors 6. Pre- and Post Test Scores	SD For Test Scores from the Pre-test to Post-Test, SD For Dissimilarity of Explanations and Dissimilarity of References.
(Trowbridge, 1987)	1. Students working alone 2. Students working in dyads 3. Students working in groups of three 4. Students working in groups of four	Students were presented with a computer-based task simulating current flow through a complete circuit.	Cooperative CBI	58 Seventh & Eighth Grade Students	1. Keyboard behavior 2. Cognitive behaviors 3. Social Behaviors	Pairs and triads had higher levels of cognitive and social interactivity than either individuals or quads. As group size increased, dispersion in interactivity increased. NSD between groups for academic achievement

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Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Underwood, Underwood, Pheasey, & Gilmore, 1996)	Case Study Examining How Group Discussion Impacts Performance While Small Groups of Children Work at a Programming Exercise	Students Were Introduced to A Programming Environment Employing Graphical Re-write Rules and Programming by Direct Observation.	Collaborative CBI	26 Seventh and Ninth Grade Students	1. Time Needed to Complete Task 2. Time Allocated For Rule Writing 3. Time Testing Rules	Discussion of Task Predicted Performance. Number of Analyzing Statements Correlated Highly With Tension Relieving Statements. Writing Rule Statement Time Correlated Highly With Statements Giving Suggestions or Directions
(Underwood et al., 1994)	1. Same Sex pairs 2. Mixed Sex Pairs	Complete a Paragraph of Text Which Had a Number of Letters Replaced by Hyphens	Cooperative CBI	36 Elementary School Children	1. Number of Letters Attempted 2. Number of Letters Correctly Answered 3. Number of Different Words Attempted 4. Number of Words Correctly Completed 5. Sessions	SD For Sessions across all pairings, for Cooperating pairs over non-cooperating pairs, for letter efficiency ratio, word efficiency ratio

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Underwood et al., 1990)	1. Same Sex pairs 2. Mixed Sex Pairs	Complete a Paragraph of Text Which Had a Number of Letters Replaced by Hyphens	Cooperative CBI	18 Elementary School Children	1. Number of Letters Attempted 2. Number of Letters Correctly Answered 3. Number of Different Words Attempted 4. Number of Words Correctly Completed 5. Sessions	SD For Sessions across all pairings, for Cooperating pairs over non-cooperating pairs, for letter efficiency ratio, word efficiency ratio
(Webb, Ender, & Lewis, 1986)	Case Study	Instruction in Microcomputer BASIC Programming	Cooperative CBI	30 11 to 14 Year Old Students	1. Planning 2. Debugging 3. Group interaction	Findings: Most Planning & Debugging was Done at the Operation Level of Abstraction, and for Statements Rather Than Chunks, Planning & Debugging Carried Out in the Context of Instructor Conversations Were Negatively Related to Programming Achievement

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Webb, 1985)	1. Individual Study 2. Group Study	Instruction in Microcomputer BASIC Programming	Collaborative CBI	55 Students Aged 11 to 14 Years Old	1. Mathematics 2. Verbal Influence 3. Nonverbal Reasoning 4. Spatial Ability 5. Age	SD For Individual Mathematics, Individual Spatial Ability, Individual Field Independence. NSD Between Group or Individual Programming Outcome. Predictors of Learning in the Group Setting Were Not Necessarily The Same As The Individual Setting
(Webb, 1984)	Case Study	Instruction in microcomputer LOGO programming	Cooperative CBI	35 Junior High Students	1. Cognitive Measures 2. Group Interaction Variables	Findings: Students Not at the Keyboard Seemed to be as Involved With the Material as Students at the Keyboard, Receiving Explanations In Response to Errors was Beneficial, Group Verbal Interaction did not seem to Influence Learning How To Interpret and Generate Programs

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Wild, 1996)	Ethnographic Observation of Students Cooperative Verbal Interactions	Interactions Were Recorded While Children Used a Program Called DISCLOZE On Macintosh Computers	Collaborative CAI	60 Children Aged Between 8 and 9 Years Old	1. Interaction Types 2. Analysis of Metacognitive Behaviors	Only Collected Type Patterns Emerged In Recorded Interactions. Verbal Interactions Implied Creation of Knowledge Within and as a Result of an Interaction.
(Wild & Winniford, 1993)	Case Study	Remote Collaboration Among University Students In Texas and Hawaii	Collaborative NBI	56 University Students From Texas and Hawaii	Observation of Interactions and Evaluation of Decisions Made By Collaborative Groups	Overall Improvement In Quality of Decisions Made By Students When Compared To Past Courses, Positive Reactions From Students Regarding Case
(Whyte, Knirk, Casey, & Willard, 1990-1991)	Cognitive Style	Self paced computer tutorial which reviewed basic DOS commands	Cooperative CAI	86 Undergraduate Students	1. Mode of Instruction 2. Achievement 3. Attitude	SD For Cognitive Style
(Yelland, 1995)	1. Copy Tasks 2. Path Tasks 3. Same Sex Dyad Task Completion 4. Mixed Sex Dyad Task Completion	Students Were Given A Variety of Tasks in Apple Logo	Collaborative CAI	60 Children With a Mean Age of 7 Years and 3 Months	1. Accuracy Scores for Copy Task 2. Accuracy Scores For Path Task 3. Analysis of Interaction	SD For Girl Pairs with Boy Pairs and Boy/Girl Pairs for Offers of Information and Explanation, Asking for Proposals, Offering Proposals, Agreeing With Proposals

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Yelland, 1994)	1. Copy Tasks 2. Path Tasks 3. Same Sex Dyad Task Completion 4. Mixed Sex Dyad Task Completion	Students Were Given A Variety of Tasks in Apple Logo	CAI	60 Children With a Mean Age of 7 Years and 1 Month	1. Number of moves made in order to complete task 2. Time Taken to Complete Task 3. Number of Errors Made	SD For Number of Moves made for task completion between girls and both boys and boy/girl pairs. Girls were significantly more accurate in copying tasks. SD between girls and boy/girl pairs in the frequency of offers of information or explanations, agreement with explanations, asking for, offering, and disagreeing with proposals
(Yelland, 1993)	1. Individual Completion of Task 2. Same Sex Dyad Completion of Task 3. Mixed Sex Dyad Completion of Task	Students Were Given A Variety of Tasks in Apple Logo	Collaborative CAI	18 Children With a Mean Age of 7 Years and 6 Months	1. Number of Moves Made 2. Number of Errors Made 3. Time Taken to Complete Task	SD For Gender, Mixed Sex Risk Taking

Appendix A

Study	Treatment	Content	Cooperative/ Collaborative CBI/CAI/CBT/NBI	Number of Subjects	Dependent Variables	Results
(Yueh & Alessi, 1988)	1. Reward Structure 2. Group Ability Composition	Three topics in beginning Algebra (Fractions, Percentages, Simplifying Exercises)	Cooperative CAI	70 Junior High Students	1. Individual Performance 2. Group Performance 3. Homogenous Grouping 4. Heterogeneous Groups	SD For Reward Structure on Direct Learning Items, Helping Behavior
(Zammuner, 1995)	1. Individual draft/ 2. Individual revision 3. Individual draft/ Dyad revision 4. Dyad draft/ Dyad revision	Students were asked to write a narrative using pre-defined characters and settings. Some time later students were asked to revise the story. All composition was done on computers.	Cooperative CBI	34 9 and 10 year old children	1. Text quality score 2. Text Features 3. Text Correctness 4. Story content and structure	Story length averaged from 220 words to 260 words that expressed 37 idea units by means of 41 clauses, each of about 5 words. Cooperative revision process significantly improved story quality

REFERENCES

Amigues, R., & Agostinelli, S. (1992). Collaborative problem-solving with a computer: How can an interactive learning environment be designed? European Journal of Psychology of Education, 7(4), 325-337.

Bandura, A. (1969). Principles of behavior modification. New York: Holt, Rinehart & Winston.

Bandura, A. (1971). Social learning theory. New York: General Learning Press.

Bandura, A. (1986). Social foundations of thought and action. Engelwood Cliffs, NJ: Prentice-Hall.

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

Chernick, R. S. (1990). Effects of interdependent, coactive, and individualized working conditions on pupils' educational computer program performance. Journal of Educational Psychology, 82(4), 691-695.

Clements, D. H., & Nastasi, B. K. (1988). Social and cognitive interactions in educational computer environments. American Educational Research Journal, 25(1), 87-106.

Dalton, D., Hannafin, M. J., & Hooper, S. (1989). Effects of individual and cooperative computer-assisted instruction on student performance and attitudes. Educational Technology Research & Development, 37(2), 15-24.

Deutsch, M. (1949a). An experimental study of the effects of co-operation and competition upon group process. Human Relations, 2(3), 199-232.

Deutsch, M. (1949b). A theory of co-operation and competition. Human Relations, 2(2), 129-152.

Dewey, J. (1974) John Dewey on Education: Selected Writings. ed. R.D. Archambault. Chicago: University of Chicago Press.

Dick, W., & Carey, L. (1990). The systematic design of instruction. New York: HarperCollins Publishers.

Eraut, M. (1995). Groupwork with computers in British primary schools. Journal of Educational Computing Research, 13(1), 61-87.

Eraut, M., & Hoyles, C. (1989). Groupwork with computers. Journal of Computer Assisted Learning, 5(1), 12-24.

Guntermann, E., & Tovar, M. (1987). Collaborative problem solving with Logo: Effects of group size and group composition. Journal of Educational Computing Research, 3(3), 313-334.

Herschel, R. T. (1994). The impact of varying gender composition on group brainstorming performance in a GSS environment. Computers in Human Behavior, 10(2), 209-222.

Hooper, S., Temiyakarn, C., & Williams, M. D. (1993). The effects of cooperative learning and learner control on high- and average-ability students. Educational Technology Research & Development, 41(2), 5-18.

Hooper, S. (1992). Effects of peer interaction during computer-based mathematics instruction. Journal of Educational Research, 85(3), 180-189.

Hooper, S., & Hannafin, M. J. (1988). Cooperative CBI: The effects of heterogenous versus homogenous grouping on the learning of progressively complex concepts. Journal of Educational Computing Research, 4(4), 413-424.

Hooper, S., Temiyakarn, C., & Williams, M. D. (1993). The effects of cooperative learning and learner control on high- and average-ability students. Educational Technology Research & Development, 41(2), 5-18.

Hooper, S., Ward, T. J., Hannafin, M. J., & Clark, H. T. (1989). The effects of aptitude composition on achievement during small group learning. Journal of Computer Based Instruction, 16(3), 102-109.

Howe, C., Tolmie, A., Anderson, A., & Mackenzie, M. (1992). Conceptual knowledge in physics: The role of group interaction in computer-supported teaching. Learning and Instruction, 2(3), 161-183.

Howe, C., Tolmie, A., & MacKenzie, M. (1995). Computer support for the collaborative learning of physics concepts. In C. O'Malley (Ed.), Computer supported collaborative learning (pp. 51-68). Berlin: Springer-Verlag.

Jackson, A. C., Fletcher, B. C., & Messer, D. J. (1992). When talking doesn't help: An investigation of microcomputer-based group problem solving. Learning and Instruction, 2(3), 185-197.

Johnson, D. W., & Johnson, R. T. (1991). Learning together and alone. (1 ed.). Englewood Cliffs, NJ: Prentice Hall.

Johnson, D.W. & Johnson, R.T. (2004). Cooperation and Technology. In D. Jonassen (Ed.). Handbook of research for educational communications and technology. (2 ed., pp 785-811). Mahwah, NJ: Lawrence Erlbaum Associates.

Johnson, D. W., & Johnson, R. T. (1996). Cooperation and the use of technology. In D. Jonassen (Ed.), Handbook of research for educational communications and technology (1 ed., pp. 1017-1044). New York: Macmillan Library Reference.

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1993). Circles of learning: Cooperation in the classroom. (Fourth Edition ed.). Edina, MN: Interaction Book Company.

Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. Psychological Bulletin, 89(1), 47-62.

Joiner, R. (1995). The negotiation of dialogue focus: An investigation of dialogue processes in joint planning in a computer based task. In C. O'Malley (Ed.), Computer supported collaborative learning (pp. 203-221). Berlin: Springer-Verlag.

Laurillard, D. (1992). Learning through collaborative computer simulations. British Journal of Educational Technology, 23(3), 164-171.

Lewin, K. (1947). Frontiers in group dynamics: Concept, method and reality in social science; social equilibria and social change. Human Relations, 1(1), 5-41.

Light, P., & Blaye, A. (1990). Computer-based learning: The social dimensions. In H. C. Foot, M. J. Morgan, & R. H. Shute (Eds.), Children helping children (pp. 135-147). New York: John Wiley & Sons.

Maller, J.B. (1929). Cooperation and competition: An experimental study in motivation. Teachers College Contributions to Education. Number 384. New York. Columbia University Press.

Malouf, D. B., Wizer, D. R., Pilato, V. H., & Grogan, M. M. (1990). Computer assisted instruction with small groups of mildly handicapped students. Journal of Special Education, 24(1), 51-68.

Oshima, J. (1989). Design concepts for background operations: Analysis of the current CSILE. Hiroshima Forum for Psychology, 14, 25-40.

Oshima, J., Bereitner, C., & Scardamalia, M. (1995). Information-access characteristics for high conceptual progress in a computer-networked learning environment. In J. L. Schnase & E. L. Cunnius (Eds.), Proceedings of CSCL '95: The first international conference on computer supported collaborative learning (pp. 259-268). Mahwah, NJ: Lawrence Erlbaum Assoc.

Panitz, T. (2001). Personal communication: email received May 19, 2001.

Papert, S. (1993). Mindstorms: Children, Computers and Powerful Ideas. (2nd ed.). New York: Basic Books.

Pavlov, I. P., & Anrep, G. V. i. i. (1927). Conditioned reflexes; an investigation of the physiological activity of the cerebral cortex. London: Oxford University Press: Humphrey Milford.

Piaget, J., Gruber, H. E., & Voneche, J. J. (Eds.). (1995). The essential Piaget (100th Anniversary Edition ed.). Northvale NJ: Jason Aronson Press.

Repman, J. (1993). Collaborative, computer-based learning: Cognitive and affective outcomes. Journal of Educational Computing Research, 9(2), 149-163.

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), Computer supported collaborative learning (pp. 69-97). Berlin: Springer-Verlag.

Rubtsov, V. (1992). Group work with the computer: The developing organization of joint action. European Journal of Psychology of Education, 7(4), 287-293.

Scardamalia, M. (1989). Theory-based design constraints. Hiroshima Forum for Psychology, 14, 41.

Scardamalia, M., Bereiter, C., & Lamon, M. (1994). The CSILE Project: Trying to bring the classroom into World 3. In K. McGilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice (pp. 201-228). Cambridge, MA: Massachusetts Institute of Technology.

Scardamalia, M., & Bereitner, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. The Journal of the Learning Sciences, 1(1), 37-68.

Scardamalia, M., & Bereitner, C. (1996). Computer support for knowledge building communities. In T. Koschmann (Ed.), CSCL: Theory and practice of an emerging paradigm (pp. 249-268). Mahwah, NJ: Lawrence Erlbaum Associates.

Scardamalia, M., Bereitner, C., Brett, C., Burtis, P. J., Calhoun, C., & Lea, N. S. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.

Scardamalia, M., Bereitner, C., McLean, R. S., Swallow, J., & Woodruff, E. (1989). Computer-supported intentional learning environments. Journal of Educational Computing Research, 5(1), 51-68.

Schon, D.A. (1987). Educating the reflective practitioner. San Francisco: Jossey-Bass.

Sherman, G. P. (1994). The effects of cued interaction and ability grouping during cooperative computer based science instruction. Unpublished Dissertation, Arizona State University.

Skinner, B. F. (1953). Science and human behavior. New York,: Macmillan.

Skinner, B. F. (1957). Verbal behavior. New York,: Appleton-Century-Crofts.

Skinner, B. F. (1961). Cumulative record (Enl. ed.). New York,: Appleton-Century-Crofts.

Skinner, B. F. (1968). The technology of teaching. Englewood Cliffs, NJ: Prentice-Hall.

Slavin, R. E. (1980). Cooperative learning. Review of Educational Research, 50(2), 315-342.

Slavin, R. E. (1983). When does cooperative learning increase student achievement? Psychological Bulletin, 94(3), 429-445.

Slavin, R. E. (1994). Cooperative learning. In T. Husen & T. N. Postlethwaite (Eds.), The International Encyclopedia of Education (2nd ed., pp. 1094-1099). Kidlington, Oxford: Elsevier Science.

Tolmie, A., & Howe, C. (1993). Gender & dialogue in secondary school physics. Gender and Education, 5(2), 191-209.

Underwood, G., Jindal, N., & Underwood, J. (1994). Gender differences and effects of cooperation in a computer based language task. Educational Research, 36(1), 63-74.

Underwood, G., McCaffrey, M., & Underwood, J. (1990). Gender differences in a cooperative computer-based task. Educational Research, 32(1), 44-49.

Vygotsky, L. S. (1962). Thought and language (Eugenia Hanfmann Gertrude Vakar, Trans.). Cambridge, MA: The M.I.T. Press.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Watson, J. B. (1925). Behaviorism. New York,: W. W. Norton & Company Inc.

Webb, N. M. (1987). Peer interaction and learning with computers in small groups. Computers in Human Behavior, 3, 193-209.

Webb, N. W., & Lewis, S. (1988). The social context of learning computer programming. In R. E. Mayer (Ed.), Teaching and learning computer programming: Multiple research perspectives (pp. 179-206). Hillsdale, NJ: Lawrence Erlbaum Associates.

Winn, W., & Snyder, D. (1996). Cognitive perspectives in psychology. In D. H. Jonassen (Ed.), Handbook of research for educational communications and technology (pp. 112-142). New York: MacMillan Library Reference.

Yelland, N. (1993). Young children learning with LOGO: An analysis of strategies and interactions. Journal of Educational Computing Research, 9(4), 465-486.

Yelland, N. (1995). Collaboration and learning with Logo: Does gender make a difference? In J. L. Schnase & E. L. Cunnius (Eds.), Proceedings of CSCL '95: The first international conference on computer supported collaborative learning (pp. 397-401). Mahwah, NJ: Lawrence Erlbaum Assoc.

Yelland, N. J. (1994). The strategies and interactions of young children in LOGO tasks. Journal of Computer Assisted Learning, 10, 33-49.

References of Studies Cited in Appendix A

Bueno, K. A., & Nelson, W. A. (1993). Collaborative second language learning with a contextualized computer environment. Journal of Educational Multimedia and Hypermedia, 4(2), 177-208.

Burns, B., & Coon, H. (1990). Logo programming and peer interactions: An analysis of process and product oriented collaborations. Journal of Educational Computing Research, 6(4), 393-410.

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

Chang, K. R., & Smith, W. F. (1991). Cooperative learning and CALL/IVD in beginning Spanish: An experiment. The Modern Language Journal, 75(2), 205-211.

Chernick, R. S. (1990). Effects of interdependent, coactive, and individualized working conditions on pupils' educational computer program performance. Journal of Educational Psychology, 82(4), 691-695.

Clements, D. H., & Nastasi, B. K. (1985). Effects of computer environments on social-emotional development: Logo and computer-assisted instruction. Computers in the Schools, 2(2-3), 11-31.

Clements, D. H., & Nastasi, B. K. (1988). Social and cognitive interactions in educational computer environments. American Educational Research Journal, 25(1), 87-106.

Cohen, M., & Riel, M. (1989). The effect of distant audiences on students' writing. American Educational Research Journal, 26(2), 143-159.

Cousins, J. B., & Ross, J. A. (1993). Improving higher order thinking skills by teaching with the computer: A comparative study. Journal of Research On Computing In Education, 26(1), 94-113.

Cox, D. A., & Berger, C. F. (1985). The importance of group size in the use of problem solving skills on a microcomputer. Journal of Educational Computing Research, 1(4), 459-468.

Crooks, S. M., Klein, J. D., Jones, E. E. K., & Dwyer, H. (1995). *Effects of cooperative learning and learner control modes in computer based instruction.* Paper presented at the Association for Educational Communications & Technology, Anaheim, CA.

Cummings, R. (1985). Small-group discussions and the microcomputer. Journal of Computer Assisted Learning, 1, 149-158.

Dalton, D., Hannafin, M. J., & Hooper, S. (1989). Effects of individual and cooperative computer-assisted instruction on student performance and attitudes. Educational Technology Research & Development, 37(2), 15-24.

Del Marie Rysavy, S. and Sales, G. C. (1991). Cooperative learning in computer-based instruction. Educational Technology, Research and Development. 39(2), 70-79

Dubrovsky, V. J., Kiesler, S., & Sethna, B. N. (1991). The equalization phenomenon: Status effects in computer-mediated and face-to-face decision making groups. *Human-Computer Interaction, 6,* 119-146.

Ehman, L. H., Glenn, A. D., Johnson, V., & White, C. S. (1992). Using computer databases in student problem solving: A study of eight social studies teachers' classrooms. Theory and Research in Social Education, 20(2), 179-206.

Fletcher, B. C. (1985). Group and individual learning of junior school children on a microcomputer-based task: Social or cognitive facilitation? Educational Review, 37(3), 251-261.

Galegher, J., & Kraut, R. (1990). Computer-mediated communication for intellectual teamwork: A field experiment in group writing, CSCW '90: Proceedings of the conference on computer supported cooperative work (pp. 65-78). New York, NY: Association for Computing Machinery.

Guntermann, E., & Tovar, M. (1987). Collaborative problem solving with Logo: Effects of group size and group composition. Journal of Educational Computing Research, 3(3), 313-334.

Harasim, L. (1993). Collaborating in cyberspace: Using computer conferences as a group learning environment. Interactive Learning Environments, 3(2), 119-130.

Herschel, R. T. (1994). The impact of varying gender composition on group brainstorming performance in a GSS environment. Computers in Human Behavior, 10(2), 209-222.

Hine, M. S., Goldman, S. R., & Cosden, M. A. (1990). Error monitoring by learning handicapped students engaged in collaborative microcomputer-based writing. The Journal of Special Education, 23(4), 407-422.

Hooper, S. (1992). Effects of peer interaction during computer-based mathematics instruction. Journal of Educational Research, 85(3), 180-189.

Hooper, S., & Hannafin, M. J. (1988). Cooperative CBI: The effects of heterogenous versus homogenous grouping on the learning of progressively complex concepts. Journal of Educational Computing Research, 4(4), 413-424.

Hooper, S., & Hannafin, M. J. (1991). The effects of group composition on achievement, interaction, and learning efficiency during computer-based cooperative instruction. Educational Technology Research & Development, 39(3), 27-40.

Hooper, S., Temiyakarn, C., & Williams, M. D. (1993). The effects of cooperative learning and learner control on high- and average-ability students. Educational Technology Research & Development, 41(2), 5-18.

Hooper, S., Ward, T. J., Hannafin, M. J., & Clark, H. T. (1989). The effects of aptitude composition on achievement during small group learning. Journal of Computer Based Instruction, 16(3), 102-109.

Howe, C., Tolmie, A., Anderson, A., & Mackenzie, M. (1992). Conceptual knowledge in physics: The role of group interaction in computer-supported teaching. Learning and Instruction, 2(3), 161-183.

Hoyles, C., Healy, L., & Pozzi, S. (1992). Interdependence and autonomy: Aspects of groupwork with computers. Learning and Instruction, 2(3), 239-257.

Huang, J. C. Y. (1995). *The effects of types of feedback on achievement and attitudes during computer-based cooperative condition.* Paper presented at the Association for Educational Communications and Technology, Anaheim, CA.

Jackson, A. C., Fletcher, B. C., & Messer, D. J. (1992). When talking doesn't help: An investigation of microcomputer-based group problem solving. Learning and Instruction, 2(3), 185-197.

Jegede, O. J., Okebukola, P. A., & Ajewole, G. A. (1991). Computers and the learning of biological concepts: Attitudes and achievement of Nigerian students. Science Education, *75*(6), 701-706.

Johnson, D. W., & Johnson, R. T. (1986). Computer-assisted cooperative learning. Educational Technology, *26*(1), 12-18.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1985). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. Journal of Educational Psychology, 77(6), 668-677.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1986). Comparison of computer-assisted cooperative, competitive, and individualistic learning. American Educational Research Journal, 23(3), 382-392.

Justen, J. E., Waldrop, P. B., & Adams, T. M. (1990). Effects of paired versus individual user computer-assisted instruction and type of feedback on student achievement. Educational Technology, 30(7), 51-53.

Keeler, C. M., & Anson, R. (1995). An assessment of cooperative learning used for basic computer skills instruction in the college classroom. Journal of Educational Computing Research, 12(4), 379-393.

King, A. (1989). Verbal interaction and problem-solving within computer-assisted cooperative learning groups. Journal of Educational Computing Research, 5(1), 1-15.

Light, P., Foot, T., Colbourn, C., & McClelland, I. (1987). Collaborative interactions at the microcomputer keyboard. Educational Psychology, 7(1), 13-21.

Mabrito, M. (1992). Real-time computer network collaboration: Case studies of business writing students. Journal of Business and Technical Communication, 6(3), 316-336.

Makuch, J. R., Robillard, P. D., & Yoder, E. D. (1991-1992). Effects of individual versus paired/cooperative computer assisted instruction on the effectiveness and efficiency of an in-service training lesson. Journal of Educational Technology Systems, 20(3), 199-208.

Mevarech, Z. R. (1993). Who benefits from cooperative computer assisted instruction? Journal of Educational Computing Research, 9(4), 451-464.

Mevarech, Z. R. (1994). The effectiveness of individualized versus cooperative computer based integrated learning systems. International Journal of Educational Research, 21, 39-52.

Mevarech, Z. R., & Kramarski, B. (1992). How and how much can cooperative Logo environments enhance creativity and social Relationships? Learning and Instruction, 2(3), 259-274.

Mevarech, Z. R., Silber, O., & Fine, D. (1991). Learning with computers in small groups: Cognitive and affective outcomes. Journal of Educational Computing Research, 7(2), 233-243.

Mevarech, Z. R., Stern, D., & Levita, I. (1987). To cooperate or not to cooperate in CAI: That is the question. The Journal of Educational Research, *80*(3), 164-167.

Nastasi, B. K., & Clements, D. H. (1992). Social-cognitive behaviors and higher-order thinking in educational computer environments. Learning and Instruction, 2(3), 215-238.

Nastasi, B. K., & Clements, D. H. (1994). Effectance motivation, perceived scholastic competence, and higher-order thinking in two cooperative computer environments. Journal of Educational Computing Research, 10(3), 249-275.

Nastasi, B. K., Clements, D. H., & Battista, M. T. (1990). Social-cognitive interactions, motivation, and cognitive growth in Logo programming and CAI problem-solving environments. Journal of Educational Psychology, 82(1), 150-158.

Newman, D., Goldman, S. V., Brienne, D., Jackson, I., & Magzamen, S. (1989). Computer mediation of collaborative science investigations. Journal of Educational Computing Research, 5(2), 151-166.

O'Brien, G., & Peters, J. (1994). Effect of four instructional strategies on integrated science process skill achievement of preservice elementary teachers having different cognitive development levels. Journal of Elementary Science Education, 6(1), 30-45.

Okey, J. R., & Majer, K. (1976). Individual and small-group learning with computer assisted instruction. AV Communications Review, 24(1), 79-86.

O'Malley, C. E., & Scanlon, E. (1990). Computer-supported collaborative learning: Problem solving and distance education. Computers and Education, 15(1-3), 127-136.

Paoletti, G. (1995). Peer interaction and writing: The process of revision. In C. O'Malley (Ed.), Computer supported cooperative learning (pp. 39-50). Berlin: Springer-Verlag.

Pozzi, S., Hoyles, C., & Healy, L. (1992). Towards a methodology for analysing collaboration and learning in computer-based groupwork. Computers in Education, 18(1-3), 223-229.

Reglin, G. L. (1990). The effects of individualized and cooperative computer assisted instruction on mathematics achievement and mathematics anxiety for prospective teachers. Journal of Research on Computing in Education, 22(4), 404-412.

Repman, J. (1993). Collaborative, computer-based learning: Cognitive and affective outcomes. Journal of Educational Computing Research, 9(2), 149-163.

Rocklin, T., O'Donnell, A., Dansereau, D. F., Lambiotte, J. G., Hythecker, V., & Larson, C. (1985). Training learning strategies with computer-aided cooperative learning. Computers and education, 9(1), 67-71.

Rubtsov, V. (1992). Group work with the computer: The developing organization of joint action. European Journal of Psychology of Education, 7(4), 287-293.

Sabin, R. E., & Sabin, E. P. (1994). Collaborative learning in an introductory computer science course. SIGCSE Bulletin, 26(1), 304-308.

Salomon, G., Globerson, T., & Globerson, E. (1989). The computer as a zone of proximal development: Internalizing reading-related metacognitions from a reading partner. Journal of Educational Psychology, 81(4), 620-627.

Scardamalia, M., Bereitner, C., Brett, C., Burtis, P. J., Calhoun, C., & Lea, N. S. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.

Seymour, S. R. (1994). Operative computer learning with cooperative task and reward structures. Journal of Technology Education, 5(2), 40-51.

Sherman, G. P. (1994). The effects of cued interaction and ability grouping during cooperative computer based science instruction. Unpublished Dissertation, Arizona State University.

Shlechter, T. M. (1990). The relative instructional efficiency of small-group computer-based training. Journal of Educational Computing Research, 6(3), 329-341.

Simsek, A., & Hooper, S. (1992). The effects of cooperative versus individual videodisc learning on student performance and attitudes. International Journal of Instructional Media, 19(3), 209-218.

Stephenson, S. D. (1992-1993). The effect of student-instructor interaction on achievement in a dyad computer-based training (CBT) environment. Journal of Educational Technology Systems, 21(1), 27-35.

Strommen, E. F. (1993). "Does your's eat leaves?" Cooperative learning in an educational software task. Journal of Computing in Childhood Education, 4(1), 45-56.

Sutter, E. G., & Reid, J. B. (1969). Learner variables and interpersonal conditions in computer-assisted instruction. Journal of Educational Psychology, 60(3), 153-157.

Tolmie, A., & Howe, C. (1993). Gender & dialogue in secondary school physics. Gender and Education, 5(2), 191-209.

Trowbridge, D. (1987). An investigation of groups working at the computer. In D. E. Berger, K. Pedzek, & W. P. Banks (Eds.), Applications of cognitive psychology: Problem solving, education, and computing (pp. 47-58). Hillsdale, NJ: Lawrence Erlbaum Associates.

Underwood, G., Jindal, N., & Underwood, J. (1994). Gender differences and effects of cooperation in a computer based language task. Educational Research, 36(1), 63-74.

Underwood, G., McCaffrey, M., & Underwood, J. (1990). Gender differences in a cooperative computer-based task. Educational Research, 32(1), 44-49.

Underwood, G., Underwood, J., Pheasey, K., & Gilmore, D. (1996). Collaboration and discourse while programming the KidSim microworld simulation. Computers and Education, 26(1-3), 143-151.

Webb, N. M. (1984). Microcomputer learning in small groups: Cognitive requirements and group processes. Journal of Educational Psychology, 76(6), 1076-1088.

Webb, N. M. (1985). Cognitive requirements of learning: Computer programming in group and individual settings. AEDS Journal, 18(3), 183-194.

Webb, N. M., Ender, P., & Lewis, S. (1986). Problem-solving strategies and group processes in small groups learning computer programming. American Educational Research Journal, 23(2), 243-261.

Whyte, M. M., Knirk, F. G., Robert J. Casey, J., & Willard, M. L. (1990-1991). Individualistic versus paired/cooperative computer-assisted instruction: matching instructional method with cognitive style. Journal of Educational Technology Systems, 19(4), 299-312.

Wild, M. (1996). Investigating verbal interactions when primary children use computers. Journal of computer assisted learning, 12, 66-77.

Wild, R. H., & Winniford, M. (1993). Remote collaboration among students using electronic mail. Computers and Education, 21(3), 193-203.

Yelland, N. (1993). Young children learning with LOGO: An analysis of strategies and interactions. Journal of Educational Computing Research, 9(4), 465-486.

Yelland, N. (1995). Collaboration and learning with Logo: Does gender make a difference? In J. L. Schnase & E. L. Cunnius (Eds.), Proceedings of CSCL '95: The first international conference on computer supported collaborative learning (pp. 397-401). Mahwah, NJ: Lawrence Erlbaum Assoc.

Yelland, N. J. (1994). The strategies and interactions of young children in LOGO tasks. Journal of Computer Assisted Learning, 10, 33-49.

Yueh, J. S., & Alessi, S. M. (1988). The effect of reward structure and group ability composition on cooperative computer-assisted instruction. Journal of Computer-Based Instruction, 15(1), 18-22.

Zammuner, V. L. (1995). Individual and cooperative computer-writing and revising: Who gets the best results? Learning and Instruction, 5, 101-124.