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Small Group and Individual Learning with Technology: A Meta-Analysis

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This study quantitatively synthesized the empirical research on the effects of social context (i.e., small group versus individual learning) when students learn using computer technology. In total, 486 independent findings were extracted from 122 studies involving 11,317 learners. The results indicate that, on average, small group learning had significantly more positive effects than individual learning on student individual achievement (mean ES = *+0.15), group task performance (mean* ES = *+0.31), and several process and affective outcomes. However, findings on both individual achievement and group task performance were significantly heterogeneous. Through weighted least squares univariate and multiple regression analyses, we found that variability in each of the two cognitive outcomes could be accounted for by a few technology, task, grouping, and learner characteristics in the studies.*

Computer technology (CT) and the tremendous growth of information technologies are transforming the world and the way education is conducted. Electronic data processing, information systems, graphic designs, and computer-mediated communication are making the computer an increasingly indispensable tool in nearly every aspect of work and life. In schools, students are using CT to facilitate their learning in various subjects as well as to acquire CT knowledge and skills to meet the challenges in this rapidly changing technological and information age. For example, in mathematics and science, educators and scientists are beginning to worry that school learning cannot keep pace with the developments in science, and they suggest using CT to help fill the gap (Molnar, 1997). More efforts than ever before are being made by governments and institutions to introduce and integrate computers in schools. It is estimated that over 4.4 million computers are currently installed in America's classrooms and the ratio of students to computers has dropped from 125 students per computer in 1984 to the current ratio of 10 students per computer (Coley, Cradler, & Engel, 2000).

Although CT has the potential to be a powerful and flexible tool for learning (Scardamalia & Bereiter, 1996), past experiences with the integration of older technologies into schools (e.g., radio, television, early computer-assisted instruction) emphasize that merely installing the hardware does not produce the desired outcomes (Clark, 1983). Successful and effective learning with CT must rely on sound instructional strategies (Albright & Graf, 1991; Coley, Cradler, & Engel, 2000). One of the instructional strategies concerns social context; specifically, whether students learn with CT individually (i.e., with one computer per student, each working on his or her own task) or in a group (i.e., with two or more students per computer on the same task in a face-to-face setting, or two or more students collaborating on the same task synchronously or asynchronously over a distance).

Historically, the most common instructional strategy was to have students work individually at a computer. When Skinner (1961) invented his first teaching machine, it was designed to individualize instruction using principles of operant conditioning through careful sequencing of the instruction and appropriate reinforcement. During the 1960s, popular programs such as Individually Prescribed Instruction and Keller's Personalized Systems of Instruction influenced the trend toward individualized use of computers. The rationale was that learning would be facilitated when instruction could be adapted to the students' individual differences (e.g., prior knowledge, interests, and learning styles). CT with its flexible sequence, interactivity, and feedback made individualized instruction possible. Therefore, during the 1960s and 1970s, when the computer was first introduced to schools, computer-assisted instruction (CAI) was usually designed in the form of drill-and-practice activities and was used to individualize student learning. It was hoped that CT would enable each learner to work at his or her own pace, on materials at his or her own difficulty level, and would provide immediate feedback for what he or she had done.

The initial expectation that CT would revolutionize education, however, was not realized for several reasons (Means, 1994). First, CT was not adequately advanced and flexible at the time; the machines in use were slow, not very powerful, and not easy to use. Second, in terms of the instructional design, the computer programs were mostly text-based drill-and-practice (Kulik & Kulik, 1986) and, therefore, limited in terms of meeting a broad range of pedagogical activities and learning goals. Third, many teachers feared that they would be replaced by machines, and especially those without adequate training often avoided using them outside of special computer lab activities with the computer teacher. Finally, many teachers and parents feared that individual learning with computers might produce "social misfits" (Crook, 1994) who by working alone would be devoid of the social skills normally part of the regular classroom routine.

Since the 1980s, with the widespread appearance of the microcomputer and its ever-increasing power, capabilities, and lower prices, there has been a renewed enthusiasm for integrating CT in education. Various types of computer programs have been designed and used in schools. The earlier single type drill-and-practice program has now been expanded into a greater variety: microworlds, intelligent tutorials, simulations and games, interactive hypermedia and multimedia environments, computer-mediated communication, and Web-based courses.

Another difference from the earlier use of computers in schools is that students are often assigned to work in small groups for several reasons (Jackson, Fletcher, & Messer, 1986, 1988). First, few classrooms have sufficient technological resources to afford all students individual access to computers at will. Thus, there are practical and economic constraints which affect student access and encourage teachers to find ways for students to use technology together as a tool for learning. Second, several theories (e.g., constructivism, socially shared cognition, distributed learning, and so forth) and empirical investigations support the concept that students learn well together. For example, peer collaboration, exposure to multiple perspectives, and so on can be important processes in the learner's construction of knowledge. In other words, regardless of practical constraints, it may be advisable for students to collaborate when using CT for learning.

Considerable research has been conducted since the mid-1980s investigating the effects of social context when learning with CT. The results, however, are not consistent. Some researchers found support for group learning. For example, Johnson, Johnson, and Stanne (1985, 1986) found that cooperative group learning could overcome the social isolation commonly associated with individual learning with CT and that students learning in small cooperative groups achieved more than students in the individual condition. However, these findings on the effects of group learning were not consistently supported by other research results. In a narrative review of 20 studies comparing small group learning with CT and individual learning with CT, Shlechter (1991) found that the collective evidence was not clear. The research reviewed indicated no consistent effects for either small group or individual learning on students' academic achievement or retention scores.

The unclear nature of the effects of social context when students learn with CT and the fact that considerably more research has been conducted on the topic since Shlechter's (1991) review calls for a more systematic and up-to-date integration of the literature both for theory development and for pedagogical guidance. We believe that learning with CT may represent different circumstances and contexts in which learning occurs than learning without CT presents. For example, mouse and keyboard control may affect the nature of learning dynamics; it cannot be assumed that the quality and quantity of collaborative learning experiences with CT are necessarily the same as when CT is absent. Furthermore, the apparent inconsistency of the study results on the effects of social context when learning with CT suggests that the context for effective learning with CT may not simply be a question of small group versus individual learning. Some characteristics inherent in the studies, such as technology and task design or group learning strategies, may mediate the effects of social context.

The purpose of this review is, therefore, to conduct an extensive meta-analysis of the empirical literature on small group versus individual learning with CT. Specifically, this meta-analytic review seeks answers to the following questions:

1. Does small group learning with CT enhance student achievement and other outcomes, compared to individual learning with CT? If so, to what extent?
2. What study features moderate the effects of social context in learning with CT? Is the moderating influence of study features similar across different outcomes?
3. What are the optimal conditions for effective small group learning with CT? For example, when should it occur and what type of small group learning facilitates better learning with CT?

4. Are there any conditions in which individual learning with CT may be more effective? For example, what design characteristics of computer programs facilitate better individual learning?

In the following sections, we review findings in two areas of research, that is, the research on learning with CT and the research on small group learning, to help identify features to consider in our own quantitative integration of the effects of social context on learning with CT.

Types of Programs

Over the last five decades, a variety of computer programs have been developed and used to support student learning: from early mainframe-based or microcomputer-assisted instruction (CAI) or computer-based instruction (CBI), to Logo, simulations, hypertext, computer-mediated communication (CMC), and the Internet. Guided by different learning theories, philosophies, or developments in technology, each type of program appears to have distinct characteristics, purposes, and different ways to facilitate student learning. Means (1994) classified various types of learning with CT into four main categories: tutor, exploratory environment, tool, and communication media. Tutoring programs are used to directly teach students by providing information, demonstration, and practice opportunities. Examples of tutor programs are tutorials or practice CAI. Exploratory programs are used to encourage active student exploration and discovery learning. Examples of exploratory programs include microworlds (e.g., Logo), simulations, and hypertext-based or hypermedia-based learning environments. Tool programs refer to the general-purpose technological tools such as word processing, spreadsheet, and data-analysis software, which are used to accomplish tasks such as writing, data storage, and data analysis. Computer-mediated communication media include e-mail, computer-conferences, computer-supported-collaborative learning (CSCL) systems, and the Internet, which allow groups of teachers and students to communicate and share information electronically, to learn and to collaborate across distance.

Extensive research has been conducted on the effects of learning with CT. The results of several meta-analyses (Kulik, Kulik, & Cohen, 1980; Kulik, Bangert-Drowns, & Williams, 1983; Bangert-Drowns, Kulik, & Kulik, 1985; Samson, Niemiec, Weinstein, & Walberg, 1985; Kulik & Kulik, 1986, 1991; Niemiec, Samson, Weinstein, & Walberg, 1987; Ryan, 1991; Fletcher-Flinn & Gravatt, 1995; Fazal, 1996) have generally indicated overall positive effects of learning with CT on student achievement, attitudes toward learning, and self-concept as compared to traditional instruction. However, other quantitative and narrative reviews indicate that the effects of learning with CT appear to differ for different types of programs.

Niemiec, Samson, Weinstein, and Walberg's (1987) meta-analysis on the effects of learning with CT at the elementary school level found that the effects appeared greater for drill-and-practice programs (mean $ES = +0.47$) and tutorials (mean $ES = +0.34$) than for problem solving (mean $ES = +0.12$) programs. Similar results were found by Kulik and Kulik (1991) at pre-college levels but not at post-secondary levels. They found that at pre-college levels, CAI (mean $ES = +0.36$) appeared more effective than CEI (i.e., computer-enriched instruction, which is similar to exploratory and tool programs defined by Means, 1994). The mean effect size for the latter was not significantly different from zero. But at the post-secondary levels, the mean effect sizes for CAI and CEI were both significantly positive (mean *ES* = +0.27, and +0.34, respectively).

Sivin-Kachala and Bialo (1994) reviewed research on the effectiveness of learning with technology in schools during 1990–1994. They found that tutorial and tool programs produced differential achievement gains in mathematics for high school students. While those using the tutorial program demonstrated higher achievement in computational skills, those using the tool program achieved higher scores in conceptual understanding.

Reeves (1998) summarized and organized the evidence on the effects of using technology for learning in two categories: learning "from" technology (i.e., technology as a tutor) versus learning "with" technology (i.e., technology as a cognitive tool or exploratory environment). The review suggests that the greater value of technology-based tutors was in its ability to motivate the students, decrease instruction time, and increase equity of access to quality instruction. In contrast, the greater value in using technology-based cognitive tools such as databases, spreadsheets, expert systems, and communication software was the learners' engagement in real world tasks such as exploring, analyzing, and interpreting information, solving complex problems, and communicating effectively what they knew to others. These tools enabled the learners to take active control of their learning, and to construct knowledge rather than to reproduce it.

Similar conclusions were reached by Coley, Cradler, and Engel (2000), who surveyed the status of CT use in schools. Based on their review, the authors concluded that drill-and-practice forms of CAI are effective in producing achievement gains in students and that although more pedagogically complex uses of technology generally show more inconclusive results, many offer promising and inviting educational vignettes.

Other Technology and Task Design Characteristics

Computer programs also differ in a number of other technological design features. Sivin-Kachala and Bialo's (1994) review described four major instructional software design characteristics that significantly affected student learning. These four characteristics were instructional control, type of feedback, embedding of cognitive strategies, and inclusion of animated graphics. Studies on instructional control showed that students learning under mainly learner-control conditions outperformed those learning under mainly system-control conditions. Studies on feedback showed that students working with programs that provided feedback performed better than those working with programs that provided no feedback and that those receiving adaptive feedback performed better than those receiving static feedback. Other studies on cognitive strategies found that embedding cognitive strategies such as repetition, rehearsal, paraphrasing, outlining, cognitive mapping, and drawing analogies and inferences in computer programs facilitated student learning. Studies with animated graphics in reading and physics found that the use of animated graphics significantly increased achievement or reduced the necessary time on task.

Azevedo and Bernard (1995) conducted a meta-analysis of 22 studies on the effects of different types of feedback. They found large positive effects of feedback on student learning when measured by immediate achievement tests (mean *ES* =

+0.80) and moderate positive effects when measured by delayed posttests (mean *ES* = +0.35). They also found that students receiving feedback that verified not only the correctness of the learner's answer but also the underlying causes of error achieved significantly higher than students receiving evaluative feedback only.

Davie and Inskip (1992) studied the effects of designing fantasy role-plays, providing pre-structured databases, and involving guest visits in a computer-mediated distance learning course in literature. Their qualitative research results suggest that these instructional design strategies promoted the success of their CMC course. The authors, therefore, argue that the success of CMC courses depends on creative instructional design to support active learning and participation.

Lundgren-Cayrol (1996) studied the effects of different levels of facilitator intervention in computer conferences that supported an undergraduate distance learning course in educational technology. She found that different levels of facilitator intervention had differential effects on student learning. Those who learned under the higher level of intervention achieved significantly higher than those who learned under the lower level of intervention.

Small Group Learning Strategies and Task Structure

A variety of group learning strategies are employed when students learn in small groups. In some studies, specific cooperative learning strategies were used to ensure positive interdependence and individual accountability; in other studies, students were generally encouraged to work together; and in still other studies, there were no specific strategies employed at all, beyond the physical placement of learners together and the lack of prohibitions on collaboration.

Johnson and Johnson (1989) conducted a meta-analysis of studies comparing classrooms using cooperative learning approaches versus those using competitive or individualistic approaches. Their results indicate that students in the cooperative condition learned significantly more than those in either the competitive condition (mean *ES* = +0.67) or the individualistic condition (mean *ES* = +0.64). Cooperative learning strategies also produced medium to large positive effects on student attitudes toward the subject matter and learning, liking of other students, feelings of social support, and self-concept.

Slavin (1989) conducted a meta-analysis of cooperative learning studies using his "best evidence" approach. His review showed a small positive effect of cooperative learning on student achievement (median *ES* = +0.21). He also found that students learned significantly more in groups where both positive interdependence and individual accountability strategies were used than when either one was used alone.

When working in groups, students may work on a variety of tasks. Some tasks may be ill-structured and open; others may be highly structured and closed. Cohen's (1994) review of small group learning found that groups were not productive when tasks were closed with only one fixed answer to the question; groups were more productive when tasks were open to multiple perspectives and solutions. Cohen argued that in the former case, extended group discussions may not be necessary; whereas in the latter case, open exchange and elaborated discussion are necessary to facilitate conceptual learning through cognitive dissonance and elaboration.

More recently, Lou et al. (1996; Abrami et al., 2000; Lou, Abrami, & Spence, 2000) conducted a meta-analysis on the effects of within-class grouping (including both cooperatively structured groups and non-structured groups) versus whole class instruction. Their results showed that, on average, there is a small positive effect of within-class grouping over whole class instruction on student achievement (mean *ES* = +0.17). However, the results also showed that there was significant heterogeneity in the effect sizes analyzed. Through study features analyses, they identified a few study features that accounted for the significant variability across the findings. The substantive moderators include: group learning strategy, group size, grouping basis, amount of teacher training in the cooperative learning methods, and adaptation of instructional material and methods to small group learning. They found that students learned more under cooperative outcome interdependence than when no such structure was in place; small groups of three to four members were more effective than larger groups; group learning was most effective when grouping was based on mixed criteria rather than on ability alone; and teacher training in and experience with small group instructional strategies and adaptation of instruction methods and materials helped maximize student learning in small groups.

Learner Characteristics

The literatures on both technology-supported learning and small group learning suggest that the effects of learning with technology or in small groups may depend on characteristics of the learners such as computer experience, gender, grade level, and ability levels. Jackson, Fletcher, and Messer (1988) studied the effects of experience on microcomputer use in primary schools. The results of their study showed that learners' experience with CT was an important factor. They found that inexperience with computers often caused computer anxiety or computer phobia, which tended to exaggerate the difficulty level of a computer task.

Similar findings were observed by other researchers. When studying the effects of networked computers on class discussion, Bump (1990) reported that the initial lack of knowledge about the computer system stressed the students. The author reported that students felt frustrated and that they required time to gain ease in the use of the system. Bridwell, Sirc, and Brooke (1985) also found that experience with computer programs influenced the effects of using word processors for writing.

Niemiec, Samson, Weinstein, and Walberg's (1987) meta-analysis of the studies conducted in elementary schools indicates that CAI (particularly drill-and-practice programs) was most effective for lower ability students and for students at lower primary grades, especially when tasks were simple, involving paired association such as vocabulary acquisition and mathematical computation. On the other hand, Roblyer, Castine, and King's (1988) meta-analysis found that the mean effect size for low-achieving students (mean *ES* = +0.45), although somewhat higher, was not significantly different from that for regular students (mean *ES* = +0.32).

Some researchers have studied gender differences among students learning with computers. While the common belief is that male students learn more from computers, Roblyer, Castine, and King's (1988) review of 10 studies that provided separate results for males and females indicated no significant differences between males and females in student achievement. Results for student attitudes toward computers revealed a nonsignificantly higher mean effect size for male students (mean *ES* = +0.29) than for female students (mean *ES* = +0.05).

Fletcher-Flinn and Gravatt (1995) conducted a meta-analysis of 120 CAI studies published between 1987 and 1992. They found that the effects of learning with CAI appeared highest for kindergarten and preschool (mean *ES* = +0.55), followed by elementary school (mean *ES* = +0.46), then high school (mean *ES* = +0.32), then college/university (mean *ES* = +0.26) and finally, adults in training situations (mean *ES* = +0.22).

Lou et al.'s (1996) meta-analysis of within-class grouping found that small group learning had differential effects for students at different relative ability levels. Although the mean effect sizes were positive for all ability levels, group learning was more effective for lower ability learners than for medium ability learners. In addition, they found that different group ability composition had differential effects for students at different ability levels. Lower ability students learned more in heterogeneous groups, whereas medium ability students learned more in homogeneous ability groups. For high ability students, there was no significant difference whether they learned in heterogeneous or homogeneous groups. Lou et al. suggested that low ability students may gain most when they have more able peers to provide them with timely and elaborated assistance and guidance; high ability students may benefit from providing those elaborated explanations. Medium ability students, however, may not benefit from heterogeneous groups when they neither give nor receive explanations. Homogeneous ability grouping may be better for medium ability students because they may share in giving and receiving explanations among themselves. In addition, Lou et al. suggested that homogeneous grouping may benefit from group cohesiveness since students may share similar expectations about group goals. Medium and high ability students may especially benefit from homogeneous grouping without compromising their aspirations or pace of learning to accommodate the lower ability students.

In summary, the research reviewed on learning with CT indicates that although it has generally positive effects, the effectiveness of learning with CT is significantly related to several characteristics such as type of programs, feedback, learner control, computer experience, and ability levels. Similarly, the research on small group learning indicates that although it in general has positive effects on learning outcomes, the effectiveness of small group learning is significantly related to several characteristics such as cooperative learning strategies, task structure, teacher training, group size, group composition, and ability levels. These findings have important implications for the initial design of the present meta-analysis on the effects of small group learning with CT. It is possible that both sets of factors may influence whether small group or individual learning may be more effective when learning with CT. We therefore included them in our attempts at identifying the moderator study features used in this meta-analysis.

Method

This meta-analysis quantitatively integrates the findings from primary research on the effects of social context when students learn with CT. The procedures employed to conduct the quantitative integrations are outlined below under the following headings: identification of studies, outcomes and study features coding, effect size calculations, number of findings extracted, and data analyses.

Identification of Studies

Studies included in this meta-analytic review were first located through a comprehensive search of the literature. Electronic searches were performed on the

ERIC (1966–1999), PsycLit (1974–1999), and Dissertation Abstracts (1965–999)[1] databases. Although the search strategy varied depending on the database, search terms included: *computer** and any terms related to small group learning such as *cooperative or collaborative learn**, or *small group**, or *team**. Through branching from primary studies and review articles, other citations were identified.

To be included in this meta-analysis, each study had to meet all the following inclusion/exclusion criteria:

1. The study had to involve situations where students learned using computers (i.e., students were directly involved in using computers for learning, whether learning CT skills or using CT to learn other subjects).
2. The study had to have employed an experimental design which allowed for the comparison of small group learning with CT versus individual learning with CT. More specifically, the investigation of social context meant comparing learning with computers in small groups (i.e., with two or more students per computer on the same task in a face-to-face setting, or two or more students collaborating either synchronously or asynchronously on the same task electronically) versus learning with computers individually (i.e., with one computer per student, each working on his or her own task).
3. The minimum group size was 2 and the maximum group size was 10. (Ten was used as an inclusion criteria when coding the studies. However, the largest group size found in any of the studies was 5).
4. The study had to report cognitive outcomes, process measures, or affective outcomes for both experimental and control groups. Different types of outcomes were coded and analyzed separately (see the section "Outcomes and Study Features Coding" for the types of outcomes coded and analyzed; some outcomes were dropped due to small sample sizes). Studies with insufficient data for effect size calculations (e.g., with means but no standard deviations or no inferential statistics) were excluded.

Using the above inclusion and exclusion criteria, abstracts from electronic searches, references from primary studies and review articles were examined to identify potential studies for inclusion. If there was doubt, the study was collected. Next, the collected studies were read independently by two researchers for possible inclusion. Any study that was considered for exclusion by one researcher was checked by the other. One hundred and twenty-two studies met all the inclusion criteria.

Outcomes and Study Features Coding

The purpose of coding outcomes and study features was to identify those methodological and substantive characteristics that may be responsible for significant variations in the findings. Three steps were followed in coding the studies. First, based on the review of the related literature, a broad coding scheme was developed outlining four categories of substantive study features that might interact with the effects of social context in learning with CT. These four categories were technology, task, grouping, and learner characteristics. In addition, outcome and methodological features were also included in the coding scheme.

Next, using the broad scheme as a framework, a random sample of 25% of the primary studies was nomologically coded to identify salient study features in the literature as well as salient categories within each study feature so as to avoid researcher bias (Abrami, Cohen, & d'Apollonia, 1988; Abrami, d'Apollonia, & Cohen, 1990). As a result of the nomological coding, the original coding scheme was revised and developed into a codebook. Outcomes and features with more than three occurrences in the sample were included in the codebook.

Table 1 describes individual achievement, group task performance, and several learning process and affective outcomes extracted and analyzed in this review. Individual achievement and group task performance were coded and analyzed separately in this meta-analysis as a result of our preliminary analysis which showed that the two outcomes were significantly different not only in their mean effect sizes but also in the factors moderating the relationship with social context. The analysis that used individual achievement as the outcome compared the achievement scores of those who learned in small groups versus those who learned individually on individually administered immediate or delayed posttests. The analysis that used group task performance as the outcome compared group performance versus individual performance during task realization. Thus, the analysis that included group task performance explored the relationship between social context and performance where students learning in groups completed a group task and where students working individually completed an individual task.

Process measures included frequencies of positive peer interaction, interactivity with computers, request help from teachers, task completion time, task attempted, use of strategies, perseverance, and success rate. Affective outcomes included student attitudes toward computers, subject or instruction, group work and classmates, and academic self-concept.

Table 2 describes the 30 methodological, outcome, and substantive study features coded for each study. Methodological features included student equivalence, publication status, and publication year. Outcome features included type of outcome, outcome measure source, outcome measure time, and whose outcome. Substantive features were coded in four categories: technology, task, grouping, and learner characteristics. Technology characteristics included type of programs, design orientation, feedback, instructional control, teacher support, and setting of collaboration. Task characteristics included subject, type of tasks, task structure, task familiarity, and task difficulty level. Grouping characteristics included group composition, presence of others, group learning strategy, group work experience or instruction, group size, amount of peer interaction, number of sessions, and session duration. Learner characteristics included grade level, relative ability level, gender, and computer experience.

Finally, the coding was performed by two coders independently. Their initial coding agreement was 80.55%. Disagreements between the two coders were resolved through discussion and further review of the disputed studies.

Effect Size Calculations

The basic index for the effect size calculation is the mean of the experimental group minus the mean of the control group divided by the pooled standard deviation (*PSD*). That is, the effect size is a measure of the superiority of learning with computers when working in a group *versus* working alone. The main reason for using the *PSD* is that the assumption of homogeneity of variance in the population is often reasonable, in which case the *PSD* is more stable and provides a better

TABLE 1
Outcomes Included in this Meta-Analysis

Outcome	Description
	Cognitive outcomes
Individual achievement* (I)	Achievement scores measured individually by immediate or delayed post-tests.
Group task performance* (G)	Performance scores during tasks (e.g., number of words correct, grades on group assignments). For those learning in groups, group outcome was used.
	Process measures
Positive peer interaction (I)	Including cognitive interaction (e.g:, help giving and receiving) and positive social interaction (e.g., praise and encouragement).
Interactivity with computers (G)	Amount of time or frequency interacting with computer programs (e.g., time using keyboard, number of reviews, frequency of checking options, elaborate feedback, concepts, doing practice items or quizzes, etc.).
Request help from teachers (I)	Number of times requesting help from the teacher or monitor.
Task completion time (G)	Total amount of time spent in completing the task, including both on-task and off-task time.
Task attempted (G)	Amount of tasks attempted including number of words attempted, number of responses produced, etc.
Use of strategies (I)	Including use of self-regulating strategies or appropriate strategies for the task.
Perseverance (I)	Task perseverance (e.g., stayed longer on task; had lower number of incomplete tasks).
Success rate (I)	Percentage of learners who succeeded, involving both group tasks and individual tasks.
	Affective outcomes
Attitude toward computers (I)	Attitude toward computers in general, including computer anxiety reduction.
Attitude toward subject or instruction (I)	Attitude toward the subject being learned or attitude toward instruction or learning the subject matter with computers.
Attitude toward group work (I)	Attitude toward learning in small groups.
Attitude toward classmates (I)	Attitude toward classmates, including academic or social recognition.
Academic self-concept (I)	Self-perception of learning ability.

Note. *Achievement was recoded into individual achievement and group task performance based on the results of preliminary analyses that the effect sizes for group outcomes were significantly higher than those for individual outcomes. G = group measure for those learning in groups; I = individual measure, that is, all students were assessed individually.

TABLE 2
Study Features Coded

Study Feature	Description
	Methodological features
Student equivalence	Were random assignment or statistical control used to achieve the equivalence of students in the experimental and control conditions?
Publication status	Was the study published or unpublished?
Publication year	Was the study reported in the last five years or earlier?
	Outcome features
Outcome type	What type of outcome was measured (in the case of achievement, whether the skills measured were of higher-order or lower-order)?
Outcome measure source	Was the outcome measure standardized, researcher-made, or teacher-made?
Outcome measure time	Was the outcome measured during the treatment, immediately after the treatment, or by delayed post-tests?
Whose outcome*	Was the outcome a group result or individually assessed?
	Substantive features
Technology characteristics	
Type of program	What type of computer program was used? Was it a tutorial, drill-and-practice, exploratory environment (e.g., simulations, microworlds, hypermedia, and hypertext), tool for other tasks (e.g., word processor for writing, e-mail, or computer-conference for course assignments), or programming languages?
Design orientation	Was the program designed for individual use or group use?
Feedback	Did the program provide no, minimal, or elaborate feedback?
Instructional control	Was the instruction more learner-controlled or more system-controlled?
Teacher support	Was teacher or monitor present to provide technical or content support?
Setting of collaboration	Was the collaboration in a face-to-face setting or via electronic means?
Task characteristics	
Subject	What was the subject area studied by the students?
Type of task	Did the task involve problem solving or factual learning?
Task structure	Was the task open or closed?
Task familiarity	Were the students familiar with the task?
Task difficulty	Was the task easy, moderately difficult, or difficult?
Grouping characteristics	
Group composition	On what bases were students assigned to groups?
Presence of others	Were other peers working close by?
Group learning strategy	Was there a specific cooperative strategy used in the experimental condition?

TABLE 2
Study Features Coded (continued)

Study Feature	Description
Group work exp./instruction	Did students have previous group work experience or were they provided with training/instructions for effective group work?
Group size	What was the average number of students in a group?
Amount of peer interaction	Was there a lot of interaction among the students?
Number of sessions	What was the length of the experimental treatment?
Session duration	How long did the session last?
Learner characteristics	
Grade level	What was grade level of the students? If post-secondary, were the students in college, military, or corporate training?
Relative ability level	What was the relative ability level of the students in the class?
Gender	What was the gender of the students?
Computer experience	Did the students have previous computer experience?

Note. *Group or individual outcome was used in the preliminary analyses, whose results led to the subsequent recoding and specification of these characteristics for each outcome described in Table 1.

estimate of the population variance than the control group *SD* alone (Hedges & Olkin, 1985; Hunter & Schmidt, 1990; Rosenthal, 1991). Another reason for the choice of the *PSD* is that estimated effect sizes based on incomplete results (e.g., *t* values, *F* values, ANOVA tables, or *p* levels) are more readily comparable to effect sizes calculated in this manner.

In studies that report post-test data only, we used the post-test mean difference in the numerator and the post-test *PSD* in the denominator. In studies that provided gain scores or both pre-test and post-test data, we used the gain score difference in the numerator to control for pre-test differences, but the post-test *PSD* was used in the denominator rather than the gain score *PSD*. The gain score *PSD* is usually smaller than the post-test *PSD* (Glass, McGaw, & Smith, 1981), and therefore estimates of effect size tend to be larger when gain score *PSDs* are used. When the post-test *SDs* were not provided in the study, we tried to estimate the post-test *PSD*. Such estimation requires knowing test reliability, which is, unfortunately, not usually reported in studies. In several cases, we had to estimate a "typical" reliability for that class of measures based upon our knowledge of the literature. Specifically, we estimated $r = .85$ for standardized tests and $r = .75$ for unstandardized tests.

Effect sizes from data in the form of *t* value, *F* value, *p* level, frequencies, *r* value, etc. were computed via formulas provided by Glass, McGaw, & Smith (1981) and Hedges, Shymansky, & Woodworth (1989). For studies that reported only a significance level, effect sizes were estimated. When the direction of the effect was not available, we used an estimated effect size of zero. When the direction was reported, a "midpoint" approach was taken to estimate a representative *t* value (i.e., midpoint between 0 and the critical *t* value for the sample size to be significant) (Sedlmeier & Gigerenzer, 1989).

Formulas for calculating effect sizes were entered into an EXCEL (Microsoft, 1997) spreadsheet. Raw data for each finding were extracted by two researchers separately and then checked for reliability. The initial agreement between the two researchers was 93%. Disagreements were subsequently resolved through discussion and further review of the disputed study findings.

Number of Findings Extracted

There are generally two major approaches regarding the number of findings to be extracted from each study: a single finding per study or multiple findings per study. The advantage of extracting only one finding per study is that the assumptions of independence are met. However, a major problem with this approach is that the differences within a study between different categories of subjects (e.g., males and females), or between different treatments under investigation (e.g., groups using specific cooperative learning strategies versus groups that were only generally encouraged to work together), or between different outcome measures (e.g., achievement and task performance) are lost.

Multiple effect sizes extracted from a single study, on the other hand, can be problematic because methods of research integration normally assume that effect sizes are independent. Non-independence can increase Type I or Type II error rates (Glass, McGaw, & Smith, 1981). The problem of dependence was resolved in the following three ways in the present meta-analysis. First, findings for each outcome were analyzed separately. Only one finding per outcome was extracted from each study unless they represented different subjects. This approach enables one to examine different outcomes while ensuring independence among the findings for each outcome (Gleser & Olkin, 1994). Secondly, multiple effect sizes provided by the same subjects for the same category of outcome (e.g., achievement measured by the post-test and by the delayed post-test) were dealt with by randomly taking a single value from the set of correlated effect sizes per feature for each affected study. This method eliminates the problem of dependency while ensuring that all levels of a study feature were represented (Lou et al., 1996). For example, for the analysis of the "outcome measure time," the selection of within-group findings was made randomly from among outcomes measured by immediate post-tests and delayed post-tests. This method was applied after all the study findings had been extracted and coded. Thirdly, when findings within the same category of outcomes in a study were not distinguishable by any of the study features coded, the effect sizes were averaged.

The study findings were extracted by two coders separately. The initial coding agreement on the number of findings to extract per study was 87.16%. Disagreements between the coders were resolved through subsequent discussion and further review of the disputed findings. Overall, 710 findings were extracted prior to random sampling within studies. After random sampling, 486 independent findings were selected for analysis.

Data Analyses

For each outcome, the unit of analysis was the independent study finding. Data screening was first performed using the SPSS for Windows (SPSS, 1998) frequency and descriptive procedures. Several study features with almost no variability (e.g., measure source, setting of collaboration) or with over 90% missing data (e.g., technical support, content support) were dropped from further analysis. Categories within some variables (e.g., group size, subject areas, and type of learners) were combined based on frequency distributions, conceptual meaning, and the preliminary results from the homogeneity analyses.

Outlier analyses were performed using standardized residual procedures (Hedges & Olkin, 1985). A few outliers with standardized residuals larger than ±2.00 were identified. These data were then carefully examined to see if there were any computational errors in the studies or if there was any feature in these studies that made them different from other studies. Two computational errors were found in the original source material for one study and their values were corrected based on other information available in the study. For other outliers, no computational or other serious errors were found. In addition, no obvious difference was found between these data and others in terms of their study features. Consequently, it was decided that these data should be included in the data analyses, especially in the study features analyses since excluding them might lead to biased results. However, in order to avoid their over-influence due to their extreme values, these effect sizes were modified (i.e., their absolute values reduced) to bring their residuals just equal to ±2.00 (Tabachnick & Fidell, 1996).

Effect sizes extracted from studies were then aggregated and tested for homogeneity (Hedges & Olkin, 1985). Each effect size was first corrected for bias and weighted by the inverse of its sampling variance. Thus, more weight was given to findings that were based on larger sample sizes. The weighted effect sizes were then aggregated to form an overall weighted mean estimate of the small group learning effects (d_+). The significance of d_+ was judged by its 95% confidence interval. If the confidence interval did not contain zero, d_+ was considered significantly positive or negative depending on the sign of the mean value. To determine whether the findings shared a common effect size, the set of effect sizes was tested for homogeneity by the homogeneity statistics (Q_T). When all findings share the same population effect size, Q_T has an approximate chi-square distribution with $k - 1$ degrees of freedom, where k is the number of effect sizes. If the obtained Q_T value is larger than the critical value, the findings are determined to be significantly heterogeneous, meaning that there is more variability in the effect sizes than chance fluctuation would allow.

For two of the significantly heterogeneous outcomes (i.e., individual achievement and group task performance), study features analyses were performed, first univariately and then with multiple regression, to identify factors that significantly moderated the effects of social context on each of the two cognitive outcomes.

Univariate Analyses of Study Features

In the univariate analyses, each study feature was tested through two homogeneity statistics, between-class homogeneity (Q_B) and within-class homogeneity (Q_W). Q_B tests for homogeneity of effect sizes across classes. It has an approximate chi-square distribution with $p - 1$ degrees of freedom, where p is the number of classes. If Q_B is greater than the critical value, it indicates a significant difference among the classes of effect sizes. When a study feature had more than two classes, Scheffé post-hoc comparisons were performed to control for Type I error rate. Q_W indicates whether the effect sizes within each class are homogeneous. It has an approximate chi-square distribution with $m - 1$ degrees of freedom, where m is the number of effect sizes in each class. If Q_W is greater than the critical value, it indicates that the effect sizes within the class are heterogeneous. Univariate study features analyses were conducted using the meta-analysis software DSTAT (Johnson, 1989) for its relative convenience in analyzing a large number of variables.

Multiple Regression Model Testing

Multiple regression models were tested using SPSS for Windows (SPSS, 1998). Based on the results from the univariate analyses, two weighted least squares multiple regression analyses were performed for each outcome. Analysis 1 aimed to identify study features that accounted for significant unique variances in the findings. All the significant predictors identified from the univariate analyses were entered as one block in a simple weighted least squares regression. Significance of each regression coefficient was determined by z test[2]. In Analysis 2, hierarchical weighted least squares regressions (Hedges & Olkin, 1985) were performed to develop a parsimonious model. First, all univariately significant study features were entered in blocks stepwise in this order: grouping characteristics, technology and task characteristics, learner characteristics, and publication status. Next, all other nonsignificant variables were entered stepwise to see if any additional variance might be explained by other variables. At each block, only variables that explained significant additional variance throughout the model testing were retained.

In the weighted least squares multiple regression, the sums of squares for regression (Q_R) (which is similar to Q_B in the univariate categorical model analysis) has an approximate chi-square distribution with $p - 1$ degrees of freedom, where p is the number of variables entered. Additional variance explained by each variable is the difference between Q_R at the current step and at previous step (i.e., Q_R increment), which is tested as a chi-square with 1 degree of freedom when the variable is dichotomous. Model specification is tested by goodness-of-fit statistics Q_E (which is similar to Q_W in the univariate categorical model analysis) with $k - p$ degrees of freedom.

The multiple regression analyses have two advantages over the univariate analyses. First, in the univariate analyses, the Type I error rate may be inflated due to the number of tests that are performed. In the multiple regression analyses, the error rate is controlled. The second advantage of the multiple regression analyses is that they can control for shared variance among the study features to develop a parsimonious model.

All variables were dummy coded into dichotomous variables for the multiple regression analyses. A few variables with more than two levels were combined into dichotomous variables based on the *post-hoc* analyses results of each of these study features. The higher value(s) was coded "1", the lower value(s) was coded "0". The missing data for each variable were coded either "1" or "0" depending on whether the mean effect size of the missing data was similar to the mean effect size for the higher value or the lower value. We chose to compute the fewest dichotomous dummy variables to avoid problems with low statistical power had we created a large number of dummy variables to represent multiple values of each variable (Lou, Abrami, & Spence, 2000; Abrami et al., 2000). The recoding was done globally for the heterogeneous outcomes analyzed with primary consideration given to the achievement outcome and secondly to the pattern that appeared to exist across the outcomes.

Results

In total, 486 independent effect sizes were extracted from 122 studies involving a total of 11,317 learners comparing the effects of small group learning with CT versus individual learning with CT on student individual achievement, group task performance, and several process and affective outcomes. Most of the individual achievement and group task performance outcomes were measured by locally developed or teacher-made instruments or criteria specific to what had been learned on the computer tasks. The majority of the studies were well controlled, employing either random assignment of students to experimental and control conditions or using statistical control for quasi-experimental studies. About half of the studies were published journal articles and half were unpublished reports or doctoral dissertations.

Overall Effects of Social Context on Student Cognitive, Process, and Affective Outcomes

Table 3 presents the number of independent findings extracted, number of studies involved, the weighted mean effect size, 95% confidence interval and overall homogeneity statistics for each of the cognitive, process, and affective outcomes analyzed.

TABLE 3

Overall Effects of Social Context on Cognitive, Process and Affective Outcomes

Outcome	k	d_+	95% CI	Q_T
	Cognitive outcomes			
Individual achievement (I)	178 (100)	+0.16	+0.12 / +0.20	341.95*
Group task performance (G)	39 (22)	+0.31	+0.20 / +0.43	102.90*
	Process measures			
Positive peer interaction (I)	6 (4)	+0.33	+0.05 / +0.61	50.72*
Use of strategies (I)	9 (5)	+0.50	+0.26 / +0.73	18.60*
Perseverance (I)	4 (2)	+0.48	+0.17 / +0.78	2.60
Task attempted (G)	37 (19)	−0.05	−0.17 / +0.06	90.54*
Success rate (I)	6 (5)	+0.28	+0.03 / +0.53	4.28
Interactivity with computers (G)	17 (9)	−0.19	−0.35 / −0.02	28.86
Request help from teacher (I)	3 (3)	−0.67	−0.93 / −0.41	21.02*
Task completion time (G)	66 (39)	−0.16	−0.08 / −0.24	257.20*
	Affective outcomes			
Attitude toward group work (I)	26 (15)	+0.52	+0.41 / +0.62	280.15*
Attitude toward classmates (I)	11 (6)	+0.29	+0.11 / +0.48	7.86
Attitude toward computers (I)	27 (20)	+0.02	−0.07 / +0.12	21.34
Attitude toward subject/ instruction (I)	47 (29)	+0.07	0.00 / +0.15	84.84*
Academic self-concept (I)	10 (4)	+0.04	−0.17 / +0.25	1.78

Note. k is the total number of independent findings integrated. The values in parentheses are the numbers of studies from which the findings were extracted. d_+ is the weighted mean effect size. 95% CI is the 95% confidence interval for d_+. Q_T is the homogeneity statistics, where * = $p < .05$, indicating that the effect sizes integrated are heterogeneous. G = group measure for those learning in groups; I = individual measure, that is, all students were assessed individually.

The overall effect of social context on individual achievement was based on 178 independent effect sizes extracted from 100 studies. The mean weighted effect size (d_+) was +0.16 (95% confidence interval is +0.12 to +0.20; and $Q_T = 341.95$, $df = 177$, $p < .05$) before outlier procedures. Individual effect sizes ranged from −1.14 to +3.37, with 105 effect sizes above zero favoring learning in groups, 15 effect sizes equal to zero, and 58 effect sizes below zero favoring individual learning. Fifteen outliers with standardized residuals larger than ±2.00 were identified. After outlier procedures, the mean effect size was +0.15 (95% confidence interval is +0.11 to +0.19). The results indicate that, on average, there was a small but significantly positive effect of small group learning on student achievement as measured by individually administered immediate or delayed post-tests. In general, average students (i.e., those at the 50th percentile) learning in small groups achieved at slightly above average (i.e., at about the 56th percentile) compared to students learning individually. However, homogeneity statistics ($Q_T = 259.55$, $df = 177$, $p < .05$) indicate that the findings on individual achievement were significantly heterogeneous both before and after the outlier procedure.

Thirty-nine independent effect sizes were extracted from 22 studies that explored the relationship between social context and performance where students learning in groups completed a group task and where students working individually completed an individual task. Group task performance measures included number of words or letters correct, number of problems, cases or puzzles solved, degree of success, percentage of correct responses, number of errors made (with the positive or negative sign of the effect size reversed), number of questions correct, quality of drawing, writing, projects or simulation results, number of errors identified or corrected, and scores on group assignments. The mean weighted effect size was +0.31, which was significantly different from zero (95% confidence interval is +0.20 to +0.43). The results indicate that, on average, there was a moderate positive effect of small group learning on group task performance. In general, groups performed significantly better than individuals during the study. However, the variability in the findings suggested significant heterogeneity ($Q_T = 102.90$, $df = 38$, $p < .05$). The effect sizes ranged from −0.86 to +2.53, with 30 effect sizes above zero favoring group task performance and 9 effect sizes below zero favoring individual task performance.

Relatively fewer studies reported learning processes and student task behaviors. Based on the findings extracted and analyzed in this review, small group learning had significantly positive effects on several learning processes. On average, students learning in groups had a significantly higher frequency of positive peer interaction ($d_+ = +0.33$), a higher frequency of using appropriate learning or task strategies ($d_+ = +0.50$), were more perseverant on tasks ($d_+ = +0.48$), and more students succeeded ($d_+ = +0.28$) than those learning individually. Students learning individually on average interacted more with computer programs ($d_+ = -0.19$), requested significantly more help from the teacher or monitor ($d_+ = -0.67$) and accomplished tasks faster than those working in groups ($d_+ = -0.16$). No significant differences were found between groups and individuals on amount of tasks attempted. Homogeneity statistics indicate that the findings on perseverance ($Q_T = 2.60$, $df = 3$), success rate ($Q_T = 4.28$, $df = 5$), and interactivity with programs ($Q_T = 28.22$, $df = 16$) were homogeneous, suggesting that the effect sizes were consistent. However, each set of effect sizes for the other measures was significantly heterogeneous, indicating considerable variability in the findings within each of these process measures.

Results on affective outcomes indicate that working with others in small groups when learning with CT had significantly positive effects on student attitude toward group work ($d_+ = +0.52$), and attitude toward classmates ($d_+ = +0.29$). No significant differences were found between students learning in small groups or individually on their attitudes toward computers, subject or instruction, or academic self-concept. Homogeneity statistics indicate that the findings on student attitude toward classmates ($Q_T = 7.86$, $df = 10$), computers ($Q_T = 21.23$, $df = 26$), and academic self-concept ($Q_T = 1.78$, $df = 9$) were homogeneous, suggesting that the effect sizes were consistent. However, findings on student attitude toward group work and toward learning with computers were significantly heterogeneous, indicating considerable variability in the findings within each of the two datasets.

In order to identify any potential pedagogical and/or contextual factors that may moderate the effects of social context, study features analyses were performed on each of the two heterogeneous cognitive outcomes.

What study features moderate the effects of social context on individual achievement in learning with CT? And what are the optimal conditions for small group learning?

Twenty-three study features were analyzed to identify factors that significantly moderated the effects of social context on individual achievement. Several study features (including outcome measure source, design orientation, teacher support, setting of collaboration, presence of others, and amount of peer interaction) were dropped from the analyses due to almost no variability or missing values in 90% of the findings.

Table 4 presents the results of the univariate analyses. Of the 23 study features analyzed, 9 study features were significantly related to the variability in the individual achievement findings. Each of the significant study features is described below.

Publication status. Effects of social context on student individual achievement were significantly more positive ($Q_B = 5.11$, $df = 1$, $p < .05$) in published journal articles ($d_+ = +0.20$) than in unpublished conference reports and dissertations ($d_+ = +0.10$). However, both means were significantly positive favoring student learning in small groups.

Types of programs. The types of programs with which students were learning was significantly related to the effects of social context on student individual achievement ($Q_B = 13.07$, $df = 2$, $p < .05$). Five types of computer programs were initially identified and coded. They were: tutorial, drill-and-practice, exploratory environments, productivity tools, and programming languages. Based on both conceptual similarity and post hoc analyses, tutorial and drill-and-practice were combined as tutor; exploratory environments and productivity tools were combined as exploratory/tool. Effect sizes were significantly larger when students were learning with tutor programs ($d_+ = +0.20$) or programming languages ($d_+ = +0.22$) than when using exploratory or tool programs ($d_+ = +0.04$).

TABLE 4

Results of the Univariate Study Features Analyses: Individual Achievement Findings

Study Feature	Q_B	k	d_+	95% CI	Q_W
Methodology features					
Student equivalence	3.33	178			
Publication status	5.11*	178			
Journal		84	+0.20	+0.14 / +0.25	110.80*
Report/dissertation		94	+0.10	+0.04 / +0.16	143.64*
Publication year	0.44	178			
Outcome features					
Outcome type	3.24	163			
Outcome measure time	3.49	178			
Technology characteristics					
Type of programs	13.07*	177			
Tutor		107	+0.20	+0.14 / +0.26	185.78*
Exploratory/tool		52	+0.04	−0.03 / +0.11	26.84
Programming language		18	+0.22	+0.10 / +0.34	32.50*
Feedback	4.19	121			
Instructional control	1.22	137			
Task characteristics					
Subject	7.95*	177			
Math/science/language arts		97	+0.11	+0.05 / +0.16	151.04*
Computer skills		39	+0.24	+0.16 / +0.33	81.15*
Social sciences and other		41	+0.20	+0.10 / +0.30	101.25*
Type of tasks	1.51	171			
Task structure	5.64*	152			
Open		66	+0.11	+0.04 / +0.17	66.76
Closed		86	+0.22	+0.15 / +0.28	160.77*
Task familiarity	.96	72			
Task difficulty	.32	28			
Grouping characteristics					
Group composition	9.68*	123			
Random/heterogeneous ability		76	+0.21	+0.14 / +0.28	180.96*
Homogeneous ability		22	+0.22	+0.11 / +0.32	28.11
Homogeneous gender		9	−0.04	−0.30 / +0.21	8.85
Heterogeneous gender		7	−0.07	−0.30 / +0.15	4.70
Mixed		9	+0.13	−0.01 / +0.28	7.05
Group learning strategy	16.11*	178			
Specific cooperative		120	+0.21	+0.15 / +0.25	194.25*
General encouragement		21	−0.04	−0.15 / +0.08	23.02
No specific/individualistic		37	+0.08	−.010 / +0.18	26.16
Group work exp./instruction	16.24*	178			
Yes		52	+0.29	+0.21 / +0.36	96.20*
Unknown		126	+0.10	+0.05 / +0.15	147.11
Group size	5.05*	178			
2		125	+0.18	+0.13 / +0.23	185.59*
3–5		53	+0.08	+0.00 / +0.15	68.91
Number of sessions	1.77	178			
Session duration	0.03	122			

TABLE 4

Results of the Univariate Study Features Analyses: Individual Achievement Findings (continued)

Study Feature	Q_B	k	d_+	95% CI	Q_W
	Learner characteristics				
Grade level	1.43	173			
Relative ability level	12.09*	178			
Low		24	+0.34	+0.21 / +0.47	47.39*
Medium		13	+0.09	−0.09 / +0.28	9.69
High		26	+0.24	+0.11 / +0.36	39.52*
Mixed		115	+0.12	+0.07 / +0.16	150.87*
Gender	1.30	27			
Computer experience	0.44	52			

Note. Q_B is the between-class homogeneity statistics, k is the number of findings, and d_+ is the weighted mean effect size. 95% CI is the 95% confidence interval for d_+. Q_W is the within-class goodness-of-fit statistics.

$^*p < .05$.

While the former two means were significantly positive, the latter was not significantly different from zero.

Subject. Effects of social context on student individual achievement varied in different subject areas ($Q_B = 7.95$, $df = 2$, $p < .05$). Initially, subjects were coded into six categories: math, science, reading/writing and language arts, computer skills, social studies, and other. Due to the small sample size in reading/writing and language arts and no significant differences among the mean effect sizes for math, science, and reading/writing and language arts, these three categories were combined; similarly, social studies and other were combined as the mean effect sizes for the two categories were not significantly different from each other. Analysis of the resulting three categories indicate that the effects of social context on student individual achievement were larger when the subjects involved were computer skills ($d_+ = +0.24$), social sciences and other ($d_+ = +0.20$) than when the subjects were math/science/language arts ($d_+ = +0.11$). However, all three mean effect sizes were significantly positive favoring small group learning with CT over individual learning with CT.

Task structure. Effects of social context on student individual achievement were significantly larger ($Q_B = 5.64$, $df = 1$, $p < .05$) for closed-ended tasks ($d_+ = +0.22$) than for open-ended tasks ($d_+ = +0.11$). Still, both means were significantly positive, indicating the superiority of small group learning with CT over individual learning with CT for both types of task structure.

Group composition. Type of group composition was significantly related to the effects of social context on student individual achievement ($Q_B = 9.69$, $df = 4$, $p < .05$). The effect sizes were significantly positive for both heterogeneous ability groups ($d_+ = +0.21$) and homogeneous ability groups ($d_+ = +0.22$). That is, students using CT in either homogeneous or heterogeneous ability groups outperformed students working alone using CT when all students were measured on individual tests of achievement. When groups were formed based on either homogeneous gender ($d_+ = -0.04$) or heterogeneous gender ($d_+ = -0.07$) the effects of group composition did not differ significantly from zero. Finally, the mean effect size for groups based on mixed criteria ($d_+ = +0.13$) was also positive but not significantly different from zero.

Group learning strategy. The group learning strategy employed was significantly related to the effects of social context on student individual achievement ($Q_B = 16.11$, $df = 2$, $p < .05$). Effect sizes were significantly more positive when specific cooperative learning strategies were employed ($d_+ = +0.21$) than when students were generally encouraged to work together ($d_+ = -0.04$) or when students in groups worked under individualistic goals or when no group learning strategy was described in the study ($d_+ = +0.08$), with the latter two means not significantly different from zero.

Group work experience or instruction. Effects of social context on student individual achievement were significantly more positive ($Q_B = 16.24$, $df = 1$, $p < .05$) when students had group work experience or instruction ($d_+ = +0.29$) than when no such information was reported ($d_+ = +0.10$). Both were significantly positive when compared to students learning with CT alone.

Group size. Effects of social context on student individual achievement were significantly more positive ($Q_B = 5.05$, $df = 1$, $p < .05$) when students worked in pairs ($d_+ = +0.18$) than when they worked in three to five member groups ($d_+ = +0.08$). Both group size conditions were significantly positive compared to students learning alone with CT.

Relative ability level of students. Effects of social context on student individual achievement were significantly related to the relative ability level of the students ($Q_B = 12.09$, $df = 3$, $p < .05$). There was a moderate positive effect of social context for low ability learners ($d_+ = +0.34$) and a small positive effect for high ability students ($d_+ = +0.24$). For medium ability learners, the effects were also positive but not significantly different from zero ($d_+ = +0.09$). Effect sizes for low ability students were significantly larger than those for medium ability students.

Other features. Most of the studies were published in the 1990s. The findings from the studies published in the last five years were not significantly different from those published in the earlier years. Over 90% of the studies were well controlled. The results from a few studies that did not use experimental control were not significantly different from the others. Type of feedback, types of tasks, task familiarity, task difficulty, number of sessions, session duration, grade level, gender, computer experience, instructional control, and whether achievement outcomes measured were of higher-order skills or lower-order skills were not found to be significantly related to the variability in the effects of social context on student individual achievement.

The next phase of the analysis of individual student achievement used multiple regression as a tool for model development. Analysis 1 identified unique variance explained. Analysis 2 identified a parsimonious model of important predictors.

Multiple Regression Analysis 1: Testing for unique variances using univariately significant predictors. The nine significant predictors ($p < .05$) identified from the univariate study features analyses were tested for their unique variances in a weighted least squares multiple regression. All variables were entered as one block. Of the nine variables entered, four accounted for significant unique variances in the findings: publication status (4.72%), group work experience/instruction (3.83%), subject (3.21%), and relative ability level (2.00%). Another 8.36% of the systematic variance was shared by the nine variables entered. Overall, the nine study features accounted for 22.12% of the total variance. Goodness-of-fit statistics (Q_E = 197.44, df = 167) indicate that the remaining variance can be explained by sampling error.

Multiple Regression Analysis 2: Hierarchical regression model development. Results of the hierarchical regression analyses are presented in Table 5. Six variables entered the model. Group work experience/instruction, subject, relative ability level, and publication status that were significant in Analysis 1 remained significant in the hierarchical regression model. Two univariately significant variables, group learning strategy and type of program, that were not significant in Analysis 1 each accounted for a significant amount of variance in the hierachical regression model. Together, the six variables accounted for 21.12% of the total variance in the findings. Goodness-of-fit statistics (Q_E = 199.96, df = 170) indicates that the model fits the data and that the remaining variance may be explained by sampling error. Three other study features including task structure, group composition, and group size were significant when analyzed separately but were not significant in the multiple regression model due to their correlation with other predictors.

TABLE 5

Hierarchical Regression Model Development: Individual Achievement Findings

Predictor	Step #	Q_R	$Q_{R\ increment}$	Q_E	% exp.
Group work exp./instruction	1	14.68*	14.68*	238.82*	5.79%
Group learning strategy	2	20.76*	6.08*	232.74*	8.19%
Type of program	3	28.53*	7.77*	224.98*	11.25%
Subject	4	33.19*	4.66*	220.32*	13.09%
Relative ability level	5	41.08*	7.89*	212.43*	16.20%
Publication status	6	53.54*	12.46*	199.96	21.12%

Note. Q_R is the Sum of Squares associated with all the predictors in the regression model. $Q_{R\ increment}$ is the additional Sums of Squares associated with the new predictor. Q_E is the goodness-of-fit statistics for the model. % exp. is the percentage of variance explained by the model. Group work experience/instruction, subject, relative ability level, and publication status each explained a significant amount of unique variance in Analysis 1.

$^*p < .05$.

TABLE 6
The Optimal Regression Model: Individual Achievement Findings

Predictor	*B*	*SE*
Group work exp./instruction: yes	.18*	.05
Group learning strategy: cooperative	.10*	.05
Type of program: tutor/programming	.11*	.05
Subject: social science/computer skills	.13*	.04
Relative ability level: low	.18*	.07
Publication status: journal	.16*	.04
Intercept for the model	–.20	.06

Note. B is the unstandardized regression coefficient upon entry. *SE* is the standard error of B.
$^*p < .05$.

Table 6 presents the regression coefficients and their standard errors in the optimal regression model. The results indicate that the effects of small group learning with CT on individual achievement were significantly larger when: (a) students had group work experience or specific instruction for group work rather than when no such experience or instruction was reported; (b) cooperative group learning strategies were employed rather than general encouragement only or individual learning strategies were employed; (c) programs involved tutorials or practice or programming languages rather than exploratory environments or as tools for other tasks; (d) subjects involved social sciences or computer skills rather than mathematics, science, reading, and language arts; (e) students were relatively low in ability rather than medium or high in ability; and (f) studies were published in journals rather than not published. When all the positive conditions were present, students learning in small groups could achieve 0.66 standard deviation more than those learning individually. When none of the positive conditions were present, students learning individually could learn 0.20 standard deviation more than those learning in groups.

What study features moderate the effects of social context when students learn with CT on group task performance? And what are the conditions for optimal group task performance?

Seventeen study features were analyzed to explore the variability in the group task performance data. In addition to those that were dropped from analysis on individual achievement, a few more study features were dropped from analysis on group task performance due to almost no variability or missing values in 90% or more of the findings. These included group work experience or instruction, session duration, relative ability level, and computer experience. In most of these studies, experimental sessions lasted from about 10 to 60 minutes; there was no description about group work experience or instruction; no description about computer experience; and no separate results for students of different relative ability levels. Outcome measure time does not apply here since all group task performance outcomes were measured during the study. Outcome type also does not apply since only task performance was measured here and the difference in task type is already represented by another study feature (i.e., type of task).

Table 7 presents the results of the univariate study features analyses on the group task performance data. Of the 17 study features analyzed, 5 study features were significantly related to the effects of social context on group task performance. Each of the significant study features is described below.

Feedback. Type of feedback provided by computer programs was significantly related to the effects of social context on group task performance, ($Q_B = 16.62$, $df = 2$, $p < .05$). Effect sizes were significantly more positive when programs provided no feedback ($d_+ = +0.47$) or minimal feedback ($d_+ = +0.29$) than when elaborate feedback was available in the computer programs ($d_+ = -0.24$). While the former was significantly positive favoring groups, the latter was significantly negative favoring individuals. Individuals benefit from computer-based feedback but groups do better without computer-based feedback when completing group tasks.

Instructional control. Effect sizes on group task performance were significantly more positive ($Q_B = 9.68$, $df = 1$, $p < .05$) when the software was mostly learner-controlled ($d_+ = +0.41$) than when the software was mostly system-controlled ($d_+ = -0.02$). While the former mean effect size was significantly positive, the latter was not different from zero. The advantage of working together and completing a group task was enhanced when students working together had control over the software they were using. This advantage disappeared when students working together on a group task had no control over the software they were using.

Task difficulty. Level of task difficulty was significantly related to the effects of social context on group task performance ($Q_B = 8.89$, $df = 2$, $p < .05$). Significantly more positive effect sizes were found when tasks were difficult ($d_+ = +0.13$) than when tasks were moderately difficult ($d_+ = -0.34$) or not difficult ($d_+ = -0.57$). When tasks were not difficult, the mean effect size was significantly negative favoring individuals ($d_+ = -0.57$); when tasks were moderately difficult, the mean effect size was also negative ($d_+ = -0.34$); but when tasks were difficult, the mean effect size was more positive favoring students working in groups ($d_+ = +0.13$). However, the latter two means were not statistically different from zero.

Group composition. Effect sizes on group task performance varied significantly for different group compositions ($Q_B = 27.03$, $df = 4$, $p < .05$). When groups were formed based on mixed criteria (i.e., ability and other criteria), the effect size was large ($d_+ = +1.15$) and significant. When groups were homogeneous in terms of gender, effect sizes were moderately large ($d_+ = +0.51$) and also significant. Finally, the mean effect size ($d_+ = +0.29$) for homogeneous ability groups was also significantly positive. However, the mean effect sizes for heterogeneous ability groups and heterogeneous gender were not significantly different from zero. Not all groups are created equal: Working in groups on a group task is superior to working alone on an individual task when groups are composed using mixed criteria, when groups are homogeneous in ability, or when groups are either all males or all females.

Group size. Effect sizes on group task performance were significantly larger ($Q_B = 15.34$, $df = 1$, $p < .05$) for three- to five-member groups ($d_+ = +0.87$) than

TABLE 7

Results of Univariate Study Features Analyses: Group Task Performance Findings

Study Feature	Q_B	k	d_+	95% CI	Q_W
	Methodology features				
Student equivalence	0.05	39			
Publication status	0.47	39			
Publication year	3.06	39			
	Technology characteristics				
Type of program	2.57	39			
Feedback	16.62*	30			
No		18	+0.47	+0.24 / +0.70	38.81*
Minimal		8	+0.29	+0.09 / +0.49	20.75*
Elaborate		4	–0.24	–0.56 / –0.09	8.92
Instructional control	9.68*	38			
Mostly learner-control		31	+0.41	+0.27 / +0.54	50.78*
Mostly system-control		7	–0.02	–0.26 / +0.21	41.27*
	Task characteristics				
Subject	2.39	39			
Type of task	0.34	39			
Task structure	0.32	38			
Task familiarity	3.11	30			
Task difficulty	8.89*	8			
Not difficult		3	–0.57	–0.92 / –0.21	1.27
Moderately difficult		2	–0.34	–0.86 / +0.17	3.51
Difficult		3	+0.13	–0.17 / +0.43	3.84
	Grouping characteristics				
Group composition	27.03*	27			
Random/heterogeneous ability		9	–0.16	–0.43 / +0.11	15.87
Homogeneous ability		4	+0.29	+0.01 / +0.59	20.10*
Homogeneous gender		10	+0.51	+0.29 / +0.73	13.62
Heterogeneous gender		2	+0.04	–0.61 / +0.69	0.00
Mixed		2	+1.15	+0.67 / +1.62	6.95*
Group learning strategy	5.09	39			
Group size	15.34*	39			
2		31	+0.22	+0.10 / +0.34	64.45*
3–5		8	+0.87	+0.57 / +1.17	23.11*
Number of sessions	0.49	39			
	Learner characteristics				
Grade level	1.97	38			
Gender	0.68	17			

Note. Q_B is the between-class homogeneity statistics. k is the number of findings. d_+ is the weighted mean effect size. 95% CI is the 95% confidence interval for d_+. Q_W is the within-class goodness-of-fit statistics.

$^*p < .05$.

for pairs ($d_+ = +0.22$), although both means were significantly positive. Working in larger groups and completing group tasks is generally superior to working in smaller groups.

Other features. Student equivalence across conditions, publication status, publication year, type of program, subject, type of task, task structure, task familiarity, group learning strategy, number of sessions, grade level, and gender were not found to be significantly related to the variability in the effects of social context on group task performance.

The next phase of the analysis of group task performance used multiple regression as a tool for model development. Analysis 1 identified unique variance explained. Analysis 2 identified a parsimonious model of important predictors.

Multiple Regression Analysis 1: Testing for unique variances using univariately significant predictors. Unique variances accounted for by each variable were tested in a weighted least squares multiple regression with all five significant study features identified from the univariate analyses entered in one block. Three study features were significant, each accounting for a significant amount of unique variance in the findings: task difficulty (8.96%), feedback (5.53%), and group size (5.62%). Another 27.77% of the systematic variance was shared by the 5 variables entered. Overall, the five study features accounted for 47.88% of the total variance. Goodness-of-fit statistics ($Q_E = 56.22$, $df = 33$), however, indicated that the model does not fit the data and that there may be other significant predictors which were not included in this model.

Multiple Regression Analysis 2: Hierarchical regression model development. Results of these analyses are presented in Table 8. Group size, task difficulty, and feedback that were significant in Analysis 1 remained significant in the hierarchical regression. After variance due to the three variables had been accounted for, task structure, which was not significant in the univariate analysis, accounted for a significant amount of additional variance ($Q_{R\ increment} = 16.93$). Together, the four variables accounted for 60.81% of the total variability. Goodness-of-fit statistics ($Q_E = 42.27$, $df = 34$) indicate that the model fits the data and that the remaining

TABLE 8
Multiple Regression Model Development: Group Task Performance Findings

Predictor	Step #	Q_R	$Q_{R\ increment}$	Q_E	% exp.
Group size	1	15.43*	15.43*	92.42*	14.31%
Task difficulty	2	43.43*	28.00*	64.43*	40.27%
Feedback	3	48.65*	5.22*	59.21*	45.11%
Task structure	4	65.58*	16.93*	42.27	60.81%

Note. Q_R is the Sum of Squares associated with all the predictors in the regression model. $Q_{R\ increment}$ is the additional Sums of Squares associated with the new predictor. Q_E is the goodness-of-fit statistics for the model. % exp. is the percentage of variance explained by the model. Group size, task difficulty, and feedback each explained a significant amount of unique variance in Analysis 1.
*$p < .05$.

variability may be explained by sampling error. Two other study features, instructional control and group composition, that were significant when analyzed separately were not significant in the multiple regression analyses due to their correlation with other predictors.

Table 9 presents the regression coefficients and their standard errors in the optimal regression model. The results indicate that the superiority of group performance over individual performance was stronger when: (a) group size was relatively large with three to five members; (b) the learning tasks were difficult; (c) programs provided minimal or no feedback, and (d) the tasks' structure was closed-ended. When all the positive conditions were present, group performance was about 3.02 standard deviation better than individual performance. When none of the positive conditions were present, individual performance would be about 1.66 standard deviation better than group performance. However, the finding concerning task structure may not be stable since it was not a significant predictor when analyzed separately, where the mean effect sizes for open-ended tasks and closed-ended tasks were both significantly positive favoring group task performance over individual task performance.

Discussion

Based on a total of 486 independent findings extracted from 122 studies involving 11,317 learners, the results of the series of meta-analyses conducted in this review indicate that social context plays an important role when students learn with CT. In general, small group learning with CT had more favorable effects than individual learning with CT on student cognitive, process and affective outcomes. On average, there was a small but significantly positive effect of social context on student individual achievement (mean *ES* = +0.15) and a moderate positive effect on group task performance (mean *ES* = +0.31). These positive results indicate that when working with CT in small groups, students in general produced substantially better group products than individual products and they also gained more individual knowledge than those learning with CT individually.

Analyses of several learning processes indicate that students learning with CT in small groups or individually tended to exhibit different task behaviors. Students learning individually with CT often accomplished tasks faster (mean *ES* = –0.16) through interacting more with the programs (mean *ES* = –0.19) and by getting more help from the teacher (mean *ES* = –0.67). In contrast, students learning in small

TABLE 9
The Optimal Regression Model: Group Task Performance Findings

Predictor	*B*	*SE*
Group size: 3–5	.44*	.21
Task difficulty: difficult	1.14*	.19
Feedback: no/minimal	.81*	.17
Task structure: closed	.63*	.15
Intercept for the model	–1.66	.25

Note. B is the unstandardized regression coefficient upon entry. *SE* is the standard error of *B*.
*p < .05.

groups benefited from greater social and cognitive interaction with peers (mean *ES* = +0.33), increased use of appropriate learning strategies (mean *ES* = +0.50), and better task perseverance (mean *ES* = +0.48). Finally, small group learning with CT had a significant positive effect on student attitudes toward group work (mean *ES* = +0.52) and toward classmates (mean *ES* = +0.29).

However, not all groups perform equally well and not all students learning in small groups using CT learned more than those learning individually with CT under all conditions. Through weighted least squares univariate and multiple regression analyses of individual achievement and group task performance outcomes, we found that the significant variability in each of the two cognitive outcomes could be accounted for by a few technology, task, grouping and learner characteristics.

Pedagogical and Contextual Factors that Moderate the Effects of Small Group Learning with CT on Student Individual Achievement

The study features that accounted for the most variability in the individual achievement findings were: group work experience or instruction, group learning strategies, type of program, subject, relative ability level, and publication status, with each accounting for a significant amount of independent variance. Group size was also a significant predictor when analyzed separately but not in the multiple regression analyses due to its correlation with other predictors. The effects of small group learning were significantly enhanced when: (a) students had group work experience or instruction; (b) specific cooperative learning strategies were employed; (c) group size was small (i.e., two members); (d) using tutorials or practice software or programming languages; (e) learning computer skills, social sciences and other subjects such as management and social studies; and (f) students were either relatively low in ability or relatively high in ability. When all the positive conditions are present, especially when studies were published in journals, moderate positive effects of social context (mean *ES* = +0.66) may be expected.

We did not find any category within a study feature, when analyzed separately, that showed significant negative effects of social context favoring individual learning on individual achievement. A few conditions were not significant univariately. These included conditions in which: (a) no specific cooperative learning strategies were used to facilitate group learning; (b) programs involved exploratory environments or were used as tools for other tasks; and (c) students were relatively medium in ability. Collectively, when all these conditions are present, especially when the subject matter involves mathematics, science, or language arts and the studies were reported in unpublished conference papers and dissertations, a small negative effect of social context (mean *ES* = –0.22) favoring individual learning with CT may be expected.

These results suggest that prior group learning experience and the teacher's use of cooperative learning strategies are important pedagogical factors that may influence how much students learn when working in small groups using CT. Explanations of group dynamics suggest that not all groups function well; for example, groups often do not function well when some members exert only minimal effort (Sharan & Sharan, 1976, 1992; Shepperd, 1993). Students need practice working together on group activities and training in how to work collaboratively (Webb, 1997; Farivar & Webb, 1994a; 1994b). Experience in group work may enable members to use acquired strategies for effective group work. Specific instruction for cooperative learning ensures that students learning in small groups will have positive interdependence as well as individual accountability that are essential qualities of effective cooperative learning (Abrami et al., 1995).

The more positive effects of small group learning with CT when specific cooperative learning strategies were employed are consistent with the meta-analysis by Lou et al. (1996 and Lou, Abrami, & Spence, 2000) of within-class grouping and with the quantitative syntheses of the cooperative learning literature (Johnson & Johnson, 1989; Slavin, 1989). Abrami et al. (1995) summarized myriad motivational and learning explanations of the positive effects of cooperative learning. These explanations may help illuminate the positive effects of social context when students learn with CT.

Motivational explanations concentrate on explaining student interest in, involvement with, and persistence at learning. Slavin (1992) argued that both cooperative incentives and cooperative task structures increase performance when they lead to encouragement among group members to perform the group task and to help one another in doing so. Johnson and Johnson (1994) used the theory of social interdependence to explain how the perception of interdependence among students motivates them to engage in promotive interactions that facilitate the realization of mutual goals. Ames (1984) suggested that a morality-based motivational system underlies cooperative goal structures such that students are motivated by the desire to help others and place special emphasis on individual and group efforts to achieve, making causal ascriptions to effort more salient than attributions to ability. Social cohesion explanations (Cohen, 1994; Sharan & Sharan, 1992) argue for the pre-eminent role of group cohesion which arises from care and concern for the group and its members.

Learning explanations concentrate on how the interactions among students affect their understanding and cognitive processes. Cognitive elaboration perspectives (Dansereau, 1985; Webb, 1989) suggest that the learner must engage in cognitive restructuring if information is to be retained and related to information already in memory, particularly by giving and receiving elaborated explanations. Johnson and Johnson (1992) describe several ways that the promotive interactions affect student thinking including: oral rehearsal, perspective-taking, peer monitoring, feedback, and cognitive controversy. Damon (1984) highlighted the cognitive-developmental perspectives of Piaget and Vygotsky who both emphasized how the interaction among students around cognitively appropriate tasks increases the mastery of critical concepts via discovery, idea generation, argumentation, verification, and criticism. Other explanations focus on practice effects, time-on-task, and classroom organization explanations.

The differential effects of small group learning for students of different relative ability levels are consistent with those found in Lou et al. (1996). The heterogeneous effects on individual achievement occurred mainly in the heterogeneous ability groups. Lou et al. (1996), Webb (1997), and Webb & Palincsar (1996) explained that in heterogeneous ability groups, low and high ability students benefit from receiving and giving explanations. For example, receiving explanations may help low ability students correct misconceptions and acquire appropriate learning strategies. Giving explanations may help high ability students clarify and organize their own learning. In contrast, medium ability students may benefit less from learning in small heterogeneous ability groups as they may neither give explanations as frequently as high ability students nor receive explanations as frequently as low ability students.

When using CT, students learned more working in pairs than in three to five-member groups. This finding is different from the within-class grouping research (Lou et al., 1996) where the optimal group size was larger. The difference may be due to the physical constraints associated with computer use. Group size may have to be small enough for all group members to sit comfortably around the computer in face-to-face collaborations in order to participate equally and actively. Alternatively, the computer itself may function as a prominent group member or tutor (Crook, 1991), requiring extraordinary coordination among students to insure proper engagement, pace, task sequencing, perspective-taking, and so on.

The effects of social context were more positive with drill-and-practice or tutorial programs than with exploratory or tool programs. There are several plausible explanations for these unexpected findings. First, when working in groups, especially when programs were exploratory in nature, the collaborators may have focused on actions and results rather than taking the time to articulate their mental processes or provide explanations for their actions (Daiute, 1989). Second, motivation may be another plausible explanation. When working with tutorials or drill-and-practice programs, students may find it more enjoyable and motivating to learn with peers than to work alone. Third, incidental learning outcomes of exploratory programs may not be captured by achievement post-tests, thus under-representing the effects of collaboration.

Factors Moderating the Effects of Social Context on Group Task Performance

The study features that accounted for the most variability in group task performance findings include group size, task difficulty and type of feedback. The superiority of group performance over individual performance was more pronounced when: (a) tasks were especially difficult; (b) groups consisted of three to five members; and (c) no or minimal feedback was available from the programs. When all the optimal conditions are present, a large positive effect of social context of more than 2 standard deviations may be expected on group task performance, as compared to individual task performance.

Work on socially shared cognition and distributed learning (Resnick, Levine, & Teasley, 1991; Salomon, 1993) emphasizes the impact of the social context on learners—both as individuals and within groups in face-to-face as well as computer-mediated environments—and gives rise to the conceptualization of groups as information processors (Hinsz, Tindale, & Vollrath, 1997). When working together, the group is capable of doing more than any single member by comparing alternative interpretations and solutions, correcting each other's misconceptions, forming a more holistic picture of the problem if the task is complex, or simply pooling resources. This advantage may be especially important when tasks are difficult and when minimal or no feedback is available from the programs. Under these conditions, students working alone may not have all the necessary cognitive resources and skills to complete the tasks well. In addition, when the software is capable of providing elaborate feedback, it may serve as an intellectual partner (Crook, 1991), ameliorating the effect of individual learning.

Differences between Student Individual Achievement and Group Task Performance

The results on student individual achievement and group task performance suggest that the two cognitive outcomes appeared different not only in their mean effect sizes but also in the factors that accounted for the variability in the two outcomes. A comparison of several predictors of individual achievement and group task performance indicated a differential pattern of moderating effects (see Figure 1). When cooperative learning strategies were employed, when students worked in pairs, and when programs involved tutorials or practices or programming languages, there was a small but significantly positive effect on both group task performance and individual achievement. However, when no specific cooperative learning strategies were employed, when students worked in larger three to five member groups, and especially when programs were used as exploratory environments or as tools for other tasks, although there were larger positive effects on group task performance, there were no significant positive effects on individual achievement.

In contrast, the effect sizes involving feedback showed a different pattern of moderating effects across group task performance and individual achievement outcomes. When programs provided minimal or no feedback, positive effects were found on both group task performance and individual achievement. However, when programs provided elaborate feedback, although the mean effect size on group task performance was significantly negative favoring individual learning, a significant positive mean effect size was observed on individual achievement.

These findings suggest that significantly higher group task performance does not necessarily mean significant individual learning, or vice versa. One plausible explanation for these differential effects is the different requirements for group task performance and individual achievement. While the former may reflect the collective wisdom and efforts of all or some of the participating members, the latter requires that each member of the group be actively engaged, interact and learn from each other in order to gain more knowledge from learning together (Webb, 1997). Caution should therefore be exercised when no specific cooperative strategies are used and when group size is larger than two members and especially when programs involve exploratory learning or are used as tools. Under these conditions, although one may generally expect significantly higher group performance over individual task performance, each individual student may not learn equally well.

On the other hand, the differential influence of elaborate feedback on group task performance and individual achievement suggest that articulation of ideas and discussion may be more important in facilitating student learning than simply reading the feedback provided on the computer screens. The cognitive elaboration (Vygotsky, 1978), cognitive dissonance (Piaget, 1954), and peer help and explanation (Webb, 1982a, 1982b) when working with others may create a deeper processing of ideas and, hence, better learning.

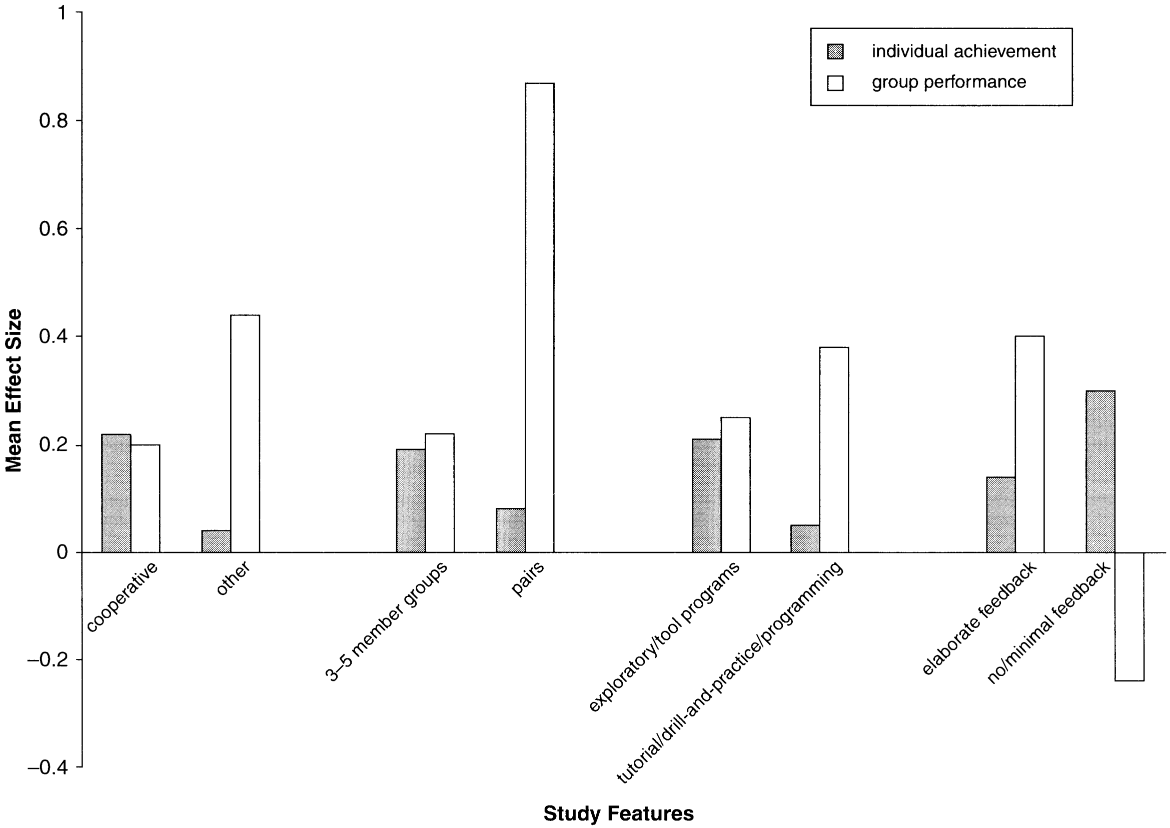

FIGURE 1. *Differential moderating effects of study features on individual achievement and group task performance.*

These results suggest that group task performance using CT is not the same as individual achievement using CT given the differences in moderating influences. When students work together on group projects, it is important to differentiate group products and individual learning outcomes. There are situations when collaborative task completion is defensible scholastically, demonstrating what a collection is capable of, enhancing motivation and group cohesiveness via pride in a collective accomplishment, and so on. However, if the focus is on individual achievement, effective cooperative learning strategies such as positive interdependence and individual accountability (e.g., requiring students to take turns and agree on answers, to summarize and explain their group's work), emphasizing that all members learn, should be employed to ensure the successful learning of all students.

Strengths, Limitations, and Future Directions

This meta-analysis extends knowledge of the role of social context when students learn with CT on various cognitive, process, and affective outcomes. It has addressed the question of whether and to what extent small group learning with CT is more effective than individual learning with CT and on which outcomes. It has identified a number of study features that moderated the effects of social context when learning with CT on group task performance and individual achievement. Through weighted least squares multiple regression analyses, parsimonious models were developed that accounted for the variability of social context effects on group task performance and individual achievement outcomes.

We caution the readers, however, that this meta-analysis, like others, has several limitations. First, meta-analysis results, especially those concerning explanatory features are correlational in nature and, therefore, strong causal inferences are not warranted. Second, as meta-analysts do not have experimental control over data, some of the study features examined had small sample sizes, or missing data, which reduces the sensitivity of the analyses. Third, multiple regression analyses are sensitive to the order variables are entered. Although care was taken to limit the influence from this artifact by testing two models in a different way, we do not claim that the hierarchical regression model is final and conclusive. It is also possible that some other factors not included in primary studies and in this review may provide some additional explanation. Finally, results of this meta-analysis may be limited by the design quality of the programs used in the primary studies. The majority of the programs were designed with an individual orientation or with no special design for group work. The few programs that provided special design for group use such as dual keyboards or computer allocation of turn-taking were of limited success. More effective program designs for small group learning should be developed and tested. For example, a program that is designed for small group use may provide built-in opportunities for each member to articulate and compare choice of task solutions and rationales.

As computers become ubiquitous tools for learning and instruction, and as teachers and students develop greater facility with their use to promote learning, we may learn more about the empowering effects of social context. For now, we are satisfied that old fears of social isolation can be overcome and that students collectively can learn well with technology.

(*text continues on page 510*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Aguirre (1997)	grade 4–6	geography	individual achievement		32	–0.02
Amigues & Agostinelli (1992)	grade 9	physics	interactivity with computers	familiar situation, difficult task	24	–0.60
Amigues & Agostinelli (1992)	grade 9	physics	interactivity with computers	unfamiliar situation, difficult task	24	0.60
Amigues & Agostinelli (1992)	grade 9	physics	task attempted	familiar situation, difficult task	24	0.74
Amigues & Agostinelli (1992)	grade 9	physics	task attempted	unfamiliar situation, easier task	24	0.00
Amigues & Agostinelli (1992)	grade 9	physics	use of strategies	familiar situation, easier task	24	1.13
Amigues & Agostinelli (1992)	grade 9	physics	use of strategies	unfamiliar situation, easier task	24	0.61
Anderson (1997)	grade 6	math	individual achievement		28	0.20
Baron & Abrami (1992)	grade 5–6	reading/language arts	individual achievement	group of 2	23	0.18
Baron & Abrami (1992)	grade 5–6	reading/language arts	individual achievement	group of 4	23	0.16
Belinski (1993)	college	art	individual achievement		78	0.00
Bellows (1986)	grade 2	geography	individual achievement	group of 2	33	0.00
Bellows (1986)	grade 2	geography	individual achievement	group of 3	44	–0.25
Benbunan (1997)	college	social studies	attitude toward subject/instruction		136	0.14
Benbunan (1997)	college	social studies	individual achievement		136	0.26
Berge (1990)	grade 7–8	science	individual achievement	group of 2	164	0.01
Berge (1990)	grade 7–8	science	individual achievement	group of 4	164	0.06
Berkowitz & Szabo (1977)	college	ecology	task attempted	heterogeneous ability	20	0.47
Berkowitz & Szabo (1977)	college	ecology	task attempted	homogeneous high ability	20	0.94

(continued)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Berkowitz & Szabo (1977)	college	ecology	task attempted	homogeneous low ability	20	–0.47
Berkowitz & Szabo (1977)	college	ecology	task completion time	heterogeneous ability groups	20	0.47
Berkowitz & Szabo (1977)	college	ecology	task completion time	homogeneous high ability	20	0.94
Berkowitz & Szabo (1977)	college	ecology	task completion time	homogeneous low ability	20	–0.94
Blaye & Chambers (1991, study 2)	adult	problem solving	interactivity with computers		10	–0.73
Blaye & Chambers (1991, study 2)	adult	problem solving	task attempted		10	–0.73
Blaye, Light, Jointer, & Sheldon (1991); Blaye & Chambers (1991, study 1)	grade 6	problem solving	success rate		38	0.83
Bloomer (1984)	college	computer skills	individual achievement		84	0.34
Butler (1991)	grade 6	social studies	group task performance		50	0.71
Butler (1991)	grade 6	social studies	individual achievement		80	0.07
Carrier & Sales (1987)	college	education	individual achievement		33	0.19
Carrier & Sales (1987)	college	education	task completion time		24	0.81
Cavalier & Klein (1998)	grade 5–6	earth science	individual achievement		125	0.34
Cavalier & Klein (1998)	grade 5–6	earth science	task completion time		125	–1.19
Chang & Smith (1991)	college	foreign language	individual achievement		113	0.08
Chapman (1985)	college	medicine	attitude toward computers		88	–0.03
Chapman (1985)	college	medicine	attitude toward group work		88	0.32
Chapman (1985)	college	medicine	individual achievement		81	–0.12
Cheney (1977)	college	computer skills	individual achievement		120	0.70
Chernick (1990)	grade 3–4	unknown	group task performance		30	2.31

Chernick (1990)	grade 3–4	unknown	individual achievement		50	−0.06
Chevrette (1987)	college	geography	group task performance		20	0.21
Chevrette (1987)	college	geography	individual achievement		27	0.15
Cockayne (1990)	college	biology	attitude toward group work	group of 2–3	96	0.33
Cockayne (1990)	college	biology	attitude toward group work	group of 4–5	143	0.4
Cockayne (1990)	college	biology	attitude toward subject/instruction	group of 2–3	96	−0.63
Cockayne (1990)	college	biology	attitude toward subject/instruction	group of 4–5	143	−0.53
Cockayne (1990)	college	biology	individual achievement	group of 2–3	96	−0.61
Cockayne (1990)	college	biology	individual achievement	group of 4–5	143	−0.48
Cockayne (1990)	college	biology	task completion time	group of 2–3	51	0.48
Cockayne (1990)	college	biology	task completion time	group of 4–5	48	0.64
Cox & Berger (1985)	grade 7–8	science problem solving	group task performance	group of 2	12	1.66
Cox & Berger (1985)	grade 7–8	science problem solving	group task performance	group of 3	12	1.44
Cox & Berger (1985)	grade 7–8	science problem solving	group task performance	group of 5	12	1.12
Cox & Berger (1985)	grade 7–8	science problem solving	task completion time	group of 2	7	−0.10
Cox & Berger (1985)	grade 7–8	science problem solving	task completion time	group of 3	7	−0.38
Cox & Berger (1985)	grade 7–8	science problem solving	task completion time	group of 5	7	−0.93
Crooks, Klein, Savenye, & Leader (1998)	college	education	attitude toward group work		150	1.00
Crooks, Klein, Savenye, & Leader (1998)	college	education	individual achievement		150	0.10

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Crooks, Klein, Savenye, & Leader (1998)	college	education	task attempted		150	–0.02
Crooks, Klein, Savenye, & Leader (1998)	college	education	task completion time		150	0.35
Dalton, Hannafin, & Hooper (1989)	grade 8	health	attitude toward subject/instruction	high ability, female	15	–0.18
Dalton, Hannafin, & Hooper (1989)	grade 8	health	attitude toward subject/instruction	high ability, male	14	0.46
Dalton, Hannafin, & Hooper (1989)	grade 8	health	attitude toward subject/instruction	low ability, female	16	1.57
Dalton, Hannafin, & Hooper (1989)	grade 8	health	attitude toward subject/instruction	low ability, male	15	–0.86
Dalton, Hannafin, & Hooper (1989)	grade 8	health	individual achievement	high ability, female	15	0.89
Dalton, Hannafin, & Hooper (1989)	grade 8	health	individual achievement	high ability, male	14	1.19
Dalton, Hannafin, & Hooper (1989)	grade 8	health	individual achievement	low ability, female	16	1.45
Dalton, Hannafin, & Hooper (1989)	grade 8	health	individual achievement	low ability, male	15	1.03
Derry, Tookey, & Roth (1993)	college	math	task completion time		16	0.15
Dossett & Hulvershorn (1983)	military	engineer	individual achievement		127	0.05
Dossett & Hulvershorn (1983)	military	engineer	task completion time		91	–0.66
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	individual achievement	group of 2	24	0.00

Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	individual achievement	group of 3	26	0.00
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	individual achievement	group of 4	24	–0.09
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	interactivity with computers	group of 2	24	–0.97
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	interactivity with computers	group of 3	26	–0.81
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	interactivity with computers	group of 4	24	–0.69
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	positive peer interaction	group of 2	24	1.64
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	positive peer interaction	group of 3	26	1.65
Durnin (1985); Trowbridge & Durnin (1984)	grade 7–8	physics	positive peer interaction	group of 4	24	0.99
Dyer (1993)	grade 5	math	academic self-concept	structured, high ability	24	0.16
Dyer (1993)	grade 5	math	academic self-concept	structured, low ability	25	–0.31
Dyer (1993)	grade 5	math	academic self-concept	unstructured, high ability	23	0.19
Dyer (1993)	grade 5	math	academic self-concept	unstructured, low ability	23	0.14
Dyer (1993)	grade 5	math	attitude toward classmates	structured, high ability	24	0.67
Dyer (1993)	grade 5	math	attitude toward classmates	structured, low ability	25	0.64
Dyer (1993)	grade 5	math	attitude toward classmates	unstructured, high ability	23	0.68
Dyer (1993)	grade 5	math	attitude toward classmates	unstructured, low ability	23	–0.06
Dyer (1993)	grade 5	math	attitude toward computers	structured, high ability	24	–0.10
Dyer (1993)	grade 5	math	attitude toward computers	structured, low ability	25	0.38

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Dyer (1993)	grade 5	math	attitude toward computers	unstructured, high ability	23	–0.01
Dyer (1993)	grade 5	math	attitude toward computers	unstructured, low ability	23	–0.07
Dyer (1993)	grade 5	math	attitude toward group work	structured, high ability	24	1.15
Dyer (1993)	grade 5	math	attitude toward group work	structured, low ability	25	1.09
Dyer (1993)	grade 5	math	attitude toward group work	unstructured, high ability	23	0.63
Dyer (1993)	grade 5	math	attitude toward group work	unstructured, low ability	23	0.30
Dyer (1993)	grade 5	math	individual achievement	structured, high ability	23	–0.12
Dyer (1993)	grade 5	math	individual achievement	structured, low ability	25	–0.02
Dyer (1993)	grade 5	math	individual achievement	unstructured, high ability	24	–0.18
Dyer (1993)	grade 5	math	individual achievement	unstructured, low ability	23	–0.36
Edelbrock (1990)	college	computer skills	attitude toward computers	female	42	0.19
Edelbrock (1990)	college	computer skills	attitude toward computers	male	32	0.62
Foot (1986, Exp. 1)	grade 3	problem solving	individual achievement		56	0.32
Foot (1986, Exp. 1)	grade 3	problem solving	success rate		56	0.24
Foot (1986, Exp. 2)	grade 3	problem solving	individual achievement	dual-keyboard	40	–0.32
Foot (1986, Exp. 2)	grade 3	problem solving	individual achievement	single-keyboard	40	0.32
Foot (1986, Exp. 5)	grade 6	problem solving	individual achievement	with justification of answers	40	0.46
Foot (1986, Exp. 6)	grade 6	problem solving	individual achievement	with justification of answers	40	0.47

Foot (1986, Exp. 6)	grade 6	problem solving	individual achievement	without justification of answers	40	–0.02
Golton (1975)	grade 6	math	individual achievement	high ability	59	–0.05
Golton (1975)	grade 6	math	individual achievement	low ability	55	–0.53
Golton (1975)	grade 6	math	individual achievement	medium ability	57	–0.01
Golton (1975)	grade 6	math	task attempted	high ability	59	–0.57
Golton (1975)	grade 6	math	task attempted	low ability	55	0.29
Golton (1975)	grade 6	math	task attempted	medium ability	57	–0.25
Goodman (1968)	college	geography	attitude toward subject/instruction	neutral CAI, female	9	–0.49
Goodman (1968)	college	geography	attitude toward subject/instruction	neutral CAI, male	20	–0.21
Goodman (1968)	college	geography	attitude toward subject/instruction	pro CAI, female	10	–0.14
Goodman (1968)	college	geography	attitude toward subject/instruction	pro CAI, male	17	0.31
Goodman (1968)	college	geography	individual achievement	neutral CAI, female	9	0.53
Goodman (1968)	college	geography	individual achievement	neutral CAI, male	20	0.24
Goodman (1968)	college	geography	individual achievement	pro CAI, female	10	–0.37
Goodman (1968)	college	geography	individual achievement	pro CAI, male	17	–0.67
Goodman (1968)	college	geography	task completion time	neutral CAI, female	9	–0.59
Goodman (1968)	college	geography	task completion time	neutral CAI, male	20	–0.21
Goodman (1968)	college	geography	task completion time	pro CAI, female	17	0.85
Goodman (1968)	college	geography	task completion time	pro CAI, male	10	0.56
Grossman (1983)	college	computer skills	attitude toward subject/instruction	fixed heterogeneous	41	0.81
Grossman (1983)	college	computer skills	attitude toward subject/instruction	varied heterogeneous	40	0.53
Grossman (1983)	college	computer skills	group task performance	fixed heterogeneous	28	0.52
Grossman (1983)	college	computer skills	group task performance	varied heterogeneous	28	0.54
Grossman (1983)	college	computer skills	individual achievement	fixed heterogeneous	41	0.12

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Grossman (1983)	college	computer skills	individual achievement	varied heterogeneous	40	–0.14
Grossman (1983)	college	computer skills	perseverance	fixed heterogeneous	28	0.44
Grossman (1983)	college	computer skills	perseverance	varied heterogeneous	28	0.51
Grossman (1983)	college	computer skills	task attempted	fixed heterogeneous	28	–0.44
Grossman (1983)	college	computer skills	task attempted	varied heterogeneous	28	–0.39
Grossman (1983)	college	computer skills	task completion time	fixed heterogeneous	28	0.02
Grossman (1983)	college	computer skills	task completion time	varied heterogeneous	28	0.16
Grubb (1964)	college	statistics	individual achievement	high ability	15	–0.33
Grubb (1964)	college	statistics	individual achievement	low ability	15	0.12
Grubb (1964)	college	statistics	task completion time	high ability	10	–1.14
Grubb (1964)	college	statistics	task completion time	low ability	10	0.07
Gunterman & Tovar (1987)	grade 4	computer skills	group task performance	group of 2	12	–0.04
Gunterman & Tovar (1987)	grade 4	computer skills	group task performance	group of 3	12	–0.30
Gunterman & Tovar (1987)	grade 4	computer skills	task completion time	group of 2	12	0.05
Gunterman & Tovar (1987)	grade 4	computer skills	task completion time	group of 3	12	–0.35
Harrison (1991)	grade 8	earth science	attitude toward subject/instruction		102	–0.10
Harrison (1991)	grade 8	earth science	individual achievement	high ability	34	–0.28
Harrison (1991)	grade 8	earth science	individual achievement	low ability	34	0.84
Harrison (1991)	grade 8	earth science	individual achievement	medium ability	34	–0.05
Harrison (1991)	grade 8	earth science	interactivity with computers	high ability	34	–0.44
Harrison (1991)	grade 8	earth science	interactivity with computers	low ability	34	–0.42
Harrison (1991)	grade 8	earth science	interactivity with computers	medium ability	34	–0.20

Harrison (1991)	grade 8	earth science	task completion time	high ability	34	0.64
Harrison (1991)	grade 8	earth science	task completion time	low ability	34	–0.39
Harrison (1991)	grade 8	earth science	task completion time	medium ability	34	0.63
Henderson (1992)	college	computer skills	attitude toward computers		125	–0.01
Henderson (1992)	college	computer skills	attitude toward group work		125	–0.31
Henderson (1992)	college	computer skills	individual achievement		125	0.15
Henderson (1992)	college	computer skills	task completion time		125	0.47
Hill (1990)	grade 8	writing	individual achievement		36	0.39
Hine, Goldman, & Cosden (1990)	grade 3–7	writing	group task performance		18	0.33
Hooper (1992)	grade 5–6	math	individual achievement	average ability	57	0.37
Hooper (1992)	grade 5–6	math	individual achievement	high ability	58	0.21
Hooper (1992)	grade 5–6	math	task completion time	average ability	31	–0.11
Hooper (1992)	grade 5–6	math	task completion time	high ability	28	–0.05
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	attitude toward group work		162	1.08
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	attitude toward subject/instruction		162	0.39
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	individual achievement	higher-order task, program control, average ability	38	0.41
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	individual achievement	higher-order task, program control, average ability	101	0.12
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	individual achievement	lower-order task, learner control, average ability	45	0.13
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	individual achievement	lower-order task, learner control, average ability	38	0.18
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	interactivity with computers		121	–0.20
Hooper, Temiyakarn, & Williams (1993)	grade 4	math	task completion time		121	–0.70

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Huang (1993)	college	health	individual achievement	high ability, elaborate feedback	20	1.83
Huang (1993)	college	health	individual achievement	high ability, minimal feedback	20	2.69
Huang (1993)	college	health	individual achievement	high ability, no feedback	20	3.37
Huang (1993)	college	health	individual achievement	low ability, elaborate feedback	20	2.42
Huang (1993)	college	health	individual achievement	low ability, minimal feedback	20	0.45
Huang (1993)	college	health	individual achievement	low ability, no feedback	20	2.10
Huang (1993)	college	health	task completion time	elaborate feedback	30	1.50
Huang (1993)	college	health	task completion time	minimal feedback	30	1.39
Huang (1993)	college	health	task completion time	no feedback	30	1.03
Inkpen, Booth, Klawe, & Upitis (1995, Phase 1)	grade 4–6	problem solving	group task performance	mix-gender, group vs. parallel individual	17	0.36
Inkpen, Booth, Klawe, & Upitis (1995, Phase 1)	grade 4–6	problem solving	group task performance	same-gender, group vs. parallel individual, female	32	1.17
Inkpen, Booth, Klawe, & Upitis (1995, Phase 1)	grade 4–6	problem solving	group task performance	same-gender, group vs. parallel ind., male	32	−0.05
Inkpen, Booth, Klawe, & Upitis (1995, Phase 2)	grade 4–7	problem solving	group task performance	female	201	0.34
Inkpen, Booth, Klawe, & Upitis (1995, Phase 2)	grade 4–7	problem solving	group task performance	male	66	0.36
Inkpen, Booth, Klawe, & Upitis (1995, Phase 2)	grade 4–7	problem solving	perseverance	group vs. parallel solos, female	92	0.68

Inkpen, Booth, Klawe, & Upitis (1995, Phase 2)	grade 4–7	problem solving	perseverance	group vs. parallel solos, male	38	0.05
Ivers (1994)	college	computer skills	attitude toward subject/instruction		97	–0.15
Ivers (1994)	college	computer skills	individual achievement		97	–0.19
Ivers (1994)	college	computer skills	task completion time		75	1.24
Ivers & Barron (1998)	college	computer skills	attitude toward subject/instruction		103	0.88
Ivers & Barron (1998)	college	computer skills	individual achievement		103	–0.08
Ivers & Barron (1998)	college	computer skills	task completion time		103	0.52
Jackson (1987, Exp. 2)	grade 5	math	individual achievement		48	0.05
Jackson (1987, Exp. 2)	grade 5	math	success rate		24	0.11
Jackson (1987, Exp. 2)	grade 5	math	task attempted		24	0.10
Jackson (1987, Exp. 2)	grade 5	math	task completion time		24	0.62
Jackson (1987, Exp. 4)	grade 5	math	interactivity with computers		24	–0.14
Jackson (1987, Exp. 4)	grade 5	math	task attempted		24	–0.20
Jackson (1987, Exp. 4)	grade 5	math	task completion time		24	0.58
Jackson (1987, Exp. 5)	grade 5	math	interactivity with computers		32	–0.48
Jackson (1987, Exp. 5)	grade 5	math	task attempted		32	–0.82
Jackson (1987, Exp. 5)	grade 5	math	task completion time		32	–0.11
Jackson, Fletcher, & Messer (1992, Exp. 1)	grade 5	math	individual achievement	silent	48	0.06
Jackson, Fletcher, & Messer (1992, Exp. 1)	grade 5	math	individual achievement	verbal	48	–0.13
Jackson, Fletcher, & Messer (1992, Exp. 1)	grade 5	math	task completion time	silent	24	–0.04
Jackson, Fletcher, & Messer (1992, Exp. 1)	grade 5	math	task completion time	verbal	24	–0.27
Jackson, Fletcher, & Messer (1992, Exp. 2)	grade 5	math	task completion time		32	–0.14

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Jegede, Okebukola, & Ajewole (1990)	grade 11	biology	attitude toward computers		40	1.30
Jegede, Okebukola, & Ajewole (1990)	grade 11	biology	individual achievement		40	0.40
Jehng (1997)	college	computer skills	individual achievement	distributed group	54	0.50
Jehng (1997)	college	computer skills	individual achievement	face-to-face group	54	0.60
Justen, Waldrop, & Adams (1990)	college	education	individual achievement	extended feedback	31	–0.34
Justen, Waldrop, & Adams (1990)	college	education	individual achievement	minimal feedback	37	0.55
Kacer (1989); Kacer, Weinholtz, & Rocklin (1992)	college	computer skills	attitude toward computers		32	0.16
Kacer (1989); Kacer, Weinholtz, & Rocklin (1992)	college	computer skills	attitude toward subject/instruction		32	0.57
Kacer (1989); Kacer, Weinholtz, & Rocklin (1992)	college	computer skills	group task performance		16	0.29
Kacer (1989); Kacer, Weinholtz, & Rocklin (1992)	college	computer skills	individual achievement		32	0.27
Keeler & Anson (1995)	college	computer skills	attitude toward computers		33	0.00
Keeler & Anson (1995)	college	computer skills	individual achievement		33	0.52
Keeler & Anson (1995)	college	computer skills	positive peer interaction		33	0.00

Kelley (1998)	college	engineer	individual achievement		78	–0.17
Kelly & O'Donnell (1994)	college	education	task attempted		53	0.61
Klein & Doran (1999)	college	management	attitude toward group work	collaborative	70	–0.02
Klein & Doran (1999)	college	management	attitude toward group work	cooperative	70	–0.08
Klein & Doran (1999)	college	management	attitude toward subject/instruction	collaborative	70	–0.47
Klein & Doran (1999)	college	management	attitude toward subject/instruction	cooperative	70	–0.64
Klein & Doran (1999)	college	management	individual achievement	collaborative	70	0.00
Klein & Doran (1999)	college	management	individual achievement	cooperative	70	0.00
Klein & Doran (1999)	college	management	task completion time	collaborative	70	0.24
Klein & Doran (1999)	college	management	task completion time	cooperative	70	0.24
Kwinn (1990)	college	computer skills	individual achievement		86	0.23
Leali (1992)	grade 9–12	math	attitude toward computers		64	0.06
Leali (1992)	grade 9–12	math	attitude toward group work		64	–0.39
Leali (1992)	grade 9–12	math	attitude toward subject/instruction		64	0.12
Leali (1992)	grade 9–12	math	individual achievement		64	0.50
LeBel (1982)	grade 10	math	individual achievement	contingency grade	35	–0.09
LeBel (1982)	grade 10	math	individual achievement	individual grade	29	–0.44
LeBel (1982)	grade 10	math	task attempted	contingency grade	35	0.16
LeBel (1982)	grade 10	math	task attempted	individual grade	29	0.29
LeBel (1982)	grade 10	math	task completion time	contingency grade	35	0.22
LeBel (1982)	grade 10	math	task completion time	individual grade	29	0.34
LeBel (1982)	grade 10	math	use of strategies	contingency grade	35	0.54
LeBel (1982)	grade 10	math	use of strategies	individual grade	29	0.45
Lee (1991)	grade 9	math	academic self-concept		73	0.18

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Lee (1991)	grade 9	math	attitude toward computers		73	0.18
Lee (1991)	grade 9	math	attitude toward group work		73	0.18
Lee (1991)	grade 9	math	attitude toward subject/instruction		73	–0.04
Lee (1991)	grade 9	math	individual achievement	high ability	29	0.34
Lee (1991)	grade 9	math	individual achievement	low ability	10	−1.09
Lee (1991)	grade 9	math	individual achievement	medium ability	34	0.00
Lemos (1979)	college	computer skills	individual achievement		215	0.46
Lidtke (1979)	college	computer skills	attitude toward computers		75	–0.11
Lidtke (1979)	college	computer skills	attitude toward group work		75	−1.29
Lidtke (1979)	college	computer skills	attitude toward subject/instruction		75	–0.02
Lidtke (1979)	college	computer skills	individual achievement	high ability	35	–0.04
Lidtke (1979)	college	computer skills	individual achievement	low ability	36	0.41
Lidtke (1979)	college	computer skills	positive peer interaction		75	–0.91
Lidtke (1979)	college	computer skills	request help from teacher		75	–0.52
Lidtke (1979)	college	computer skills	task completion time		75	0.26
Lieber & Semmel (1987)	grade 4–6	math	individual achievement	learning-handicapped	40	0.56
Lieber & Semmel (1987)	grade 4–6	math	individual achievement	regular ability	40	–0.56
Lieber & Semmel (1987)	grade 4–6	math	task attempted	learning-handicapped, heterogeneous ability	40	0.56

Lieber & Semmel (1987)	grade 4–6	math	task attempted	learning-handicapped, homogeneous ability	40	0.56
Lieber & Semmel (1987)	grade 4–6	math	task attempted	regular ability, heterogeneous ability	40	–0.56
Lieber & Semmel (1987)	grade 4–6	math	task attempted	regular ability, homogeneous ability	40	–0.56
Lieber & Semmel (1987)	grade 4–6	math	task completion time	heterogeneous ability	80	0.00
Lieber & Semmel (1987)	grade 4–6	math	task completion time	homogenous ability	80	0.40
Light & Glachan (1985)	grade 2	problem solving	task attempted	grade 2	30	–1.31
Light & Glachan (1985)	grade 7	problem solving	task attempted	grade 7	34	–0.92
Light, Foot, Colbourn, & McClelland (1987)	grade 3	problem solving	success rate	dual keyboard	40	0.48
Light, Foot, Colbourn, & McClelland (1987)	grade 3	problem solving	success rate	single keyboard	40	–0.10
Light, Littleton, Messer, Joiner (1994)	grade 6	problem solving	group task performance		75	0.27
Light, Littleton, Messer, Joiner (1994)	grade 6	problem solving	individual achievement		120	0.00
Lookatch (1990)	adult vocation	career skills	individual achievement		62	0.42
Love (1969)	grade 9–12	math	group task performance		36	0.04
Love (1969)	grade 9–12	math	individual achievement		54	–0.03
Love (1969)	grade 9–12	math	task completion time		36	–0.13
MacGregor (1987)	grade 3	reading/language arts	individual achievement		52	–0.12
MacGregor (1987)	grade 3	reading/language arts	task completion time		52	0.23
Makuch, Robillard, & Yoder (1992)	military	engineer	individual achievement		27	–0.70
Makuch, Robillard, & Yoder (1992)	military	engineer	task completion time		27	2.15
McDermott (1985)	grade 5–6	problem solving	attitude toward computers		89	–0.05
McDermott (1985)	grade 5–6	problem solving	individual achievement		89	0.06

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
McInerney, McInerney, & Marsh (1997, Study1)	college	computer skills	academic self-concept		31	–0.04
McInerney, McInerney, & Marsh (1997, Study1)	college	computer skills	attitude toward computers		31	–0.21
McInerney, McInerney, & Marsh (1997, Study1)	college	computer skills	individual achievement		31	0.07
McInerney, McInerney, & Marsh (1997, Study2)	college	computer skills	academic self-concept		30	0.20
McInerney, McInerney, & Marsh (1997, Study2)	college	computer skills	attitude toward computers		30	0.10
McInerney, McInerney, & Marsh (1997, Study2)	college	computer skills	individual achievement		30	0.46
Mehta (1993)	college	computer skills	individual achievement		31	1.40
Mevarech (1993)	grade 3	computer skills	attitude toward classmates	high ability	56	0.33
Mevarech (1993)	grade 3	math	attitude toward classmates	low ability	54	0.14
Mevarech (1993)	grade 3	math	individual achievement	high ability	53	–0.03
Mevarech (1993)	grade 3	math	individual achievement	low ability	55	–0.53
Mevarech (1993)	grade 3	math	use of strategies	high ability	55	0.81
Mevarech (1993)	grade 3	math	use of strategies	low ability	53	1.19
Mevarech (1994)	grade 3	math	individual achievement	grade 3, high ability	179	0.13
Mevarech (1994)	grade 6	math	individual achievement	grade 3, low ability	143	0.27
Mevarech (1994)	grade 6	math	individual achievement	grade 6, high ability	144	0.36
Mevarech (1994)	grade 3	math	individual achievement	grade 6, low ability	163	0.29

Mevarech & Kramarski (1993)	grade 8	computer skills	attitude toward classmates		54	0.61
Mevarech & Kramarski (1993)	grade 8	computer skills	individual achievement		54	0.55
Mevarech, Silbeer, & Fine (1991)	grade 6	math	academic self-concept	high ability	50	–0.13
Mevarech, Silbeer, & Fine (1991)	grade 6	math	academic self-concept	low ability	50	0.03
Mevarech, Silbeer, & Fine (1991)	grade 6	math	academic self-concept	medium ability	50	0.00
Mevarech, Silbeer, & Fine (1991)	grade 6	math	attitude toward subject/instruction	high ability	50	–0.18
Mevarech, Silbeer, & Fine (1991)	grade 6	math	attitude toward subject/instruction	low ability	50	0.41
Mevarech, Silbeer, & Fine (1991)	grade 6	math	attitude toward subject/instruction	medium ability	50	–0.30
Mevarech, Silbeer, & Fine (1991)	grade 6	math	individual achievement	high ability	50	0.12
Mevarech, Silbeer, & Fine (1991)	grade 6	math	individual achievement	low ability	50	0.27
Mevarech, Silbeer, & Fine (1991)	grade 6	math	individual achievement	medium ability	50	0.27
Mevarech, Stern, & Levita (1987)	grade 7–10	reading/lang. arts	attitude toward classmates		115	0.03
Mevarech, Stern, & Levita (1987)	grade 7–10	reading/lang. arts	attitude toward group work		115	0.48
Mevarech, Stern, & Levita (1987)	grade 7–10	reading/lang. arts	attitude toward subject/instruction		115	0.04
Mevarech, Stern, & Levita (1987)	grade 7–10	reading/lang. arts	individual achievement		115	0.21
Noble (1967)	grade 10	math	attitude toward computers		36	–0.25

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Noble (1967)	grade 10	math	attitude toward subject/instruction		36	0.20
Noble (1967)	grade 10	math	individual achievement		36	−0.14
Noell & Carnine (1989)	grade 9–11	biology	individual achievement		33	−0.02
Oh (1988)	college	computer skills	group task performance	cooperative incentive	51	0.21
Oh (1988)	college	computer skills	individual achievement	cooperative incentive	72	−0.07
Oh (1988)	college	computer skills	individual achievement	cooperative task	72	−0.23
Okey & Majer (1976)	college	education	attitude toward subject/instruction	group of 2	12	−0.61
Okey & Majer (1976)	college	education	attitude toward subject/instruction	group of 3–4	12	−0.56
Okey & Majer (1976)	college	education	individual achievement	group of 2	12	−0.35
Okey & Majer (1976)	college	education	individual achievement	group of 3–4	12	−0.43
Okey & Majer (1976)	college	education	task completion time	group of 2	9	0.77
Okey & Majer (1976)	college	education	task completion time	group of 3–4	9	−1.39
Olivas (1990)	adult vocation	computer skills	individual achievement		45	1.27
Orr & Davidson (1993)	grade 4–5	astronomy	attitude toward group work		190	0.00
Orr & Davidson (1993)	grade 4–5	astronomy	individual achievement		190	0.00
Park (1993)	college	chemistry	attitude toward computers		109	0.00
Park (1993)	college	chemistry	attitude toward subject/instruction		109	0.00
Park (1993)	college	chemistry	individual achievement		109	0.41

Pattison (1995)	college	computer skills	attitude toward computers		36	–0.45
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	attitude toward subject/instruction		60	0.68
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	group task performance		40	0.89
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	individual achievement		60	0.78
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	positive peer interaction		60	1.21
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	request help from teacher		60	–2.08
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	task attempted		40	–1.98
Perlmutter, Behrend, & Muller (1985)	pre-k	math/language	task completion time		40	0.00
Porter (1993)	grade 7–9	writing	group task performance		24	2.53
Priebe (1997)	college	computer skills	individual achievement		49	–0.21
Quinn, Pena, & McCune (1996)	college	science	success rate		65	0.24
Quinn, Pena, & McCune (1996)	college	science	task attempted		65	0.12
Reglin (1990)	college	math	attitude toward subject/instruction		53	0.00
Reglin (1990)	college	math	individual achievement		53	0.81
Reiter (1994)	grade 1–8	problem solving	individual achievement		19	0.53
Reiter (1994)	grade 1–8	problem solving	task attempted		19	–0.03
Repman, Weller, & Lan (1993)	grade 8	social studies	individual achievement	magnet	44	0.03
Repman, Weller, & Lan (1993)	grade 8	social studies	individual achievement	non-magnet	18	0.96

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Repman, Weller, & Lan (1993)	grade 8	social studies	task attempted	magnet	30	0.06
Repman, Weller, & Lan (1993)	grade 8	social studies	task attempted	non-magnet	14	0.36
Robinson (1998)	grade 4–6	math	attitude toward computers		174	0.07
Roussey, Farioli, & Piolat (1992)	grade 4	writing	group task performance	high expertise	24	–0.84
Roussey, Farioli, & Piolat (1992)	grade 4	writing	group task performance	low expertise	24	–0.89
Sancilio (1992)	grade 5	computer skills	attitude toward subject/instruction		28	–0.21
Sancilio (1992)	grade 5	computer skills	use of strategies		28	–0.30
Savard, Mitchell, Abrami, & Corso (1995, Study1)	college	management	attitude toward subject/instruction		72	–0.07
Savard, Mitchell, Abrami, & Corso (1995, Study1)	college	management	individual achievement		72	0.00
Savard, Mitchell, Abrami, & Corso (1995, Study2)	college	management	individual achievement		101	0.00
Savitt (1996)	college	computer skills	attitude toward computers		152	0.06
Savitt (1996)	college	computer skills	attitude toward subject/instruction		153	–0.02
Savitt (1996)	college	computer skills	individual achievement		114	0.03
Sengendo (1987)	college	science	attitude toward classmates	female	10	–0.50

Sengendo (1987)	college	science	attitude toward classmates	male	20	0.59
Sengendo (1987)	college	science	individual achievement	female	9	0.03
Sengendo (1987)	college	science	individual achievement	male	16	−1.14
Seymour (1994)	college	engineer	attitude toward subject/instruction		114	–0.08
Seymour (1994)	college	engineer	group task performance		86	0.26
Seymour (1994)	college	engineer	individual achievement		114	–0.08
Shen (1997)	college	computer skills	attitude toward computers	female	78	0.20
Shen (1997)	college	computer skills	attitude toward computers	male	78	–0.23
Shen (1997)	college	computer skills	individual achievement	female	78	0.84
Shen (1997)	college	computer skills	individual achievement	male	78	1.03
Shlechter (1990, Exp. 1)	military	engineer	individual achievement		24	–0.30
Shlechter (1990, Exp. 1)	military	engineer	task completion time		15	−1.01
Shlechter (1990, Exp. 2)	military	engineer	individual achievement		16	–0.38
Shlechter (1990, Exp. 2)	military	engineer	task completion time		10	−1.38
Shlechter (1990, Exp. 3)	military	engineer	individual achievement		19	0.53
Shlechter (1990, Exp. 3)	military	engineer	task completion time		15	–0.73
Shoffner (1997)	college	art	individual achievement	local CBI	30	0.00
Shoffner (1997)	college	art	individual achievement	Web-based	27	–0.07
Shoffner (1997)	college	art	use of strategies	local CBI	28	–0.12
Shoffner (1997)	college	art	use of strategies	Web-based	25	–0.29
Simsek & Hooper (1992)	grade 5–6	biology	individual achievement	high ability	14	1.26
Simsek & Hooper (1992)	grade 5–6	biology	individual achievement	low ability	16	1.08
Simsek & Hooper (1992)	grade 5–6	biology	task completion time	high ability	14	1.67
Simsek & Hooper (1992)	grade 5–6	biology	task completion time	low ability	16	1.59
Singhanayok (1993)	grade 6	ecology	attitude toward group work	learner control, high ability	22	2.43
Singhanayok (1993)	grade 6	ecology	attitude toward group work	learner control, low ability	25	3.39

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Singhanayok (1993)	grade 6	ecology	attitude toward group work	program control, high ability	22	1.63
Singhanayok (1993)	grade 6	ecology	attitude toward group work	program control, low ability	23	2.67
Singhanayok (1993)	grade 6	ecology	attitude toward subject/instruction	learner control, high ability	22	1.08
Singhanayok (1993)	grade 6	ecology	attitude toward subject/instruction	learner control, low ability	25	0.19
Singhanayok (1993)	grade 6	ecology	attitude toward subject/instruction	program control, high ability	22	0.34
Singhanayok (1993)	grade 6	ecology	attitude toward subject/instruction	program control, low ability	23	0.12
Singhanayok (1993)	grade 6	ecology	individual achievement	high ability, learner control	22	1.30
Singhanayok (1993)	grade 6	ecology	individual achievement	high ability, program control	22	0.45
Singhanayok (1993)	grade 6	ecology	individual achievement	low ability, learner control	25	0.62
Singhanayok (1993)	grade 6	ecology	individual achievement	low ability, program control	23	1.34
Singhanayok (1993)	grade 6	ecology	task attempted		47	0.46
Singhanayok (1993)	grade 6	ecology	task completion time		47	1.56
Sol (1995)	college	computer skills	attitude toward group work		181	1.90
Sol (1995)	college	computer skills	group task performance		117	0.38
Sol (1995)	college	computer skills	individual achievement		174	–0.04
Sol (1995)	college	computer skills	request help from teacher		117	–0.34
Sol (1995)	college	computer skills	task completion time		117	–0.66
Spaulding (1984)	grade 7–8	computer skills	individual achievement	group of 2	25	–0.02

Spaulding (1984)	grade 7–8	computer skills	individual achievement	group of 3	23	–0.37
Spaulding (1984)	grade 7–8	computer skills	interactivity with computers	group of 2	25	–0.11
Spaulding (1984)	grade 7–8	computer skills	interactivity with computers	group of 3	23	–0.22
Spaulding (1984)	grade 7–8	computer skills	task attempted	group of 2	25	0.01
Spaulding (1984)	grade 7–8	computer skills	task attempted	group of 3	23	0.78
Stephenson (1992)	college	computer skills	individual achievement	high computer experience, with teacher interaction	19	0.99
Stephenson (1992)	college	computer skills	individual achievement	high computer experience, without teacher interaction	21	–0.10
Stephenson (1992)	college	computer skills	individual achievement	low computer experience, with teacher interaction	21	0.11
Stephenson (1992)	college	computer skills	individual achievement	low computer experience, without teacher interaction	23	0.80
Strang, Hoffman, & Abide (1993, Study1)	college	education	individual achievement		56	–0.09
Strang, Hoffman, & Abide (1993, Study2)	college	education	individual achievement		56	0.01
Tanamai (1989)	college	computer skills	attitude toward computers	female	25	0.21
Tanamai (1989)	college	computer skills	attitude toward computers	male	37	–0.04
Tanamai (1989)	college	computer skills	individual achievement	female	25	–0.52
Tanamai (1989)	college	computer skills	individual achievement	male	37	0.08
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward group work	high ability, learner-control	21	2.39
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward group work	high ability, program-control	21	1.61
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward group work	low ability, learner-control	23	3.40

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward group work	low ability, program-control	20	2.68
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward subject/instruction	high ability, learner control	21	1.08
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward subject/instruction	high ability, program control	21	0.34
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward subject/instruction	low ability, learner control	23	0.19
Temiyakarn-McDonald (1993)	grade 6	science	attitude toward subject/instruction	low ability, program control	20	0.13
Temiyakarn-McDonald (1993)	grade 6	science	individual achievement	high ability, learner control	22	1.30
Temiyakarn-McDonald (1993)	grade 6	science	individual achievement	high ability, program control	22	0.45
Temiyakarn-McDonald (1993)	grade 6	science	individual achievement	low ability, learner control	25	0.62
Temiyakarn-McDonald (1993)	grade 6	science	individual achievement	low ability, program control	23	1.34
Temiyakarn-McDonald (1993)	grade 6	science	interactivity with computers		30	0.79
Temiyakarn-McDonald (1993)	grade 6	science	task completion time		30	1.67
Underwood, Jindal, & Underwood (1994)	grade 4	reading/language arts	group task performance	cooperative, all-boy-groups	12	2.02
Underwood, Jindal, & Underwood (1994)	grade 4	reading/language arts	group task performance	cooperative, all-girl-groups	12	1.79
Underwood, Jindal, & Underwood (1994)	grade 4	reading/language arts	group task performance	cooperative, mix-gender-groups	12	0.70
Underwood, Jindal, & Underwood (1994)	grade 4	reading/language arts	group task performance	non-cooperative, all-boy-groups	12	0.37

Underwood, Jindal, & Underwood (1994)	grade 4	reading/language arts	group task performance	non-cooperative, all-girl-groups	12	1.21
Underwood, Jindal, & Underwood (1994)	grade 4	reading/language arts	group task performance	non-cooperative, mix-gender-groups	12	0.79
Underwood, McCaffrey, & Underwood (1990)	grade 5	reading/language arts	group task performance	all-boy-groups	12	0.97
Underwood, McCaffrey, & Underwood (1990)	grade 5	reading/language arts	group task performance	all-girl-groups	12	1.27
Underwood, McCaffrey, & Underwood (1990)	grade 5	reading/language arts	group task performance	mix-gender-groups	12	–0.63
Underwood, McCaffrey, & Underwood (1990)	grade 5	reading/language arts	task attempted	all-boy groups	12	0.93
Underwood, McCaffrey, & Underwood (1990)	grade 5	reading/language arts	task attempted	all-girl groups	12	1.33
Underwood, McCaffrey, & Underwood (1990)	grade 5	reading/language arts	task attempted	mixed-gender groups	12	–0.47
Vadas (1986)	corporate	management	individual achievement		120	0.29
Webb (1985a)	grade 5–8	computer skills	individual achievement		55	0.00
Webb (1985b)	grade 7–9	computer skills	individual achievement	female	23	0.29
Webb (1985b)	grade 7–9	computer skills	individual achievement	male	32	–0.30
Weller, Repman, Lan, & Rooze (1995)	grade 8	social studies	individual achievement	magnet	26	0.05
Weller, Repman, Lan, & Rooze (1995)	grade 8	social studies	individual achievement	non-magnet	14	0.86
Weller, Repman, Lan, & Rooze (1995)	grade 8	social studies	task attempted	magnet	30	0.49
Weller, Repman, Lan, & Rooze (1995)	grade 8	social studies	task attempted	non-magnet	14	–0.18
Werner (1997); Werner & Klein (1999)	grade 9	chemistry & physics	attitude toward subject/instruction		78	0.09
Werner (1997); Werner & Klein (1999)	grade 9	chemistry & physics	group task performance		78	–0.41

(*continued*)

APPENDIX

Outcomes and independent findings extracted from each study included in the meta-analyses of this review (continued)

Study	Grade-Level	Subject	Outcomes Extracted	Characteristics that Distinguish the Findings within the Study	*N*	*ES*
Werner (1997); Werner & Klein (1999)	grade 9	chemistry & physics	individual achievement		78	–0.54
Werner (1997); Werner & Klein (1999)	grade 9	chemistry & physics	task completion time		78	–0.33
Whitelock, Scanlon, Taylor, & O'Shea (1995)	grade 9	physics	individual achievement	different view	55	0.00
Whitelock, Scanlon, Taylor, & O'Shea (1995)	grade 9	physics	individual achievement	similar view	65	0.00
Whitelock, Scanlon, Taylor, & O'Shea (1995)	grade 9	physics	task completion time		101	0.47
Whyte, Knirk, Casey, & Willard (1991)	unknown	computer skills	individual achievement		86	0.21
Wolf (1994)	grade 9	physical science	attitude toward computers		126	–0.18
Wolf (1994)	grade 9	physical science	attitude toward subject/instruction		126	0.18
Wolf (1994)	grade 9	physical science	individual achievement		126	0.19
Wolf (1994)	grade 9	physical science	task completion time		126	0.66
Xin (1999)	grade 3	math	individual achievement		118	0.48
Xin (1999)	grade 3	math	attitude toward classmates		93	0.35

Yadrick, Regian, Connolly-Gomez, & Robertson-Schule (1997)	adult remediation	math		group task performance	exploratory	51	0.39
Yadrick, Regian, Connolly-Gomez, & Robertson-Schule (1997)	adult remediation	math		group task performance	tutor	51	–0.34
Yadrick, Regian, Connolly-Gomez, & Robertson-Schule (1997)	adult remediation	math		individual achievement	exploratory	51	–0.38
Yadrick, Regian, Connolly-Gomez, & Robertson-Schule (1997)	adult remediation	math		individual achievement	tutor	51	1.01
Yadrick, Regian, Connolly-Gomez, & Robertson-Schule (1997)	adult remediation	math		interactivity with computers	exploratory	51	0.02
Yadrick, Regian, Connolly-Gomez, & Robertson-Schule (1997)	adult remediation	math		interactivity with computers	tutor	51	0.26
Yelland (1993)	grade 2	math		group task performance		27	–1.01
Yelland (1993)	grade 2	math		task completion time		27	–0.02

Note: *If findings were not distinguishable by the level of the coded study features, they were averaged. If more than one finding was reported for the same subject, random sampling procedure was applied to avoid the dependency problem and only the selected and analyzed independent findings are included here. *ES* is the unweighted effect size.

Notes

[1] An earlier version of the meta-analysis based on fewer studies (1965–1995) was presented at the Annual Meeting of the American Educational Research Association, San Diego, April, 1998 (Lou, Abrami, & Muni, 1998) and in Lou (1999).

[2] The standard error (SE B) in the output of SPSS was adjusted by a factor of the square root of the Mean Square error (MS_E) for the regression model according to Hedges and Olkin (1985), because the output in the SPSS was based on a slightly different model than the fixed model used here.

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