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Computers for Cognitive Development in Early Childhood—The Teacher's Role in the Computer Learning Environment

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This study was designed to examine the effect of different kinds of adult mediation on the cognitive performance of young children who used computers. The study sample included 150 kindergarten children aged 5-6. The findings indicate that children who engaged in adult-mediated computer activity improved the level of their cognitive performance on measures of abstract thinking, planning ability, vocabulary, and visual-motor coordination, as well as on measures of response style including reflectivity. Their performance on these measures was better than that of children engaged in computer activities without adult mediation or with very little mediation (accompaniment). Based on the findings, it may be concluded that integrating teacher mediation within computer learning environments for young children facilitates informed use of computer technologies in their learning system, and enhances thinking processes and work habits.

Today, computers are an integral part of education, including that of young children. Young children successfully play with and operate state-of-the-art, sophisticated computers. All by themselves, they turn them on and off, control the mouse, and know their way around the keyboard. They are intimately familiar with every aspect of computer technology and are not afraid to use it, in contrast to many of the parents, teachers, and other adults who are afraid of this sophisticated technology. However, one question remains unanswered; is the full potential of computer activities thus utilized for the development of the children's intellectual ability?

Numerous education experts raise the possible association between engaging in computer activities and cognitive development. They have high hopes for the potential of using computers to enhance intellectual abilities and individual learning strategies in early childhood (Mikhalovitz & Levita, 1989; Klein & Nir-Gal, 1992; Clements, Nastasi, & Swaminathan, 1993; Brett, 1995; Nir-Gal, 1996; Samaras, 1996; Haugland, 1997, 2000). However, research conducted in this field showed that the great expectations that arose with the introduction of computers into the educational system were not fulfilled, and today, computers are not conducive to better learning and thinking (Salomon, 2000). Moreover, based on several studies (Healy, 1998; Cordes & Miller, 2000), it may be concluded that the use of computers in early childhood may impede the intellectual and social development of young children. Based on these studies, computers prevent children from interacting with each other and with adults. While these children need stronger interpersonal ties with supportive adults, the use of the computer technology only serves to keep children and adults apart.

The introduction of computers into the educational system was led by the assumption, which persisted throughout the 70s, that computers would replace teachers. However, nowadays, computers are no longer perceived as miracle machines that can perform meaningful educational tasks without the intervention of teachers. Equipping schools with computers and software is not sufficient to bring about the changes hoped for. The computer is a tool, and handing it over to the learner ensures neither correct operation nor maximum benefit for the learners (Mevarech, 1996). Moreover, computers are not supposed to replace the personal educational interaction provided by teachers through sensitive, responsive attention to the students' needs (Katz & Offir, 1996). The introduction of computers into the educational system is an innovation that requires intensive involvement of teachers including changes in teaching methods and in defining the teacher's role in class (Offir, Katz, & Schmida, 1991).

Efficient integration of computers in the teaching process depends on the teacher's involvement. The traditional role of the teacher has to be changed from that of knowledge provider to that of organizer, diagnostician, instructor, and partner in the computer learning environment in all age groups, including early childhood (Klein & Nir-Gal, 1992; Clements et al., 1993; Fisher, 1996; Salomon, 1996; Samaras, 1996; Masters & Yelland, 1996; Haugland, 1997, 2000). However, despite everything previously stated concerning the issue of the teacher's role, none of the existing studies provides an answer to the question regarding which components of interaction between adults and young computer users may create the conditions necessary for efficient use of computers. A search conducted in the online

ERIC database from as far back as 1966 to date yielded 5,000 studies on computers in education. Only about 1% of these studies focused on computer use in early childhood. These studies dealt primarily with the various effects of computer use on young children, relating to advantages, disadvantages, and the latent potential of the computer in early childhood. The role of adults in computer-aided learning environments for young children is not commonly a focus of research.

The current study aims to examine the effects of various forms of adult teaching behavior on the development of cognitive skills of young computer users. It focuses on three types of adult teaching interaction with preschool children in a computer learning environment and their effect on children's problem solving behaviors and cognitive performance. This is the first study to apply mediated learning theory to identifying and elucidating the salient characteristics of adult-child mediation as they are expressed in the teaching process of young children in a computer-aided learning environment.

The theory of structural cognitive modifiability and mediated learning (Feuerstein, Rand, & Hoffman, 1979; Feuerstein, Rand, Hoffman, & Miller, 1980; Klein, 1985, 1996) identified basic characteristic components of adult-child interaction that constitute Mediated Learning Experiences (MLEs) for children and their potential effects on children's cognitive development. Unlike direct learning, in which a child perceives and processes information through the senses without adult intervention, mediated learning occurs when the environment is modified, changed to fit the learner's needs, interests, and abilities, by an adult who is actively adapting elements in the environment to these needs and abilities.

The mediator modifies the stimuli by altering their order, form, intensity, frequency, or context, by arousing the young learner's curiosity, vigilance, and perpetual acuity, and by trying to create or improve the young learner's required functions for temporal, spatial, and cause-effect relationships (Feuerstein & Feuerstein, 1991; Feuerstein, Rand & Rynders, 1988; Feuerstein et al., 1979, 1980). Five basic criteria of MLEs were empirically defined (Table 1), based on MLE theory (Klein & Alony, 1993; Klein, 1996).

In line with Feuerstein's theory (Feuerstein et al., 1979), the MLE processes are gradually internalized by the child and become an integrated mechanism. Adequate MLE interactions facilitate the development of various cognitive functions, learning-sets, mental operations, strategies, and need systems. The internalized MLE processes allow the developing child to use them independently later on, to benefit from learning experiences in diverse contexts, and to modify his or her cognitive processing by means of self-mediation. Based on the theory of MLE, it is assumed that the more the child experiences MLE interactions, the more he or she is able to learn from direct exposure to formal and informal learning situations. This assumption was supported by a series of longitudinal and cross-cultural studies (Klein, 1996; Klein & Alony, 1993).

Table 1

Definition and Examples of Basic Criteria of Mediation

Definition of criterion	Examples
Focusing (intentionality and reciprocity) Any act or sequence of acts of an adult that appears to be directed toward affecting a child's perception or behavior. These behaviors are considered reciprocal when the infant or child responds vocally, verbally or non-verbally.	Selecting, exaggerating, accentuation, scheduling, grouping, sequencing, or pacing stimuli. Talking and handing a toy to a child is seen as intentionality and reciprocity only when it is apparent that the adult's behavior is intentional and not accidental, and when there is an observable response from the child that he or she saw the intentional behavior. Examples of intentionality might be a parent making a visible effort to change his or her behavior and the environment by: (a) bringing an object to the child, moving it back and forth, observing the child and continuing to adjust the stimulus until he or she focuses on it; (b) moving a bottle or a particular food item in front of the infant's eyes until he or she focuses on it; (c) placing toys in the bath water; (d) placing oneself in front of the child to obtain eye to eye contact; and (e) placing objects in front of the child at a distance requiring that he or she attempt to reach them.
Affecting (exciting) An adult's behavior that expresses verbal or nonverbal excitement, appreciation, or affect, in relation to objects, animals, concepts or values.	These behaviors may include facial gestures or paralinguistic expressions (e.g., a sigh or scream of surprise). Verbal expressions of affect, classification, or labeling, and expressions of valuation of the child's or adult's experience (e.g., "Look, I'm washing your foot," "See how long this macaroni is?" or "This cup is special, it belonged to grandfather.").
Expanding (transcendence) An adult's behavior directed toward the expansion of a child's cognitive awareness, beyond what is necessary to satisfy the immediate need that triggered the interaction.	Talking to a child about the qualities of food during feeding is beyond what is necessary to assure provision of nutrition; exploring body parts or the characteristics of water during bathing is not necessary for bathing. Transcendence may be provided through expressions implying inductive and deductive reason ing, spontaneous comparisons, clarification of spatial and temporal orientation, noting strategies for short- and long-term memory, or search and recall memory activities.

(continued on next page)

Table 1 (continued)
Definition and Examples of Basic Criteria of Mediation

Definition of criterion	Examples
Encouraging (mediated feelings of competence) Any verbal or nonverbal behavior of an adult that expresses satisfaction with a child's behavior and that identifies a specific component or components of the child's behavior that the adult considers contributive to the experience of success.	Such identification can be achieved, for example, by carefully timing a verbal or gestural expression of satisfaction through repetition of a desired behavior, or through verbal or nonverbal expression (i.e., saying "good," "wonderful," "great," "yes," or clapping hands and smiling when the child successfully completes a task or part of it).
Regulating (mediated regulation of behavior) Adult behaviors that model, demonstrate and or verbally suggest to the child regulation of behavior to the specific requirements of a task, or to any other cognitive process required prior to overt action.	Behavior is regulated by the process of matching the task requirements with the child's capacities and interests, as well as through organizing and sequencing steps leading toward success. For example, "It's hot, cool it first before putting it in your mouth," "Let's wash your face carefully so that no soap gets into your eyes," "Slowly! Not so hard! It's delicate, do it gently," or "First, turn all the pieces over, then look for the right piece." Mediated regulation of behavior may be related to the process of perception (e.g., systematic exploration), to the process of elaboration (e.g., planning behavior), or to the process of expressive behavior (e.g., reducing egocentric expressions and regulating intensity and speed of behavior).

In several studies, a significant, positive relationship was found between adult-mediated computer activity and cognitive performance of preschoolers (Clements et al., 1993; Klein & Nir-Gal, 1992; Miller & Emihovich, 1986; Nir-Gal, 1996; Shani, 1986). More specifically, children using computers with adult assistance improved cognitive processes such as abstract reasoning, logical thinking, and analogical and reflective thinking. However, there was no research evidence delineating the fundamental characteristics of adult-child mediation, as expressed in the context of a computer-aided learning environment and its effect on specific cognitive processes of young children.

Three types of adult guidance of preschoolers using computers were compared in the current study: (a) mediation—throughout the child-computer interaction, the adult guidance included: focusing, affecting, expansion, encouragement, and regulation of behavior; the mediator's behavior was based on MLE theory (Feuerstein et al., 1979, 1980), as developed for intervention with young children by Klein (1996); (b) accompaniment—routine adult guidance, involving the presence of an adult responsive to questions initiated by the children in the computer-aided environment but without adult mediation; and (c) no assistance—only technical or basic instructions were provided at the beginning of a new activity.

METHOD

Subjects

Subjects were 150 kindergarten children, 79 boys and 71 girls, ranging in age between 5 and 6 years (mean age 5.4, *SD* = 0.8), from kindergartens located in the south of Israel. Most of the children (90%) came from middle-class families. All participating kindergartens (*n*=30) were randomly selected based on records of the National Board of Education. Thirty of the 32 kindergartens approached agreed to participate in the study. Of the participating children, 75% were second generation in Israel, 15% came from Eastern Europe (primarily from states previously in the Soviet Union), 5% came from Ethiopia and 5% from the USA and Canada. Most of the parents (58%) were high-school graduates and 32% had higher academic degrees. The kindergarten teachers (n=30) were all females between 25 and 39 years old (with a mean age of 30, *SD*= 3.75). All teachers were certified as required by the state, that is, graduates of colleges of education. Since the study was carried out as part of the regular activities in the kindergarten, parental permission was not required. Parents were informed about the study and were encouraged to contact the researchers with any questions or reservations. It should be noted that there was no attrition in the number of participants from the beginning to the final sample.

Procedure

Computers are available for children's use in all Israeli kindergartens, in line with the guidelines of the National Board of Education. These guidelines relate to the hardware and location of the computer (i.e., IBM, 486, colored SVGA, hard disk MB 120), placed in a corner of the kindergarten class, on a small table surrounded by two to three small chairs. The computer is turned on, loaded and ready for the children to use when they wish, throughout their entire stay at the kindergarten. Children can work individually or in small groups. All children in this study used the computer individually, three times a week, for about 25 minutes each time.

The kindergartens were randomly divided into six treatment groups. The division was made according to two independent variables: (a) type of guidance (mediation, accompaniment, and no assistance); and (b) type of program (*Logo* software and *Game* software). Each treatment group was exposed to a different combination of guidance and program.

The *Game* software had been selected by 30 "judges" (10 kindergarten computer instructors and 20 kindergarten teachers) to be the preferred software in kindergarten. The *Logo* software had been selected since it was found potentially contributive to cognitive performance of preschoolers (Clements et al., 1993; Shani, 1986).

Teacher training included the following components: (a) a 21-hour course, seven biweekly sessions of three hours each, held in the afternoons of regular school workdays; followed by (b) personal guidance in the kindergarten. Each participating teacher received 10 hours of guidance while she was interacting with the children. A professional educator specializing in computers, science education, and technology provided this type of guidance over a period of three months. These educators are commonly involved in the training of kindergarten teachers in Israel and are employed by the Board of Education. Teachers in all the treatment groups learned about the computer hardware and gained experience in using the specific programs they later introduced to the children. While the teachers in the mediation group received mediational training, the other teachers were given information regarding landmarks of development, developmental sequences, and other components commonly included in the training of early childhood educators in Israel. With the exception of the mediational components, all teachers participated in an identical training program. Examples of training exercises in mediation can be seen in Table 2, which presents mediational training for the *Logo* program. Similar exercises were designed for each of the *Game* programs.

Training of the teachers was designed to help them focus children's attention on salient factors related to the task, on characteristic features of the computer and on their own behavior. In addition, teachers in the mediation group learned how to express meaning and affect, expand learning experiences beyond the immediate context (i.e., to associate contrast, relate past, present, and future experiences, ask challenging questions, etc.), and how to encourage the child (with explanations).

The main hypothesis in this study was that adult mediation would improve children's abstract thinking, planning ability, vocabulary, visuo-motor coordination, and reflective thinking. It was also hypothesized that, in the adult mediation group using the *Logo* software, children's performance on these measures would be higher than in the adult mediation group using other *Game*s.

Following the training, all the teachers in the mediation group achieved two criteria: (a) they could verbally describe and provide examples for the basic criteria of mediation; and (b) they applied this knowledge in their interactions with the children in the computer-aided learning environment.

The adult-child-computer interactions were videotaped with a focus on the behavior of both the child and the teacher, children's response time to test items, number of correct answers, and strategies used. Teacher's mediation in the mediation groups was evaluated by means of counting the frequency of appearance of each criterion of mediation based on "Observing Mediational Interaction (OMI)" (Klein, 1996; Klein & Alony, 1993). The research design in this study was a pre postintervention design that included an experimental treatment group versus control ones; pretest scores were taken before the onset of the intervention in the kindergartens. The intervention lasted 17 weeks. Throughout the intervention period, each child used the computer in the kindergarten three times a week for 20 minutes. Children were assigned their turn to work on the computer randomly. At the end of the intervention, postintervention measures similar to those administered during the preintervention were taken for each child individually.

Measures

Three measures were used to assess levels of abstract reasoning: Raven's Colored Matrices (Raven, 1965): The Visual Association Test from the Illinois Test of Psycholinguistic Abilities (Kirk & McCarthy, 1971); and The Wechsler PrePrimer Scale of Intelligence (WPPSI) Similarities Subtest (Wechsler, 1967). Both the first and the second test are multiple-choice analogical reasoning tasks, involving geometric forms (on the Raven) and pictorial representation of objects (on the Visual Association Test). The WPPSI Similarities Test includes open-ended verbal questions requiring reasoning, for example, "How are a banana and an apple alike?" Two measures of vocabulary were used. One was the Peabody Picture Vocabulary Test (PPVT) (Dunn, 1981), measuring children's understanding of words—no verbal response is called for; the child is presented with four pictures and asked to choose the one representing the word said by the examiner. The other was the WPPSI vocabulary subtest, measuring the ability to define words, that is,

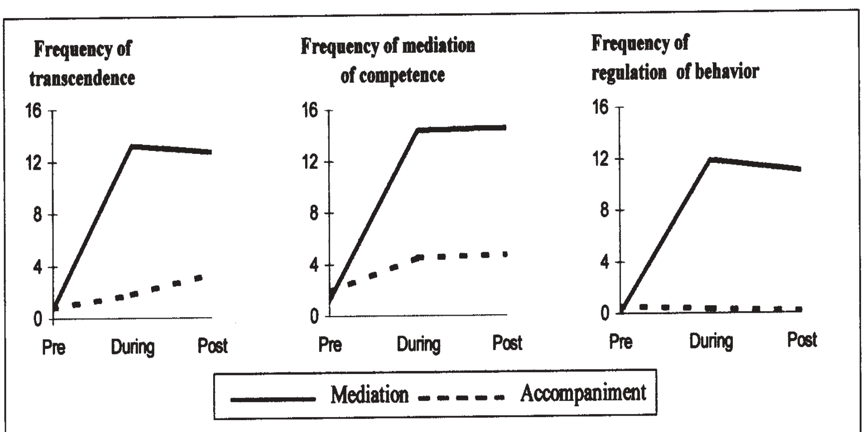
Table 2
Examples of Training Activities for Teachers in the Mediation Treatment Group (Using *Logo*)

Target Process	Examples
Focusing	“Look at this line. Look carefully. Do you see what happens to it?”
Focusing on the problem	"Let’s see, what do we need to do here?” “How can we draw the line using this turtle?”
Affecting	“Wow, isn’t this beautiful?" “Look what happens when you move the turtle.” “This is a very special program.”
Expanding	Associating what we learned with other experiences. Raising questions such as: Which other experiences require planning before doing something? Why?
Multidirectional ways for problem solving	“How else can you draw this form?” “Which is the easiest way to do it?” “Why?”
Raising awareness of the thinking process	“How do you know that this is the right way?” “You remembered all these things.” “Careful thinking about all the possibilities helped you choose the correct answer.” “Remember what you just did?” “Keep it in mind, don’t forget!”
Predicting outcome (raising hypothesis)	“What will happen if you move the turtle up there to the left?” “What will happen if…?”
Regulating behavior Control and evaluation of response	“What does the computer tell you?” “Is it correct?” “How can you tell?” “How do you know that you did well?” “What did you learn from this mistake?” “Press the key over and over again so that you can control the lines you make with the turtle.”
Controlled use of the keyboard Planning	“When you press the key, be careful that the turtle doesn’t escape.” “Let’s see what we need to do in order to draw a square: We need to move the turtle up, then to the left, down, and to the right.”
Encouraging Clarifying success	“Very good! You did well. You were careful and planned it well.” “Good, how did you do it?” “What did you do to get this beautiful square?”
Coping with failure	“What does the computer tell us now?” “Yes, it is incorrect, but you could do it again.” “Let us see, what could it be? Where is the mistake?” “How can we correct it?”

the active use of language. To evaluate visuo-motor coordination, the Beery Visual Motor Integration Test (Beery, 1989) was used, requiring copying of progressively complex geometric forms. The Mazes Subtest of the WPPSI was used for the assessment of children's planning behavior. This test is a paper and pencil test requiring the child to solve problems involving mazes. (All of these measures are commonly used in research and psychoeducational work with young children and have established reliability.) Assessment of responsiveness was based on measures of children's response time with a distinction made between easy items answered correctly and difficult items answered erroneously on the Raven's Colored Matrices.

Findings

A MANCOVA 3X2X2 (type of treatment X type of software X time before and after intervention) with repeated measures on the mediation behaviors showed a significant difference among the three groups on all five mediational behaviors [$F(10,24) = 10.89$; $p < .001$]. Separate analyses of variance for each of the mediational measures yielded significant differences between the before and after intervention measures on all the mediational measures except for mediation for meaning. A significant interaction was found between treatment and mediation of competence, transcendence, and regulation of behavior. As time passed, the differences between these treatment groups in terms of the changes that occurred in the three mediation measures—transcendence, competence and regulation of behavior—became clear. Figures 1-4 present the means of the instruction characteristics in the two treatment groups.



Figures 1-3. Means of mediational behavior in the two intervention groups

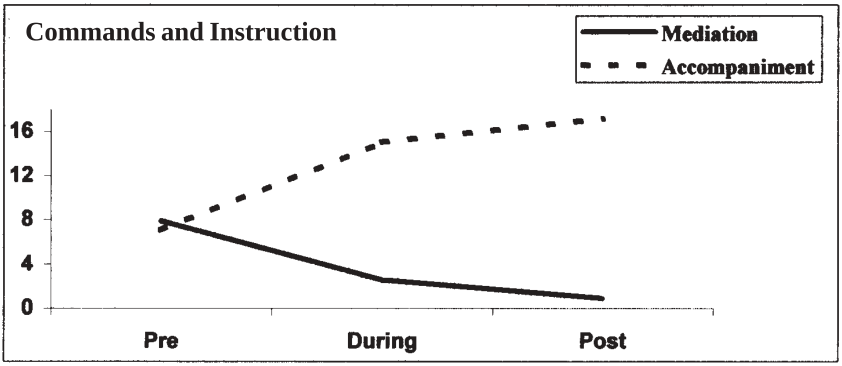


Figure 4. Means of commands and instructing behaviors in the two intervention groups

As can be seen in Figures 1-3 and 4, the frequency of transcendence, mediating feelings of competence and regulation of behavior are not different in both intervention groups at the preintervention stage, before the kindergarten teachers were trained. The difference between the two treatment groups became evident during the second assessment, after the first stage of teacher training and remained high during the third assessment, at the end of the intervention. There were almost no differences between the frequencies of teaching behavior during the second and third assessments. Throughout the intervention, in the mediation and accompaniment group teachers were observed to provide instructions about the proper use of the computer and the programs. As can be seen in Figure 4, there does not seem to be a difference in the frequency of instruction provided to the two groups before the intervention. However, in the mid-intervention and postintervention assessment, a decrease in those behaviors is noted in the mediation group, whereas an increase in those behaviors is noted in the accompaniment group. In other words, the kindergarten teachers tended to give more instructions in the accompaniment group as compared to teachers in the mediation group.

In view of the findings it may be concluded that in the mediation group, mediational behaviors increased with time, whereas instructional behaviors decreased. However, in the accompaniment group, no change was noted in the frequency of mediational behaviors, but there was an increase in frequency of instructions aimed mainly at enabling children to operate the computer and run the necessary program. It appears that kindergarten teachers trained in mediation actually used all mediational behaviors significantly more than the other teachers.

Three instructional domains—the operational domain, the specific content domain, and the cognitive domain—were found in the analysis of video films that were taken to assess the kindergarten teachers' instruction. These domains were evident in the adult-child interaction in the computerized environment of the preschoolers. In the **Instructional-Technological Domain**—the teachers aimed mainly for specific instruction concerning the operation of the computer; for instance, instructing the child how to use the mouse and the keys of the keyboard. In the **Specific Content Domain—**the teachers aimed mainly to provide knowledge and guidance concerning the content of the specific program used by the child and its activities; for instance, instruction about the rules of its *Game*s, how to play with a certain program, how to solve specific problems stemming from the activity in a program, such as how to draw a circle in the *Logo* program. In the **Cognitive Domain—**the teachers aimed mainly to nurture and encourage thinking, while adjusting the process to the child's needs and level; for instance, attention to details, spontaneous comparison, simultaneous attention to a number of variables, creation of links, restraining impulsive reactions, and choosing reflective responses, planning, problem solving skills, metacognitive instruction, and so on. In order to take advantage of the use of computers to develop the child's thinking skills, it is important to distinguish between activities that provide exposure to the technology and its proper operation on the one hand, and activities that provide high level cognitive engagement on the other.

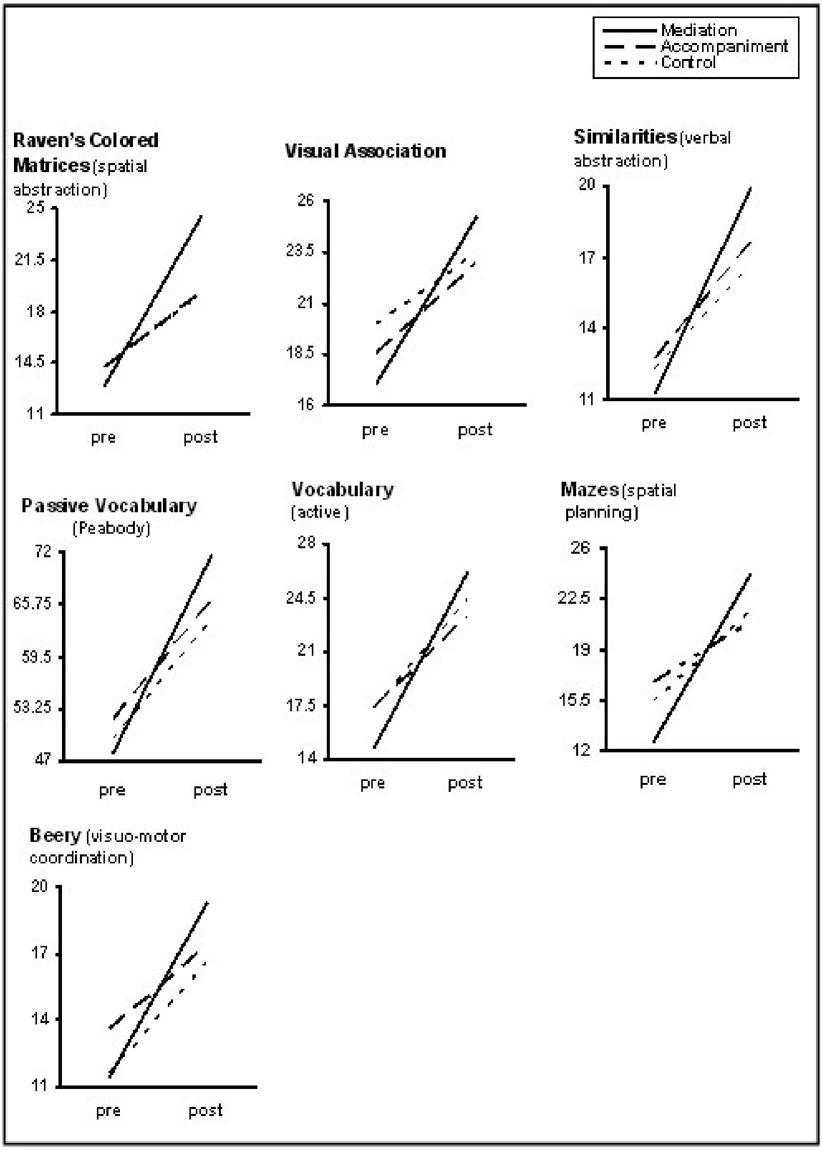
To examine the effect of the intervention on the cognitive performance and response style of the subjects, a 2X3 MANCOVA (3 types of treatment by 2 types of programs) with repeated measures was performed. The MANCOVA yielded significant differences among the three treatment groups—the mediation, accompaniment and control group—with children in the mediation group clearly scoring higher than all the others [$F(14,262) = 16.31$; $p < .001$]. The means and *SD*s of the three treatment groups on all cognitive measures before and after the intervention are presented in Table 3.

Figures 5-11 present the interactions between the type of intervention and time (pre and postintervention) on all cognitive measures. These figures show an improvement in most measures of all the treatment groups, but the improvement of the mediation group was greater than that of the other treatment groups. These differences were found to be significant in Sheffe tests performed for each of the measures.

Table 3
Means and the Standard Deviations of the Three Groups on All Cognitive Measures, Before and After the Intervention

		Adult Mediation		Adult Accompaniment		Control Group		
Test		Pre	Post	Pre	Post	Pre	Post	F(2,137)
Raven	*M*	12.96	24.50	14.12	19.34	14.18	19.24	* 66.97
	SD	.00	3.93	3.25	4.91	4.39	4.73	
Visual Association	*M*	17.14	25.18	18.58	22.98	20.02	23.38	* 26.93
	SD	.00	4.16	3.16	3.02	3.05	3.84	
Similarities	*M*	11.32	19.92	12.72	17.64	12.30	16.64	* 30.04
	SD	.00	3.63	3.38	4.25	2.33	3.12	
Mazes	*M*	12.46	24.26	16.74	20.90	15.38	21.60	* 32.46
	SD	.00	3.16	5.32	5.40	5.95	4.20	
Vocabulary	*M*	14.74	26.16	17.34	23.26	17.30	24.34	* 25.32
	SD	.00	04.00	4.88	4.18	5.55	4.35	
Peabody	*M*	47.98	71.66	51.96	66.18	49.54	63.88	* 19.67
	SD	.00	13.80	10.88	13.92	10.20	13.00	
Beery	*M*	11.48	19.22	13.58	17.30	11.64	16.54	*31.20
	SD	.00	2.34	3.42	3.15	3.79	3.61	

*$p < .001$



Figures 5-11. Mean scores for all groups on the assessment tests, by treatment type before and after the intervention

A MANOVA yielded no difference between the treatment groups that used *Logo* software and those that used *Game* software [$F(7,131) = 0.62$; $p > .05$]. However, a significant interaction of type of software by type of treatment [$F(14,262) = 1.70$; $p < .05$] was found. ANOVAs performed for each of the measures separately showed significant interaction of type of software by type of treatment on the Raven Test [$F(2,137) = 4.54$; $p < .05$] and on the Similarities Test [$F(2,137) = 3.94$; $p < .05$]. These figures show no difference between the mediation and accompaniment groups that used *Logo* software and those that used *Game* software, whereas in the control groups there seemed to be a difference between the *Logo* software and the *Game* software; the latter was associated with more improvement. It appears, therefore, that without adult intervention, *Game* software is more conducive than *Logo* software in the development of abstract reasoning as tested in the two aforementioned measures.

According to the hypothesis of the current study, the intervention program is supposed to affect the children's level of reflectiveness. The treatment group that received adult mediation was expected to exhibit a higher level of reflectiveness than the other treatment groups. To test this hypothesis, a 2X3 MANCOVA (3 treatment groups by 2 types of software) was performed. Significant differences were found among the three treatment groups with regard to the two measures of response time [$F(4,282) = 2.91$; $p < .001$]. No differences in the children's achievements were found concerning the type of software [$F(4,141) = 0.43$; $p > .05$], although a significant interaction of treatment groups by type of program [$F(4,282) = 2.79$; $p < .05$] was found. Table 4 presents means and SDs of the three treatment groups on measures of pre and postintervention as well as results of ANOVAs performed separately for each measure.

Table 4

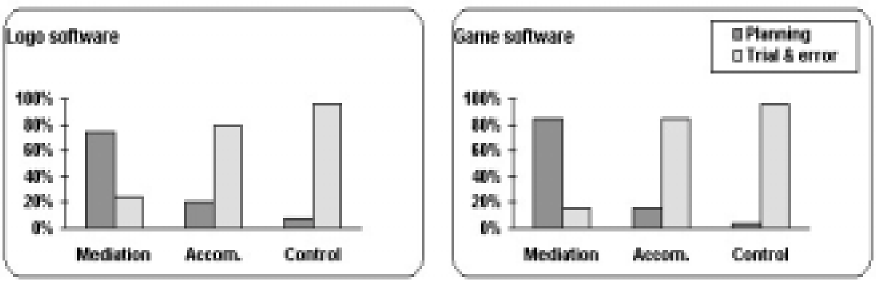
The Means and the Standard Deviations of the Level of Reflectiveness of the Three Treatment Groups Before and After the Treatment Program

		Adult Mediation		**Adult Accompaniment**		**Control Group**		
		Pre	Post	Pre	Post	Pre	Post	F(2,143)
Response time Incorrect answers	***M***	2.80	4.80	3.66	3.44	4.01	3.69	*11.16
	SD	1.11	1.89	1.15	1.02	1.19	1.17	
Response time Correct answers	***M***	2.34	3.90	3.31	3.08	3.40	3.46	* 23.78
	SD	.81	1.12	1.17	.98	.85	1.17	

*$p < .001$

Based on Table 4, it may be concluded that ANOVAs performed separately on each of the measures of responsiveness yield significant differences among the three treatment groups on both measures (response time for incorrect answers and response time for correct answers); that is, there are differences among the treatment groups concerning changes that occurred in the children's response time following the intervention. No difference in response time to the various test items was found among the treatment groups prior to the intervention. Following the intervention, the group receiving adult mediation had a longer response time to test items than the other two groups. Furthermore, the response time of all three groups to items answered correctly was greater than that of items answered incorrectly in both pre and postintervention assessments.

During the preintervention assessment, 96% of the children in all groups used trial-and-error strategies. At the postintervention assessment, differences were found among the three groups using *Logo* software (x^2 = 27.78; d.f. = 2; $p < .001$) and *Game* software (x^2 = 41.09; d.f. = 2; $p < .001$). Figures 12-13 present the frequency of use of different strategies by children in all groups.



Figures 12-13. The distribution of strategies by treatment groups using *Logo* software and *Game* software

As can be seen in Figures 12 and 13, children in the mediation group used planning strategies more frequently than the children in the accompaniment and control groups, who used the trial and error strategy as frequently as they did at the beginning of the intervention.

Children using computers with mediational instruction improved their computer operation strategies, and proceeded from use of trial-and-error to planning strategies. In contrast, children who operated computers without such instruction used the trial-and-error strategy and reacted immediately following (or during) the presentation of the test item, without any delay.

Planning ahead delayed children's reaction, and resulted in a higher number of correct answers. Moreover, children showed more insight and awareness regarding their own thinking processes.

One of the research questions in the current study related to the possible differential effects of the various treatments on children with different demographic characteristics. In order to examine this question, MANCOVAs (treatment groups by demographic background variables, i.e., gender, previous computer experience and level of parental education) were carried out. Parents were divided into high-school graduates and university graduates. Ethnic origins were noted as either Western, Eastern,or native Israeli (at least second generation in Israel). MANCOVAs carried out for each of the above variables did not yield any significant main effects or interactions of treatment (groups) by gender, ethnic origin, and parental education. However, a 3X2 MANOVA (3 treatment groups by 2 levels of experience with computers at home) yielded significant interaction of computer experience at home by treatment group on the Visual Association Test [$F(2,131) = 8.08$; $p < 0.001$]. The main difference among the various groups stems from the great improvement in the Visual Association scores of the children in the mediation group who had not used computers at home. Thus, it may be concluded that parental education, ethnic origin and children's gender did not have any significant effect on children's test performance in the current study.

DISCUSSION

The use of computers in early childhood education with or without adult mediation: Effects on children's thinking and response style. One of the major findings of this study is that young children using computers in the presence of a mediating adult learn more than other children who use the same computers and the same programs without such mediation. Furthermore, children in the mediation group score higher than all others on all the cognitive measures, that is, abstract thinking, planning, vocabulary and visuo-motor coordination, as well as on measures of response style, including reflective thinking. Following the intervention program, children in the mediation group scored significantly higher than those in the accompaniment and control groups, despite the fact that an adult was present throughout the entire period in which the children used computers. No differences were found between the accompaniment and the control groups. There was also no difference between the performance of the children who used the *Logo* software and those who used the *Game* software. The findings support the central research hypothesis, that is, that the improvement of the mediation group on cognitive measures and on measures of response style would exceed that of the accompaniment and control groups.

In their natural environment, children are engaged in activities involving various concrete materials and objects, whereas in the computer environments, they encounter activities involving pictures, graphs, and symbols. Even in children's natural milieu in which objects, *Game*s and stimuli abound, children benefit most from interactions with mediating adults, since this enhances their ability to learn from their interactions with their environment (Klein, 1985, 1996; Klein & Alony, 1993). Since both the children's natural milieu and their technological computerized environment generally do not suffice to improve their development unless adult mediation is provided, adult mediation plays a special role among the many other factors affecting their development. The probability that a child will reach higher achievements increases if adult intervention is adapted to the specific tasks at hand and to the characteristics of the child's functioning and thinking at a given time (Wachs, 1992). The explanation concerning the association between children's gains from computer environments with adult mediation is supported by Klein and Nir-Gal (1992) and by Shani (1986) in line with the theoretical framework of mediated learning (Feuerstein, Rand, et al., 1979, 1980) and by Miller and Emihovich (1986) and Samaras (1996) studying mediation in line with Vygotsky's theory of mediated teaching (Vygotsky, 1978). These studies suggest that when children used computers with adult mediation, cognitive processes such as abstract reasoning and logical, analogical and reflective thinking were enhanced.

As mentioned before, the findings of this study indicated that children who used the *Logo* software with adult mediation completed thinking tasks more successfully than those who used the *Logo* software without such mediation. The same holds true for children who used *Game* software: Those who used it with adult mediation did much better than those who used it without adult mediation. However, no difference was found between the achievements of children who used the *Logo* software and those of children who used *Game* software. As a matter of fact, the findings indicate that the use of the *Logo* software did not affect children's thinking more than the *Game* software, whether they were used with adult mediation or with adult accompaniment. The overall finding was that children in the mediation group improved their performances on all measures used, more than the children in the accompaniment group, regardless of whether they used the *Logo* software or the *Game* software. These findings suggest that the combination of the *Logo* software along with adult mediation has the most potent effect on the development of children's thinking. Based on this study, it may be concluded that although young children are able to use a variety of computer software and tools to suit their wishes or needs, these activities will enhance their thinking primarily if they are accompanied by adult mediation.

Concerning the demographic variables of the children in the study, no relations were found between the children's level of performance on the various measures used and their gender, their parents' ethnic origin and level of education. In other words, as to these measures, the intervention program similarly affected children of various demographic characteristics. In view of these findings, it appears that adult mediation is a major factor affecting children's cognitive performance across other demographic variables. These findings concur with the distinction suggested by Feuerstein and Rand (Feuerstein et al., 1980) between "distal factors" and "proximal factors" that influence child development. The distal factors include variables, such as genetic, physiological, cultural, and social factors, which affect the child's cognitive development indirectly through their effects on proximal factors, for instance, the quality of the adult-child interactions. In their opinion, the main factor that determines and shapes the child's level of functioning is the quality of the learning experiences actively mediated to the child by the child's main caregivers. Based on the current study, it may be concluded that children's activity with computers, without adult mediation, is insufficient for them to benefit optimally from computer technology. This is further supported by teachers' reports affirming that entrusting a computer to young learners does not ensure its correct operation, nor does it ensure the learner's ability to benefit from it maximally (Mevarech, 1996).

Mediated instruction in computerized learning environments for young children is a step toward the sensible integration of advanced future technologies in the learning array designed for young children.

The teacher's role in computerized learning environments for young children. Beyond the conclusion concerning the importance of mediation in computerized study environments for young children, it may be concluded, based on the present study, that it is not enough to connect between child and computer to make efficient use of the computer for the advancement of the child. The children in both the accompaniment and the control groups successfully activated computers, used computer mice fearlessly, knew the functions of the various keys on the keyboard, and had fun playing computer *Game*s. But this activity, in and of itself, had no effect on the development of the children's cognitive performance. This may be explained based on the conclusions drawn by Klein (1996), who claimed that getting children to the theater, the library, a concert, or a computer will not, in and of itself, create an inner urge to seek high-quality cognitive experiences in the future. Enjoyment per se does not create a specific urge for cognitive processes that may enhance learning, since they require adult mediation. Through human mediation, children learn behavior patterns that enable them to learn from new experiences and to develop needs that direct them to seek and obtain the most precise information available through their senses, to compare and contrast various perceptions, to plan before acting, and to benefit from learning in the future. This claim is further supported by other studies, which found that young children who used computers without mediation tended, as a result, to get caught up in trial-and-error processes that did not result in any conceptualization (Samaras, 1996). When no support or guidance was offered, the children did not spontaneously start using higher thinking skills (Masters & Yelland, 1996). Apparently, merely working with computers does not in and of itself contribute enough to the improvement of the children's thinking. In order to do so, it is necessary to do more than simply let them use computers more often.

The analysis of the videotaped child-teacher interactions in computer environments revealed that children who operated computers with mediational instruction improved their computer operation strategies, from trial-and-error to planning ahead, as opposed to children who operated computers without such instruction. The trial-and-error strategy was frequently used by all children at the onset of the study. They tended to respond immediately, following the presentation of the required task, and made many mistakes. Those who chose the planning-ahead strategy delayed their reaction in order to think before answering, resulting in more correct answers. Moreover, the mediation group children delayed their response to weigh possible solutions before entering their response, made a mental effort in order to choose the suitable response, and were aware of their working and thinking processes. The conclusion stemming from these data is that the integration of mediation in computerized teaching and learning at preschool age facilitates the development of intelligent computerized learning environments. In such environments, learners can be encouraged to engage in intelligent learning activities while investing mental effort in the planning and choosing of the appropriate response and being aware of thinking processes. Sound learning in a computerized environment stems from the learner's ability to enact intelligent thinking, or, alternatively, is caused by external means such as instruction by a teacher who stimulates the learner to think intelligently (Salomon, Perkins, & Globerson, 1991).

In this study, mediational variables were isolated and defined in relation to the teaching-learning-thinking processes that occur in computerized environments for young children. Due to the isolation of these variables, it was possible to characterize effective teaching behaviors in computerized environments with an emphasis on the following essential mediational behaviors: **focusing** (intentionality and reciprocity), intended to direct the attention, perception or behavior of a child that uses a computer; **affecting** (mediation of significance), intended to endow things with meaning, to express feelings and appreciation for different things involved in the child's work process in the computerized environment; **expanding** (transcendence), behaviors intended to expand the child's cognitive awareness, beyond what is necessary to satisfy the immediate need that triggered the interaction, such as the operation of the computer and its program; **encouraging** (mediated feelings of competence), intended to express satisfaction with various aspects of a child's behavior in the computerized environment that have contributed to his or her successful experience; and **regulating behavior**, including behaviors intended to help, shape or plan a sequence of behaviors needed to achieve a desired goal.

The attempt to define characteristics of effective teaching behavior in computerized environments for young children, may help clarify some of the necessary changes in the teacher's role in this environment, from a teacher who is a source of information to a teacher who is an instructor and a mediator of learning and thinking.

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