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# Effects of multimedia environments on kindergarten children's mathematical achievements and style of learning

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The purpose of the study is two-fold: (a) to investigate the effects of learning mathematics with multimedia embedded in different styles of learning (cooperative learning versus individual learning) in kindergarten on students' mathematical achievements; (b) to examine students' preference for style of learning with computers in kindergarten. Participants were 116 students (girls and boys) who studied in kindergarten classes. One group was exposed to multimedia embedded in cooperative learning (CL), the second group was exposed to multimedia embedded in individual learning (IL) and the control group (C) was not exposed to multimedia. Findings indicated that the CL and IL students significantly outperformed the C group in mathematical achievement. The IL students further improved their mathematical skills at the higher level, while the CL students further increased their positive attitude about cooperative learning. Theoretical and practical implications are discussed.

**Les effets des environnements multimedia sur les résultats en mathématiques des enfants de l'école maternelle et sur leur style d'apprentissage**
Le but de la présente étude est double: (a) il s'agit d'étudier à l'école maternelle les effets de l'apprentissage des mathématiques avec des multimedia intégrés dans différents styles d'apprentissage (l'apprentissage coopératif opposé à l'apprentissage individuel), sur les résultats qu'obtiennent les élèves en mathématiques. Et (b) Il s'agit d'examiner quel est le style d'apprentissage sur ordinateur que préfèrent les élèves de maternelle. Il y avait 116 participants, élèves (garçons et filles) de maternelle. L'un des groupes a été exposé aux multimedia intégrés dans l'apprentissage coopératif (CL), le deuxième groupe a été exposé aux multimedia intégrés dans l'apprentissage individuel (IL) et le groupe de contrôle (C) n'a pas été exposé aux multimedia. Les observations ont montré que les élèves de CL et IL avaient des résultats en mathématiques nettement supérieurs à ceux du groupe de contrôle (C). Les élèves en apprentissage individuel ont amélioré leurs compétences mathématiques au niveau le plus élevé tandis que les élèves en apprentissage coopératif ont renforcé leur attitude favorable vis-à-vis de l'apprentissage coopératif. L'article examine les implications théoriques et pratiques.

**Auswirkungen von Multimediaumgebungen auf die Mathematikleistungen und den Lernstil von Kindergartenkindern**
Diese Studie verfolgt zwei Ziele: (a) die Auswirkungen auf das Mathematiklernen mit Multimediaunterstützung in verschiedenen Lernformen (kooperatives Lernen vs. Einzellernen) im Kindergarten auf die

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Mathematikleistungen von Kindern zu untersuchen und (b) herauszufinden, welche Form des Lernens mit Computern die Kinder präferieren. 116 Kindergartenkinder (Mädchen und Jungen) nahmen an der Studie teil. Eine Teilgruppe nutzte Multimedia beim kooperativen Lernen (CL), die zweite beim individuellen Lernen (IL) und die Kontrollgruppe (C) arbeitete ohne Multimediaunterstützung. Die Ergebnisse wiesen darauf hin, dass die Schüler der CL und IL Gruppen bei mathematischen Leistungen die Schüler der Kontrollgruppe signifikant übertrafen. Die Teilnehmer der Einzellerner-Gruppe verbesserten außerdem ihre Fachkenntnisse auf höherem Niveau, während die Teilnehmer aus der kooperativ lernenden Gruppe außerdem ihre positive Einstellung zum gemeinsamen Lernen weiter verstärkten. Theoretische und praktische Folgerungen werden diskutiert.

## Mathematical achievements and multimedia in early childhood education

How can mathematical achievement be promoted and sustained in authentic learning environments such as multimedia in kindergarten? What style of learning characteristics should young children have to facilitate mathematical achievement? The present study addresses these issues.

The growing use of computers in offices, factories, homes and schools is often cited as a reason for introducing computers to children at an early age. Information and communication technologies (ICT) are valuable tools for learning and playing. Children are becoming exposed to computers and technology at an increasingly early age, while most of this technology has not been fully integrated in making child–computer and child–child interaction optimal (Crook, 1995). While there were earlier concerns that computers are too abstract and difficult for young children to use (see, for example, Hattie & Fitzgerald, 1987; Clarke, 1990), many educators now believe that computers can promote learning and development in early childhood education if they are used appropriately. Children need to be engaged with the uses of computers in order to meet the challenges presented by the present and future technological society (see, for example, Lipinski *et al.*, 1986; Nastasi & Clements, 1992; Teng, 1997; Nicholson *et al.*, 1998; Solomon, 1998; Lomangino *et al.*, 1999; Haugland, 2000).

Multimedia is an interactive computer-based environment that provides active engagement with multi-presentations such as texts, voices, pictures and animations. Multimedia provides the opportunity to be actively engaged in real world contexts, as well as in formal and informal mathematical contexts. According to Mayer (2003), multimedia learning occurs when students build mental representations from words, pictures and voices that are presented to them. The promise of multimedia learning is that students can learn more deeply from well-designed multimedia messages consisting of words and pictures than from more traditional modes of communication involving words alone.

There is a growing research base showing that students learn more deeply from well-designed multimedia presentations than from traditional learning, including improved performance on tests of problem solving transfer (Mandl & Levin, 1989; Schnotz & Kulhavy, 1994; Van Merrienboer, 1997; Najjar, 1998; Sweller, 1999; Mayer, 2001).

According to standards in the area of mathematical education, using technology is an integral part of fostering mathematics from an early age in the kindergarten (National Council of Teachers of Mathematics [NCTM], 1989). At this age children develop many mathematical concepts, at least in their intuitive beginnings, even before they reach school age. Infants spontaneously recognize and discriminate among small numbers of objects, and many preschool children possess a substantial body of informal mathematical knowledge. Being engaged in multimedia embedded with mathematics from the youngest age can provide opportunities for thinking and exploring.

*Style of learning*

Children have their own style of learning about themselves and the world. They acquire skills and learn about their world through exploration and discovery, through trial and error and through experiencing cause and effect relationships (Berk, 1994, 2000a,b; Haugland & Wright, 1997). Clements and Nastasi (1988) stated that the investigation of learning style within different educational environments is significant not only because social development is a fundamental educational goal, but also because these valuable interactions are essential components of children's cognitive growth.

Identifying these learning styles may provide understanding and empower teachers to carefully structure other activity settings for success. Information about these styles will assist educators to make informed judgements on the learning benefits and potential of educational computer software packages and their suitability and potential to foster positive behaviour among children (see, for example, Shahrimin & Butterworth, 2002; OECD, 2003). From a lifelong learning perspective a positive approach to learning is likely to influence the degree to which people engage in further study and continue learning throughout life (OECD, 2003). The current study investigates the effects of using multimedia embedded in alternative styles of learning: cooperative learning versus individual learning on mathematical achievement.

*Cooperative learning versus individual learning*

In the last decade theories of cognitive psychology have helped explain the potential effects of cooperative methods on students' achievement outcomes. According to constructivist theories information is retained and understood through elaboration and construction of connections between prior and new knowledge (Wittrock, 1986). Since providing explanations is one of the best means for both elaborating information and making connections, and students in cooperative settings often provide explanations to each other, the likelihood of constructing rich networks of knowledge under these conditions increases.

Social contexts give students the opportunity to successfully carry out more complex skills than they could execute alone. Performing a task with others provides an opportunity not only to imitate what others are doing, but also to discuss the task and make thinking visible. A great deal of learning is about the meaning and correct use of ideas, symbols and representations.

Studies conducted on the effectiveness of cooperative learning versus individual learning with technology indicated mixed results, making it difficult to generalize the effects of learning conditions with technology's overall impact in improving mathematical learning (see, for example, Chernick, 1990; Crook, 1991; Mevarech, 1994; Mevarech & Kramarski, 1997; Keler & Anson, 1995). While most of the research was conducted for secondary and high school students, little research was performed for the lower elementary grades and kindergarten.

The present study addressed the following questions. Using multimedia environments for learning mathematics in kindergarten raises the questions: (a) Are young students in kindergarten able to learn mathematics via multimedia environments?; (b) Is multimedia embedded in a cooperative learning style more effective for kindergarten students than multimedia embedded in an individual learning style?; (c) What are young students' preferences for learning style (cooperative learning versus individual learning) with computers?

## Method

Participants were 116 students (61 girls and 55 boys) who studied in six kindergarten classes for 2-year-olds: these were divided into young (mean age 4.5, $n$ = 55) and old (mean age 5.5, $n$ = 61) groups. The six kindergartens were selected randomly from those of medium to high socio-economic status that are learning according to the curriculum laid down by the Ministry of Education. All of them had PCs at home, used for different purposes such as playing, practicing and writing.

The students were randomly assigned to either an experimental group or the control group. The experimental group included 76 students that were exposed to the multimedia environment 'I study math' using one of two learning styles. One group was exposed to multimedia embedded in cooperative learning (CL, $n$ = 36), the second group to multimedia embedded in individual learning (IL, $n$ = 40). The control group (C, $n$ = 40) was not exposed to multimedia.

### *Treatments*

*Multimedia environment.* The multimedia was designed by the Center of Educational Technology in Israel according to the kindergarten curriculum. The main purpose of the multimedia is to foster young students' (4–7 years old) mathematical concepts and skills about numbers and operations and to engage them in self-regulated learning.

The multimedia is composed of six different stages, situated and visualized by voices, animations, words and numbers. Each stage is based on a different level of mathematical skill. There were six skills that we categorized into three different levels of mathematical computation skills.

1. Low level skills: number recognition—students were asked to recognize numbers from 1 to 10; counting—students were asked to count numbers from 1 to 10.
2. Medium level skills: grouping—students were asked to form a group of objects; comparing—students were asked to compare numbers and to choose one of them according to a given criterion.
3. High level skills: estimating—students were asked to estimate how many objects there are; adding and subtracting—students were asked to add or subtract between numbers in a story context.

Appendix A presents examples of the three levels of mathematical computation skills used in the multimedia environment.

*Multimedia groups (CL and IL) versus control group (C).* All students in the multimedia (CL and IL) and control (C) groups were exposed to the same mathematical topics for the same amount of time, 28 hours over 5 months, but involving different teaching styles. In the multimedia groups (CL & IL) the students were trained and practiced with the multimedia 'I study math' in 7 stages. Each student studied mathematics for 4 hours for each stage, 30 minutes with a teacher and $3^1/_2$ hours with the multimedia. The CL students practiced with multimedia embedded in cooperative learning and the IL students practiced with the multimedia embedded in individual learning. In the control group (C) the students studied and practiced for 30 min with a teacher and $3^1/_2$ hours with worksheets, individually or cooperatively as they preferred, but without computer aid.

### *Measures*

*Mathematical achievements.* Pre-/post-training mathematical achievement tests were used in the present study to assess students' mathematical skills about numbers and operations from 1 to 10. The test included 23 items representing six different skills categorized into three mathematical computation skills: low level skills (number recognition and counting), medium level skills (grouping and comparing) and high level skills (estimating, adding and subtracting). The post-training test was similar to the pre-training test, but with the numbers changed. Due to the young age of the students the pre-/post-training tests were administrated individually to each student by the experimenter. It took about $1^1/_2$ months each time to test the 116 children. Cronbach $\alpha$ for the whole test was 0.85.

*Attitudes about learning styles.* A pre-/post-training attitudes questionnaire was administered. The questionnaire included nine items that assessed students' attitudes about using computers and preferred learning style in a computer environment. Three items referred to the frequency of using the computer environment (e.g. 'I play almost every day with the computer at home'; 'I play almost everyday with the computer in the kindergarten'; 'I like to play with computers') and six items referred to the preferred learning style, i.e. cooperative learning versus individual learning in a computer environment (e.g. 'I preferred to play with a friend while working with the computer'; 'I was bored working alone with the computer').

Each item was constructed on a 10-point Likert-type scale ranging from 1 (never) to 10 (always). The students used a polymeter technique to assess their attitudes towards computers.

*Procedure.* The study was conducted for 5 months on 116 students in six kindergartens, both young and older students, after getting permission from the Ministry of Education and parents. A pre-/post-training mathematical test was administered individually to each student. Students were randomly assigned to one of two multimedia groups (CL or IL) or to a control group (C). In addition, the two experimental groups (CL and IL) filled out an attitudes questionnaire about using computers and learning styles in a computer environment.

## Results

### *Mathematical achievements*

The primary purpose of the present study was to investigate the effects of a multimedia environment on kindergarten students' mathematical achievement by learning style (cooperative learning versus individual learning).

Table 1. Mean scores, standard deviations and adjusted mean scores on three levels of mathematical computation skills by treatment and time

| | Pre-training | | | Post-training | | |
|---|---|---|---|---|---|---|
| | Cooperative ($n$ = 36) | Individual ($n$ = 40) | Control ($n$ = 40) | Cooperative ($n$ = 36) | Individual ($n$ = 40) | Control ($n$ = 40) |
| Total score | | | | | | |
| Mean | 73.01 | 66.87 | 79.28 | 90.17 | 92.41 | 81.33 |
| SD | 18.45 | 17.31 | 15.62 | 11.52 | 7.51 | 16.32 |
| Adjusted mean | 72.49 | 66.45 | 80.18 | 89.88 | 92.16 | 81.85 |
| Low level: number recognition and counting | | | | | | |
| Mean | 87.03 | 82.70 | 88.54 | 94.44 | 93.95 | 86.66 |
| SD | 13.28 | 16.27 | 15.64 | 9.55 | 7.77 | 13.45 |
| Adjusted mean | 86.77 | 82.41 | 88.99 | 94.30 | 93.84 | 86.91 |
| Medium level: grouping and comparing | | | | | | |
| Mean | 68.95 | 63.50 | 81.56 | 90.27 | 93.37 | 86.68 |
| SD | 32.14 | 27.99 | 21.08 | 15.16 | 10.32 | 20.95 |
| Adjusted mean | 68.31 | 62.98 | 82.66 | 89.92 | 93.09 | 87.29 |
| High level: Estimating, adding and subtracting | | | | | | |
| Mean | 62.61 | 55.10 | 66.87 | 85.76 | 90.52 | 71.87 |
| SD | 20.78 | 23.21 | 20.41 | 16.64 | 11.12 | 21.30 |
| Adjusted mean | 61.98 | 54.59 | 67.95 | 85.35 | 90.19 | 61.98 |

Table 1 presents the means, standard deviations and adjusted means of the mathematical achievement by treatment and time. Table 2 presents $F$ values from a MANCOVA repeated measures analysis.

Two-way analyses of covariance (method of treatment (3) × time (2), with repeated measures on the second factor) were performed on the total score and on each level of mathematical computation skill separately, with age as a covariant. The results on the total score indicate a significant main effect for time ($F_{1,111}$ = 48.09, $P < 0.0001$) and that the interaction between

Table 2. $F$ values of two-way MANCOVA with repeated measures on mathematical achievements by treatment and time

| Source | DF | Total score | Low level | Medium level | High level |
|---|---|---|---|---|---|
| Time | 1 | 48.09[a] | 9.96[b] | 23.03[a] | 28.60[a] |
| Treatment | 2 | 0.31 | 0.64 | 1.88 | 0.58 |
| Time × treatment | 2 | 23.28[a] | 12.03[b] | 12.16[b] | 4.92[a] |
| Age (covariant) | 1 | 45.76[a] | 11.40[b] | 27.66[a] | 10.27[b] |
| Error | 111 | | | | |

[a] $P < 0.0001$.
[b] $P < 0.001$.
[c] $P < 0.05$.

time and treatment was significant ($F_{1,111} = 23.28$, $P < 0.0001$). These findings indicate that all of the groups made significant progress in their mathematical achievements over time. Post hoc pair-wise comparisons indicated that at the end of the study the two experimental groups (CL and IL) outperformed the control group (C), whereas no significant differences were found between the two multimedia learning styles (CL versus IL).

Repeated measures on each level of mathematical computation skill indicated similar findings for the main effects and interactions. It was found that at the end of the study the two experimental styles (CL and IL) outperformed the control group (C) at each level of mathematical computation skill. No significant differences were found between the CL and IL styles for the low (number recognition and counting) and middle (grouping and comparing) levels of mathematical computation skills, whereas for the high level mathematical computation skills (estimating, adding and subtracting), it was found that the students following the individual learning style (IL) significantly outperformed the students following the cooperative learning style (CL, effect size (ES) = 0.30). Effect size was calculated by the difference between the means of both groups divided by the standard deviation of the cooperative learning group.

### *Attitudes about learning styles*

The second purpose of the present study was to compare students' attitudes to learning styles in a computer environment.

Table 3 presents the means, standard deviations and adjusted means for attitudes about the use of computers and preferred style of learning by treatment and time. Table 4 presents *F* values of a MANCOVA repeated measures analysis. Figure 1 compares the means of the attitudes about the use of computers and preferred style of learning by treatment and time.

Two-way analyses of covariance (method of treatment (3) × time (2), with repeated measures on the second factor) were performed on the two components of the attitudes questionnaire: using computers and preferred style of learning. Results indicated no significant interaction

Table 3. Mean scores, standard deviations and adjusted mean scores of attitudes about computers by treatment and time

| | Pre-training | | Post-training | |
|---|---|---|---|---|
| | Cooperative ($n$ = 36) | Individual ($n$ = 40) | Cooperative ($n$ = 36) | Individual ($n$ = 40) |
| Using computers | | | | |
| Mean | 5.16 | 6.32 | 5.01 | 5.80 |
| SD | 2.15 | 1.61 | 2.34 | 2.19 |
| Adjusted mean | 5.17 | 6.31 | 5.02 | 5.81 |
| Preferred style of learning: CL versus IL | | | | |
| Mean | 4.30 | 4.81 | 7.95 | 4.59 |
| SD | 2.90 | 2.78 | 2.35 | 2.18 |
| Adjusted mean | 4.31 | 4.80 | 7.96 | 4.58 |

High scores indicate a preference for a cooperative style of learning.

Table 4. *F* values of two-way MANCOVA with repeated measures on attitudes by treatment and time

| Source | DF | Using computers | Preferred style of learning: CL versus IL |
|---|---|---|---|
| Time | 1 | 1.05 | 1.58 |
| Treatment | 1 | 5.82[a] | 11.32[b] |
| Time × treatment | 1 | 0.60 | 21.44[c] |
| Age (covariant) | 1 | 5.14[a] | 0.003 |
| Error | 121 | | |

[a] $P < 0.05$.
[b] $P < 0.001$.
[c] $P < 0.0001$.

effect between time and treatment ($F_{1,121} = 0.60$, $P > 0.05$) on using computers but a significant interaction effect between time and treatment ($F_{1,121} = 21.44$, $P < 0.0001$) on preferred style of learning between the two multimedia learning styles. While at the end of the study no significant change on preferred style of learning was found in the individual group (ES = –0.08), in the cooperative learning group the students had a significantly increased preference for the cooperative style (ES = 1.25).

## Discussion

The present study indicates that being engaged with multimedia in kindergarten affects students' mathematical skills. These findings were found for all three levels of mathematical skills and were remarkable for the high order skills.

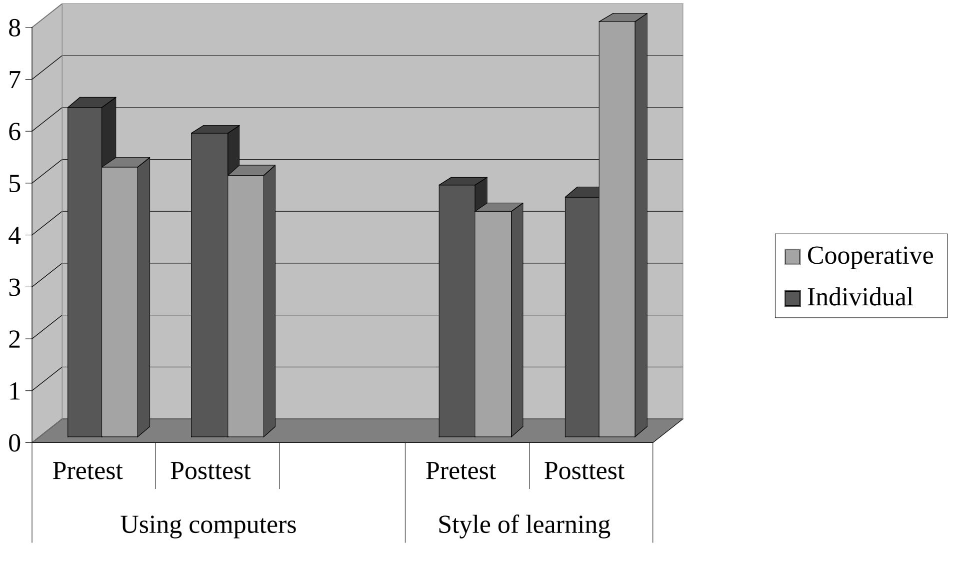


Figure 1. Attitudes about using computers and preferred style of learning (range 1–10)

*Multimedia learning*

Cognitive research has shown that learning is most effective when four fundamental characteristics are present: active engagement; participation in groups; frequent interaction and feedback; connections to real world contexts (see, for example, Haugland, 2000). It seems that being engaged in the multimedia environment 'I study math' provided the kindergarten students with the opportunity to be cognitively engaged in real world contexts with multi-presentations which in turn affected their mathematical skills.

These findings support mathematical standards for learning mathematics at a young age by providing opportunities where thinking is encouraged (NCTM, 2000). These findings expand the research on the effects of appropriate programmes embedded in a computerized environment as a tool for visualization and mathematical reasoning (see, for example, NCTM, 2000; OECD, 2003; Kramarski & Ritkof, 2002; Mayer, 2003).

*Learning styles*

The results indicate that at the end of the study students that were exposed to multimedia embedded within an individual learning (IL) style showed greater improvement on the high level mathematical computation skills (estimating, adding and subtracting) than students following the cooperative learning style.

Two factors may have contributed to the findings reported here: mathematical communication and the cognitive demands of the task.

From a cognitive perspective students who have poor communication skills are less likely to benefit from cooperative learning because they are not able to communicate their mathematical reasoning to others and they do not generally know how to ask questions or reflect upon their solution process in order to explain it to their peers (Webb, 1989, 1991; Webb & Farivar, 1994; Limon, 2001). It might be that one of the reasons why the cooperative learning students did not outperform the individual learning students in our study was because of the poor communication skills of these kindergarten students. Further research will focus on ways of structuring cooperative learning in the kindergarten that will maximize the opportunities for each student to be engaged in questioning, elaboration, explanation and other verbal communication by which students can express their ideas. One of the recommended methods is embedding explicit metacognitive instruction that focuses on skills for high level communication (see, for example, Schoenfeld, 1992; King, 1994; Kramarski & Ritkof, 2002; Kramarski & Mevarech, 2003).

The characteristics of the mathematical task have an important role in increasing mathematical communication in cooperative learning (see, for example, Henningsen & Stein, 1997; OECD, 2003). First, the mathematical task leads students to communicate in relation to the task. Second, the mathematical task provides ample opportunities for students to be involved in mutual reasoning. Third, the mathematical task raises cognitive conflicts, which in turn encourages students to discuss these conflicts and suggests ways to resolve them. Finally, the mathematical task provides opportunities for students to be involved in different contexts. It may be that the tasks in the multimedia provided fewer opportunities for students to be involved in mutual reasoning and communication and, therefore, they were more appropriate for individual learning than cooperative learning.

Additional research is needed to investigate the effects of different contexts of mathematical tasks embedded in multimedia environments on mathematical achievement in kindergarten. This is particularly important in the light of current research showing the effects of context on students' ability to solve mathematical problems (see, for example, OECD, 2003).

*Attitudes*

It was found that at the end of the study the cooperative learning students increased their positive attitude about the cooperative learning style, while no change in preference for learning style was found in the individual learning students.

The literature reveals that cooperative learning with computer use is often associated with the social nature of interactions occasioned by the social demands of complex collaborative activities on computers (Haugland & Wright, 1997). The literature also confirms that the social effects of using computers in the classroom are 'overwhelmingly positive' (Bergin *et al.*, 1993). It might be that in spite of the fact that young students have poor communication skills, they felt more comfortable and enjoyed it more in cooperative demanding environments. This might be the reason why students who were exposed to the cooperative learning style were more positive about this style of learning at the end of the study, while the individual learning students had not changed their preference for learning style at the end of the study. These findings support other conclusions that for pre-schoolers and kindergarteners the addition of computers and appropriate software to their environment has positive social consequences (Hohmann, 1994).

## Practical implications and future research

Given the findings of the present study, it seems reasonable and promising to apply a multimedia environment in kindergarten. The emphasis on multimedia learning has several implications. There is a need to design various multimedia environments focusing on mathematical tasks with different cognitive level demands and various contexts. Such tasks will challenge young students to be engaged in mathematics and will lead them to communicate in relation to the task.

The study strengthens other research conclusions that there is a need to structure learning in small groups and that features of communication such as providing/receiving elaborated explanations must be practiced and reinforced (see, for example, Schoenfeld, 1992; King, 1994; Webb & Farivar, 1994; Cohen, 1996; Kramarski & Mevarech, 2003).

Further research may continue to investigate task structures and the way in which they promote mathematics achievement and different styles of instruction (see, for example, Crook, 1994; Kramarski & Ritkof, 2002). It is important to ensure that future educational computer environments are structured and developed in such a way as to best maximize young children's cooperative behaviour, so they may scaffold one another's learning. Moreover, the educational goals of a computer environment can only be achieved if the teachers' early childhood educators and researchers are informed of the relevant issues, demand that computer programs used with children are appropriate and contribute to both theoretical and experimental databases to guide computer use with children (Silvern & Silvern, 1990).

It is recommended that teachers be aware of both the positive and negative peer discussions and behaviours that often accompany young children's cooperative interactions. Identifying these interactions may provide understanding and empower teachers to carefully structure other cooperative activity settings for success. Information about these discourses will assist educators to make informed judgements on the learning benefits and potential of educational computer environments and their suitability and potential to foster positive cooperative behaviour among children.

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**Appendix A. Examples of the three levels of mathematical computation skills used in the multimedia environment.**

(1) **Low level skills**: counting—students were asked to count from 1 to 10

*Station 1. Animal picture taking*
*The activity.* Goldilocks takes pictures of animals in the forest for her sick grandmother. The children help her count the animals in different groups as they are asked: 'How many animals are there in each of the groups?'
*Learning aims.* The children will learn to count from 1 to 10.
*Free activity.* The children choose the number of animals to be photographed by Goldilocks by pushing the appropriate number button on the computer.
*Aid tools.* Line of numbers, a microphone and a pencil.

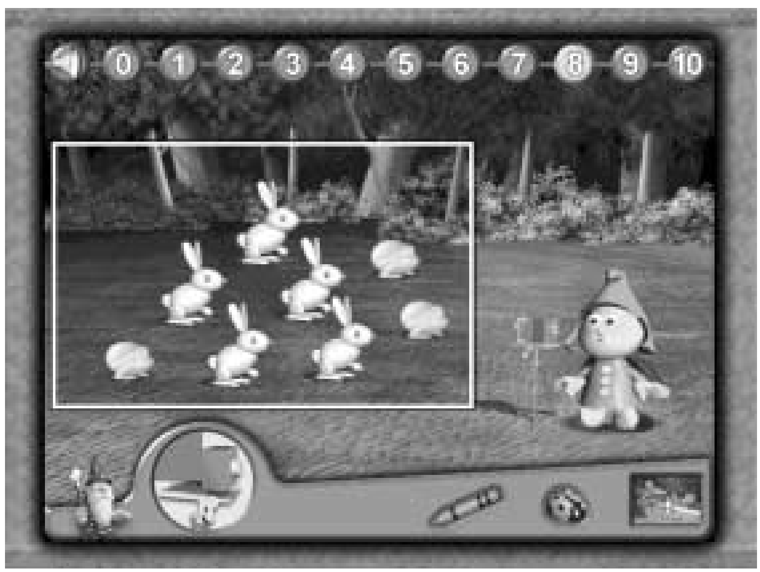


Figure A1

(2) **Medium level skills**: comparing—students were asked to compare numbers and to choose one of them according to a given criteria

*Station 2. The house of the bears* (Goldilocks and the three bears)
*The activity.* The students play in the bears' house. They have to decide what is the greater number or the lesser number between the two numbers that appear on the window of the house. Together with Goldilocks they have to compare between different quantities, change the size of groups in the computer game by changing the number of the objects in each group and comparing them.
*Learning aims.* The students will learn to find a greater or lesser number.


Figure A2

*Aid tools.* Using a funnel to grow the flowers in the window box to the required size.

(3) **High level skills**: adding and subtracting—students were asked to add or subtract between numbers in a story context.

*Station 3. Adding and subtracting—the garden of Gordonila the magician (the gift game)*
*The activity.* Gordonila and Goldilocks play with the dwarves in the gift game. Each of them gives gifts to the dwarves. The children help the dwarves to find an appropriate box for all the gifts they have received. The dwarves also give gifts to Gordonila and to Goldilocks. One of them takes away some of the gifts and the children help to find different boxes for the gifts that remain. For this reason they have to be engaged in adding and subtracting in order to find suitable boxes for the correct number of gifts. They also have to prepare an addition and subtraction table on the board.
*Learning aims.* The children will learn to add and subtract separate groups.
*Aid tools.* A magician's stick to select a box.

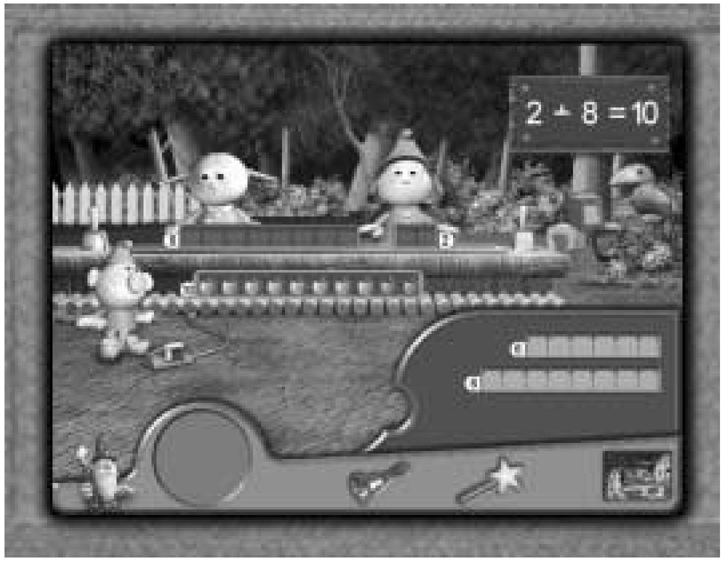


Figure A3