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Multimedia support of early literacy learning

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Abstract

In the present article, the development of a child-friendly computer software program to enhance the early literacy skills of kindergarteners in the Netherlands is described. The ergonomic aspects of designing software for young children are described along with the content of the program in connection with the literature on early literacy. The results of two studies with immigrant kindergarteners trained using the story and the vocabulary part of the program are also reported. After a short amount of training, the vocabulary of the children was found to show significant gains.

Keywords: Architectures for educational technology systems; Cross-cultural projects; Elementary education; Interactive learning environments; Media in education

1. Introduction

Research on emergent literacy has shown that such interactive activities as storybook reading, communicative writing, and language games can have considerable impact on children's oral and written language development (Sulzby & Teale, 1991; Yaden, Rowe, & MacGillivray, 2000). The interaction with symbols in an environment with literate others helps children to realise that print carries meaning, that written texts can have various forms and functions, and that ideas can be expressed with written conventions. In addition to this, interactive storybook reading helps children expand their vocabulary and gain insight into the structure of narrative text. Conditions that highlight the purpose and relevance of literacy also appear to be quite important for the development of literacy. In fact, empirical studies have shown the attainment of literacy to be clearly stimulated by the provision of a school environment that expands on the positive literacy experiences prior to school (cf. Snow, Burns, & Griffin, 1998).

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The use of computers in kindergartens can make parents frown and ask whether it is really necessary to place these youngsters behind such a machine. Practice shows, however, clear learning gains from interacting with the computer and that the children have fun. Recent qualitative research also shows many of the young children playing in a computer environment to develop an understanding of the computer as a communicative tool (Jones, 1994; Labbo, 1996; Labbo, Reinking, & McKenna, 1995; Olson, 1994). In addition to this, children's conceptual knowledge of the forms, processes, and products of electronic symbol making is enhanced by experience with computer-driven language games (see Labbo & Kuhn, 1998, for an overview).

Although there is clear evidence that computer interaction can teach young children about the use of symbol systems and communicative tools, there is a paucity of good educational software for use in the school. There is considerable entertainment software that claims educational goals, but this software is designed for the home-market and often lacks a solid educational basis (Schacter & Fagnano, 1999).

In the present study, the development of a child-friendly computer software program to enhance the early literacy skills of kindergarteners in the Netherlands was undertaken. In the Netherlands, kindergarten starts at age four and lasts two years. Kindergarten teachers follow a developmental approach in which the Vygotskian notion of "expanding the zone of proximal development" is followed (Vygotsky, 1962). Teachers try to expand a child's development by asking questions beyond the range of the child's interests and abilities and by highlighting new connections with already stored information. In order to do this, the vast majority of teachers use a kindergarten program which is a primer, linked to the reading program *Veilig Leren Lezen*—Learning to read safely—(Mommers, Verhoeven, & Van der Linden, 1990), which is typically used in grade one. The kindergarten program has four main literacy objectives: becoming familiar with books and stories (1), enlarging vocabulary (2), enhancing metalinguistic awareness (3), and discovering the alphabetic principle (4).

Teachers in the Netherlands are faced with a very diverse group of children on account of three factors. The first factor is that the classes can grow in size during the school year. During the school year, young children who have just turned four can enter a kindergarten class; these children constitute the so-called 0 group and will be in kindergarten for two more years starting the following school year. There can therefore be more than 25 children in a single kindergarten group at a time varying in age from 4 to 6 years. The children are in the first or second year of elementary school and usually stay with the same teacher. During the first year, they are the younger kindergarteners; during the second year, they are the older kindergarteners and are being prepared for—among other things—formal reading instruction.

Age difference is not the only factor that causes diversity within the kindergarten group. In the Netherlands, there is a large group of immigrant children from—among other places—Morocco, Turkey, and Suriname. These children often enter kindergarten without any knowledge of the Dutch language or with a severe lag in their knowledge. The language environment for these immigrant children can be generally characterised as follows. They are living in primarily ethnic language-speaking homes with mothers who are typically monolingual speakers of a language other than Dutch. The early language input to the children is thus restricted to this language. The Dutch language enters the lives of these children only very gradually via Dutch playmates (if at all), television and school. Research by Verhoeven and Vermeer (1992) and Stoep and Verhoeven (2001) has also shown the Dutch vocabularies of immigrant children to be much smaller than those of Dutch children. This difference tends to increase during the primary school years, which is referred to as the Matthew effect (Stanovich, 1986).

The third factor making kindergarten classes in the Netherlands so diverse is the government policy of keeping as many children in the regular as opposed to special education system as possible. It is assumed that children benefit most from such a situation, but it does place a considerable strain on the teachers involved.

The three factors mentioned earlier also call for adaptive education and individualised teaching. Well-designed educational software can obviously be a very helpful tool. The development of a computer supported literacy curriculum in which language experiences are highly emphasised has been promoted in the past (see Adam & Wild, 1997). In order to provide schools with sound educational software, the Dutch government also recently funded a project for the design of an educational computer program taking the three aforementioned factors into consideration. The project was carried out in co-operation with a school publisher (Zwijsen) and the University of Nijmegen. The computer program is linked to an already existing literacy program and therefore has some clear advantages over other computer programs. The teachers are already familiar with the principles on which the program is based and can therefore fit the software easily into their regular classroom activities. The computer program is called: *Schatkist met de Muis* (Treasure chest with the Mouse; Verhoeven, Segers, & Mommers, 1999) and consists of five CD-ROMs with the same basic framework.

In the present article, the ergonomic and educational potential of this software will be discussed. We will first describe the design of the software package and then some ergonomic aspects of designing software for young children. Very little is known about the latter, so we decided to undertake some observational studies. After consideration of the ergonomic aspects of designing software for children, the content of the program will be described in connection with the relevant research literature. In the final section, the results of two studies on vocabulary learning will be presented and discussed.

2. Program design

2.1. Ergonomic aspects

An educationally sound idea is not enough for the development of a good software product. One must also take the ergonomic aspects of program use into consideration. Kindergarteners cannot read and are not very skilled computer users. The program should therefore have a very clear structure, easy-to-understand buttons, and no written text. Very little is known about the design of computer programs for young children. Druin and Solomon (1996) address some but not all of the relevant issues. Prior to the actual designing of our product, we therefore conducted pilot research in several kindergartens. The children played with existing educational and entertainment software, and we observed just how the children interacted with the packages.

The motor skills of kindergarteners are not completely developed. They do not have perfect eye-hand co-ordination as a result, and this is exactly what was found to cause problems for the children observed in our pilot research. Many of the children had great difficulties with a picture colouring game requiring them to paint the buttons of a blouse. The buttons were simply too small. In other words, the areas/buttons to be clicked on should be as large as possible on a computer. In fact, when a child clicks close enough to the area for an item, the program should automatically accept it. In our observations, we saw how children put a lot of effort into positioning the cursor at the right place on the screen; when letting go of the mouse in order to click one of the buttons on the mouse, the cursor frequently moved and the child clicked a different location as a result.

Also due to their incomplete developed motor skills, the children in our pilot research were frequently found to have difficulties with the "drag and drop" procedure. In the design of our computer software, we therefore decided to have children select an object by clicking on it. By clicking again, the object can be "dropped" (i.e. placed in position). Joiner, Messer, Light, and Littleton (1998) reached the same conclusion after the conduct of an experiment in which children of several ages were asked to drag or click on objects and then position them.

A final observation based on our pilot work with an early version of the computer program should also be made at this point. When a child is asked to click on, for example, a tree and the child asks for help, the program points at the tree. We initially used a little white hand, which is a standard Windows mouse pointer, to point to the tree. However, many of the children failed to notice the small cursor as they obviously did not know where to look on the screen and the pointer was very small. It was also found that even when the cursor pointed at the tree, some of the children would nonetheless click on the bird above the tree because this was also being pointed at. Our solution to this problem was to use four large green arrows. The arrows could only point at one object on the screen and hardly be missed.

When the aforementioned observations were taken into account, the result was a program that is easy and fun for young children to use. In pilot studies with early versions of the program, we found that, after a short introduction to the program, most kindergarteners can work independently and without the help of an adult. Further details on the program will be presented in the following sections.

2.2. Overview of the CD-ROMs

In creating the learning environment, an attempt was made to engage the children and address their independence as learners. First, the environment was designed to have the children personally choose from the literacy activities. When children are allowed to select tasks and texts that they are most interested in, they tend to expend greater effort on the relevant learning and understanding (Schiefele, 1991). The literacy activities were also constructed to sufficiently challenge the children, to let them take control of their own learning via self-monitoring devices, and to also promote feelings of competence and self-efficacy as a result. In designing the software, the option of adaptivity was highly emphasised. Adaptivity was defined as the ability of the computer program to have the correct set of games available for each individual child and to have the games adjusted to the knowledge level of that child.

Each CD-ROM is roughly divided into a teacher part, a story/vocabulary part, and a part with language games for children. Fig. 1 provides an overview of the content of each CD-ROM. The adaptivity is marked in bold arrows. The adaptivity applies across the five CD-ROMs: when a child has access to a certain game on one of the CD-ROMs, he also has access to the same game on all of the other CD-ROMs. The software also keeps track of the letter knowledge of each child, and this information is then used in the letter booklet and word game (see Section 2.3.4).

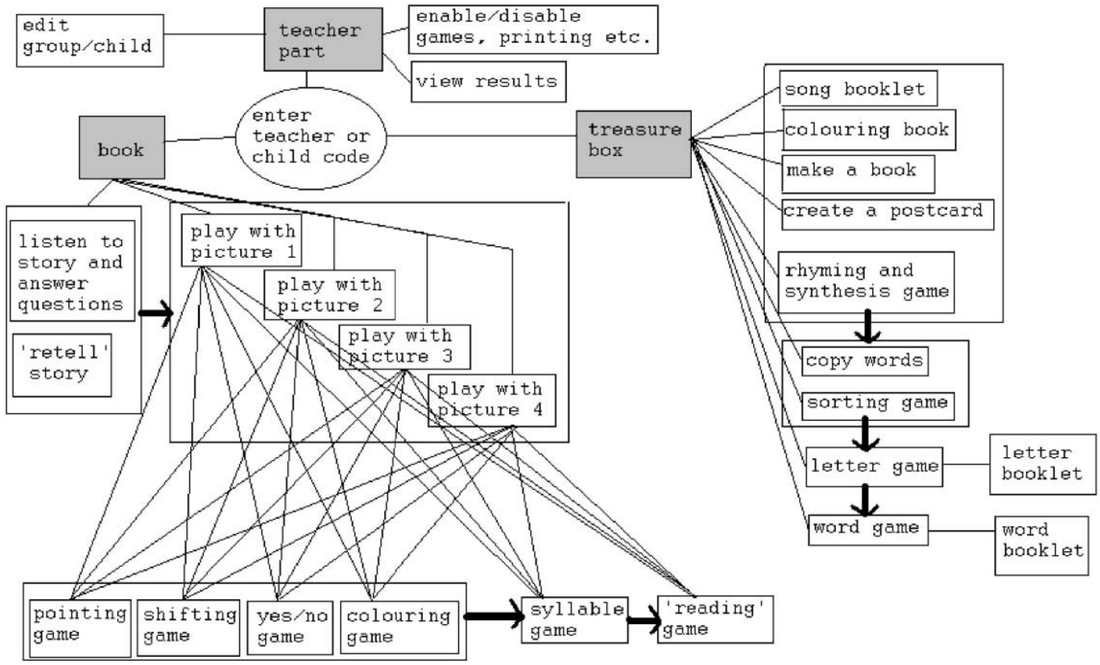

Fig. 1. Overview of the CD-ROMs. Bold arrows indicate an adaptive relationship.

2.3. *Content of each CD-ROM*

2.3.1. *Vocabulary acquisition by computer*

2.3.1.1. Listening to a story. Listening to stories has been shown to enhance vocabulary learning (Elley, 1989). This is particularly so when the teacher elaborates on the story and interacts with the children, then the learning gains can be quite high. Interactive storybooks on a computer enable children to interact with the story (Anderson, 1992; Underwood & Underwood, 1998) and can thus enhance both vocabulary (Stine, 1993) and text comprehension (Miller, Blackstock, & Miller, 1994). Children just starting to read have also been found to benefit from talking books with accompanying text and reinforcement activities (Lewin, 2000).

In our computer program, a story with story pictures as anchors can be presented (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990). When children first play with one of the five CD-ROMs and choose to play with the story/vocabulary part of the program by clicking on the little book, they listen to a story. The story is short, about 300 words, and consists of high-frequency words that kindergarteners with a limited vocabulary can be expected to understand. The story was intentionally kept short in order not to lose the children's attention. At the end of each story fragment, the parrot puppet at the bottom of the screen asks a question, which the children can then answer by clicking somewhere in the picture. In such a manner, the children are actively involved in the story and their understanding is enlarged.

If a child cannot hear or understand the question, he or she can click on the parrot to have the question repeated. When the child provides an incorrect answer, the little pirate next to the parrot helps them. First by telling the child that the answer was not correct and that he or she should try to answer the question again. If the second answer is incorrect, four large green arrows then point at the correct object in the picture. If the child still does not click in the right area, the program takes control of the cursor and points to the correct answer. The children can also ask the pirate for help by clicking on it; the four green arrows then point at the correct object.

At the end of the story, the child is asked to arrange the pictures in the correct order. This is a difficult task, but the pilot research showed that the pictures could be correctly ordered in a maximum of five attempts. The next time the child enters the storybook, he or she can choose to listen to the story again or immediately start playing with the vocabulary games, which are described later.

2.3.1.2. Vocabulary games. After the child has listened to the story at least once, vocabulary games can be played using the story pictures. The story pictures all represent a fairly "high knot" in the semantic network and thus have numerous relations: a bakery, a living room, a forest, or a supermarket. With each picture, many words can be learned by playing several types of vocabulary games.

The first type of vocabulary game is the pointing game, which requires children to point at the objects the parrot asks for. As usual, the pirate provides help when needed. The second type of vocabulary game is the shifting game, which requires the child to move an object to a particular place in the picture. The parrot asks the child, for example, to place the cup of coffee on the kitchen table. This game is of special interest for learning prepositions, which can be particularly problematic for young children (see Fig. 2 for an example). The third vocabulary game is a yes/no game. The child must decide whether an object belongs in the picture or not. The parrot asks, for example, whether you can buy a carrot in a bakery or not. The fourth vocabulary game is a colouring game in which objects in the picture have to be painted or decorated. The parrot asks the child, for example, to paint the curtains red or make the curtains flowered.

When the child demonstrates no problems with these games, two other vocabulary games become successively available. The first game is a pointing game in which the parrot chops the words into syllables (e.g. can you point to the kit-chen ta-ble?). The second game involves a word being written on the screen and the graphemes lighting up as the parrot slowly pronounces the word. These two games stimulate not only vocabulary acquisition but also metalinguistic awareness of the ability to reflect on the units of language.

As can be seen in the upper left above the picture in Fig. 2, the child has to answer five questions per session. The figures above the picture turn green, yellow, or red depending on the number of efforts it takes the child to answer a question. The answering of the five questions cannot be interrupted, so the child is not encouraged to switch from one thing to the next. Each CD-ROM contains 200 questions with 50 questions per picture.

2.3.2. Discovery games

When the children play with the program and choose from the language games by clicking on the treasure chest, they can select one of five different games. Four of the games are so-called discovery games, the fifth is a rhyming and synthesis game. The first game contains two songs and two rhymes per CD-ROM. The text appears in karaoke on screen. A child can discover that one starts reading at the top left part of a page by playing this game or that the direction of reading is

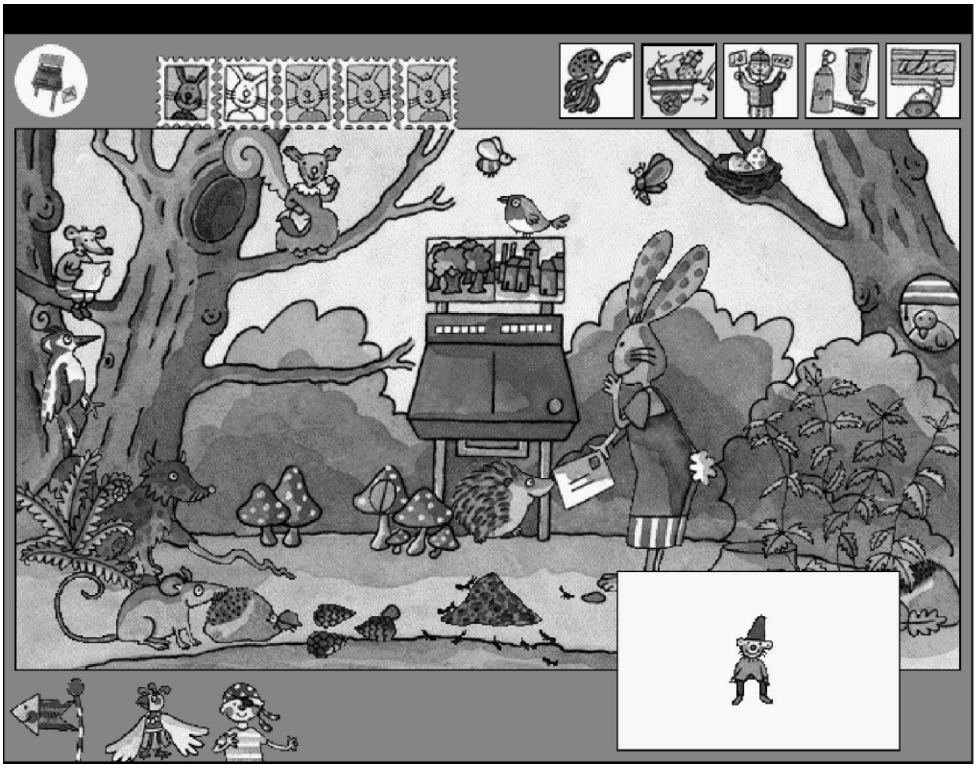

Fig. 2. Vocabulary game: can you place the elf among the mushrooms? (*Schatkist met de muis*, CD-ROM 2).

from left to right. They can also discover that sentences are divided into words and that words can rhyme.

The second discovery game is a colouring game. An example is shown in Fig. 3. Children can learn the names of colours and see the differences between the graphemes. They can also choose to leave the words out of the picture by clicking on the letter-flower at the bottom of the screen. The picture can then be filled with colours of their own preference.

The third game involves making a little booklet. Children can fill in the slots in sentences and thereby create their own book to be printed and taken home. In such a manner, they learn how thoughts can be put on paper and be recaptured by print.

The fourth discovery game is a drawing program in which children can make their own picture postcard by stamping and drawing. The learning goal is about the same as in the third game.

2.3.3. Rhyming and synthesis game

The importance of training metalinguistic awareness has been demonstrated by—among others—Lundberg, Frost, and Peterson (1988). In their study, kindergarten teachers paid special attention to this aspect of language. More recently, computer programs have also been shown to help facilitate such an awareness (see, for example, Foster, Erickson, Foster, Brinkman, & Torgeson, 1994; Reitsma & Wesseling, 1998).

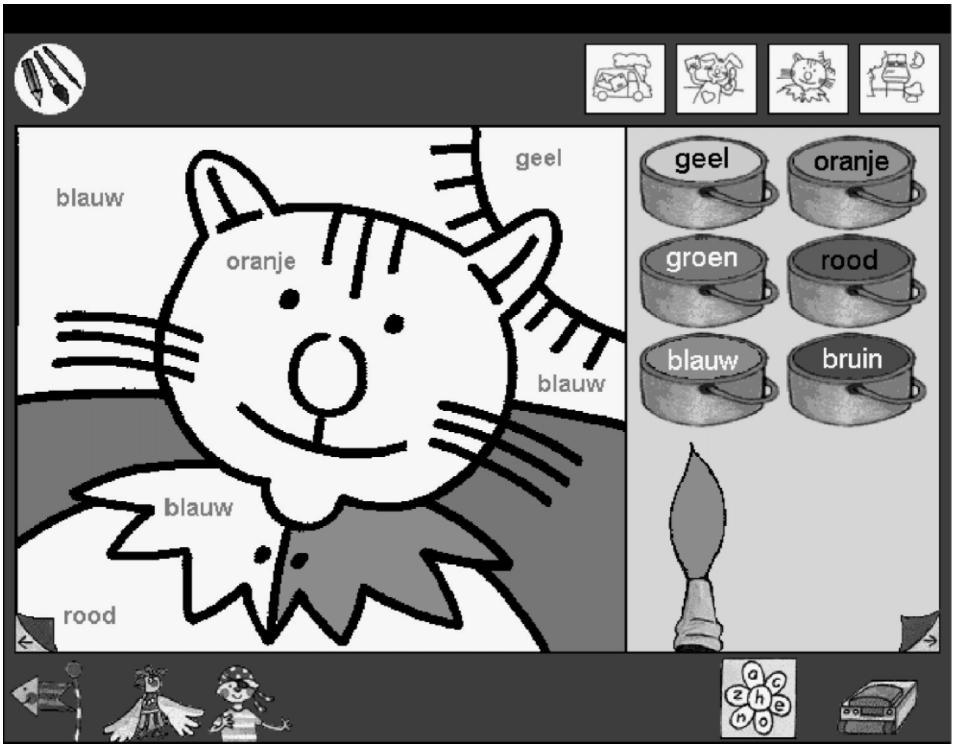

Fig. 3. Coloring game (*Schatkist met de muis*, CD-ROM 2).

In our computer program, we implemented an adaptive game that switches between 10 different rhyming and synthesis exercises. The exercises automatically increase in difficulty when the child shows no problems at a particular level. Making a sentence rhyme by selecting the right picture is an example of such a rhyming exercise: *The cat sleeps on the* [mat, chair, floor]. Selecting the right picture to go with a segmented sound pattern is an example of such a synthesis exercise: /s-ou-p/. Each type of exercise consists of three sets of five questions; this is a total of 750 questions across the five CD-ROMs.

2.3.4. Familiarity with graphemes and words

2.3.4.1. A first introduction to graphemes. Research shows the importance of combining metalinguistic awareness with letter knowledge for learning how to read (Bradley & Bryant, 1983; Roth & Schneider, 1998). For this reason, when a child is able to synthesise consonant-vowel-consonant words (with picture support) in the rhyming and synthesis game, the two games involving graphemes also become available in the treasure chest.

The first letter game demonstrates the basic reading process by spelling the phonemes and combining them into a word. The word is spoken and then removed from the screen. The child must place the accompanying picture into one of two boxes, selecting the one that represents the correct initial grapheme of the word. Children learn how ‘‘reading’’ is done and gain familiarity with the different graphemes.

The second letter game requires the children to copy simple consonant-vowel-consonant words. The graphemes for each position in the word can be found by clicking on an arrow. This game is easy to perform, which gives the children some reading success experiences. The children can also discover how a new word can be created by changing a single grapheme.

2.3.4.2. Further experiences with graphemes and words. When a child shows no problems with the previous games, a new game becomes available to test their grapheme knowledge. In this letter game, the child is asked to point at the object with the grapheme the parrot asks for. The program makes a "letter book" containing all the graphemes that a child knows for each child. This book can be printed, of course.

When the child knows enough letters to make at least five consonant-vocal-consonant words, the final game becomes available. In this game, the child makes words with the letters he or she knows and tries to find the words from which a picture is available in the program. All of the words are placed in a "word book", which can also be printed.

2.4. The role of the teacher

The teacher plays an important role when the computer is implemented into the classroom curriculum. Letting the children work with the program but without monitoring what they are doing is of little use. For this reason, a monitoring feature has been explicitly implemented into our program to supply the teacher with specific information on which games each child has played and how many errors he or she has made. The teachers can intervene when a child is not able to get any further in the program. When a child does not grasp the concept of rhyming, for example, the teacher can devote extra attention to this aspect of language separate from the computer.

Another option in such a case is to have the child who is not making any progress work together with a child who is. Schunk (1989) has shown that working together can increase children's motivation, effort, and persistence; working together can also increase their confidence in their own ability to succeed.

If teachers so desire, they can also have children play specific games. This may be particularly useful when the teacher wants a child to pay specific attention to a certain story on a CD-ROM. When the teacher reads the story to the child or children prior to its presentation on the computer, this can provide extra stimulation. In such a manner, the teacher can also activate the children's knowledge of the topic of the story and explain particularly difficult parts.

An informal survey among five teachers using the program showed the monitoring feature to be used when a child is expected to have a delay. The feature is also used to check whether the child is using the computer appropriately or not. The teachers may also sometimes block the discovery games when their monitoring shows the child to need more structure to play the games.

3. Two studies of enhancing vocabulary acquisition

To our knowledge, there is no research to date on the computer-supported vocabulary development of non-readers. Two studies were therefore undertaken to test the effectiveness of the computer vocabulary games described above. More specifically, whether immigrant children in their second year of kindergarten (study 1) or first year of kindergarten (study 2) benefit from a short-term computer-supported vocabulary training program was examined.

3.1. Study 1

3.1.1. Method

3.1.1.1. Subjects. Twenty-five children (15 males, 10 females) from two different schools in their second year of kindergarten participated in the training. They were all immigrant children: 11 were Turkish, the other 14 children had six different nationalities. The average age of the children was 65.4 months.

3.1.1.2. Material. The Passive Vocabulary Task from the Taaltoets Allochtone Kinderen (Language Test for Immigrant Children; Verhoeven & Vermeer, 1986) was administered. The average score attained by the children was 16.2 (SD = 10.3). All of the children scored *low* to *very low* when compared to the norm group of native children, but *average* when compared with the Turkish and Moroccan norm group.

In addition to the aforementioned test, a curriculum-dependent vocabulary test was constructed on the basis of the words presented on the training CD-ROM. The test consisted of 29 nouns. Children were, for example, asked to tell the experimenter if they knew what a *raisin* was. If the child could not answer the question or simply responded that it was something you can eat, the experimenter would further ask: "What does a *raisin* look like? Where have you ever seen a *raisin*?" (cf. Anglin, 1985). The child could receive a score of 0, 1, or 2 points per word. One point was accredited when the child did not provide an exact definition but was nevertheless within the correct semantic area: when the child said that *raisin bread* was the same as a *raisin*, for example. Both the reliability of this curriculum-dependent test when administered at pre-test ($\alpha = 0.75$) and the correlation between the curriculum-independent and curriculum-dependent tests ($r = 0.72$, $P < 0.001$) were found to be satisfactory.

In a pilot study, it was established that no test-retest effects occurred when the curriculum-dependent vocabulary test was administered again after a 4-week period. The subjects in the pilot study (four immigrants in their first year of kindergarten and five in their second year) were comparable with the subjects in the present two studies. A repeated measures analysis with Time (pre-test, post-test) as the within subject factor and Group (first year, second year) as the between subject factor showed no significant main effect of Time ($F(1,7) = 1.03$, $P > 0.30$) and no significant interaction between Time and Group ($F(1,7) = 0.33$, $P > 0.50$) in the pilot study.

For the first study, the children used only the story part of one of the CD-ROMs. This contained a storybook and vocabulary games pertaining to the narrative "Manja is jarig" (It's Manja's birthday).

3.1.1.3. Procedure. The first study had a pre-test–training–post-test design. At pre-test, both the curriculum-independent and curriculum-dependent vocabulary tests were administered.

The training consisted of three 25-min sessions. Each time, two children were taken out of the classroom. The children were seated in a separate room elsewhere in the school with their own computer. The children quickly learned to work independently with the program and choose between the storybook or vocabulary games.

At post-test, only the curriculum-dependent test was administered, one week after the training.

3.1.2. Results

A *t*-test revealed a significant difference between the average scores at pre- versus post-test ($t(24) = -8.56$, $P < 0.001$). In other words, the computer training positively influenced the children's vocabulary knowledge. In Table 1, the average scores and standard deviations at pre-test and post-test are presented.

A significant correlation between the children's scores at pre-test and their vocabulary gains as a result of the computer training was found ($r = 0.49$, $P < 0.05$). Those children who scored high at pre-test also learned the most.

3.1.3. Conclusions

A short training with the computer program showed positive results. The children made progress and enjoyed working with the program. Those children who scored high at pre-test also learned most from the training. This finding is in accordance with the results of studies by Robbins and Ehri (1994) and Ewers and Brownson (1999) but not in accordance with the results of a study by Elley (1989). In the latter study, those children scoring lowest at pre-test made the most progress as a result of training. However, Elley's findings were not statistically tested, and a ceiling effect may have occurred for the children scoring highest at pre-test - according to Robbins and Ehri (1994).

3.2. Study 2

The focus of the second study was on whether young immigrant children in their first year of kindergarten also learn new words as a result of working with the program and whether any long-term positive effects can be detected.

In contrast to the first study, a complete version of the program was available for the second study. The teacher/monitoring part of the program was also now available, which made it possible to keep track of the number and types of exercises the children did. The effects of these different numbers and types of exercises on the vocabulary development of the children could then be investigated. We assumed that children who performed a greater number of exercises would learn more words and that those words encountered most frequently would also be the words learned best.

Table 1
Scores at pre- and post-test of 5 year olds

	Number of children	Average score (standard deviation)
Pre-test	25	17.28 (6.42)
Post-test	25	26.68 (10.28)

3.2.1. Method

3.2.1.1. Subjects. Thirty children(13 males, 17 females) from two different schools participated in the experiment. These were the same schools as in Study 1. The children were all immigrants: 13 were Turkish, 7 Moroccan, and the other 10 children had 4 different nationalities. The children were in their first year in kindergarten; their average age was 57.3 months.

3.2.1.2. Material. The curriculum-dependent test from Study 1 was again used, and the children used the same story part of the same CD-ROM as the children in the first study.

3.2.1.3. Procedure. The study had a pre-test–training - post-test 1–post-test 2 design. On the basis of the assumption that it would be too difficult for such young children to concentrate for 25 consecutive minutes, it was decided to replace the three times 25 min training from Study 1 by six times 15 min (across a period of 3 weeks). Given the young age of the children, considerable time was also spent during the first session demonstrating how to work with the software. The training during the remainder of the sessions was comparable to that in Study 1.

The first post-test was administered one week after completion of the training; the second post-test one month later.

3.2.2. Results

3.2.2.1. Vocabulary test. A within-subjects repeated measures analysis showed a main effect of Time ($F(2,58)=55.56$, $P<0.001$). The children clearly learned during the training period. Paired samples t-tests showed differences between pre-test versus first post-test ($t(29)=-7.90$, $P<0.001$) and pre-test versus second post-test ($t(29)=-8.32$, $P<0.001$) but not between first and second post-test ($t(29)=-0.30$, $P>0.05$). In Table 2, the average scores and standard deviations for the pre-test and both post-tests are presented.

3.2.2.2. Computer use. The group of 30 children was divided into two groups of 15 children each, based on the number of exercises they performed during the training. The first group performed 32 exercises or less, the second group more than 32 exercises. Learning gain (defined as the percentage of the unknown words at pre-test later learned) was found to depend on the number of exercises performed ($t(28)=-2.15$, $P<0.05$). The average learning gain for the group of children who did the most exercises (0.18) was almost twice as high as the average learning gain for the children who did fewer exercises (0.10). At the same time, we also found that the group of children

Table 2
Scores at pre- and post-tests of 4 year olds

	Number of children	Average score (standard deviation)
Pre-test	30	14.57 (8.63)
Post-test 1	30	20.43 (9.78)
Post-test 2	30	20.57 (9.63)

who did the most exercises scored significantly higher at pre-test than the children who did fewer exercises.

In other analyses, the average number of times a word was encountered by one group of children was compared with the average progress made by the group on that word. On average, a word was seen 3.37 (SD = 2.45) times during training. Based on Robbins and Ehri (1994), who suggest that a word must be encountered on at least four occasions to be learned, the group of 29 words was divided into words seen four or more times during training versus less than four times. Only eight of the 29 words were seen four or more times during training. T-tests showed no relations between the frequency of seeing a word and progress on that word ($t(27) = -1.04$, $P > 0.05$) or the frequency of seeing a word and learning gain ($t(27) = -1.52$, $P > 0.05$).

3.2.3. *Conclusions*

Immigrant children at the kindergarten level of school clearly benefited from the computer-supported vocabulary program. In Study 2, the significant learning gains they demonstrate are found to be still visible one month after training. It is interesting to note that children's learning gains tend to be higher as they performed more exercises on the computer or as they scored higher at pre-test. However, no specific relation was found between the average number of times that a word was encountered during training and the average learning gain for that word in particular. Robbins and Ehri (1994) indicate that a word should be encountered a least four times in order to learn it and also add that four times is probably the minimum. Jenkins, Stein, and Wysocki (1984) found significant learning gains only after a word was offered six times. In Study 2 of this article, only four of the 29 words were encountered six or more times during training. A more elaborate training study is therefore called for to study the effects of viewing frequency on word learning.

4. Discussion

In the present article, we hope to have shown that the construction of a child-friendly computer program at kindergarten level is feasible. Multimedia language programs can be designed to support specific aspects of early literacy and thus for use in a multicultural kindergarten classroom. Talking books also have the potential of enhancing children's story comprehension and vocabulary knowledge. The conceptual knowledge of children "reading" such books develops, and they also gain insight into the narrative structure of stories. It was also shown how multimedia language games can promote insight into the functions and structure of written language. It can be assumed that children's interactions with symbols and word structures within a multimedia environment helps them understand that print carries meaning, that ideas can be expressed with writing conventions, and that written language has a number of functions and meanings.

In the two vocabulary studies we found that the computer support had a positive effect on the vocabulary development of kindergarten children with a minority background. The other parts of the computer program are currently being studied. Based on existing literature and the present studies, we can conclude that multimedia language interventions can produce positive learning effects. It should be kept in mind, however, that such learning effects are strongly related to the computer program being used. The computer-related literacy experiences of young children should involve a balance between open-ended activities and more closed learning activities. The question is just how different task designs affect children's literacy learning and, in this light, a distinction between *educational* versus *edutainment* software may be relevant. In the latter case, any educational considerations are often overruled by the entertainment goal of the software. A great investment is typically made on animation and special effects, which can be very motivating but also distract the child from the educational task. Additional research should be done on the optimal proportion of education and entertainment or, as Druin and Solomon (1996) put it, how much ‘‘edu'' versus ‘‘tainment'' to offer as part of children's so-called ‘‘edutainment''? (p. 69).

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