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ABSTRACT

With the advent of the computer as an instructional tool many curriculum specialists have been designing software for reading instruction. However, most of the software designed to help develop reading comprehension skills does not consider the inclusion of monitoring comprehension strategies, therefore limiting the instructional potential of the new technology as well as the availability of alternate teaching mediums and materials for English as a Second Language (ESL) reading instruction. To investigate the effectiveness of two computer-assisted metacognitive strategies on the development of sequential reading skills of ESL fourth grade students, 68 randomly selected Spanish-speaking students from a public school in a low socioeconomic setting in Puerto Rico were classified in combined language proficiency and reading ability levels and were randomly assigned to one of two treatments. Both treatment conditions used computer-mediated texts as the instructional materials. The Tutorial-Direct Monitoring Strategy (TDMS) consisted of A. S. Palincsar and A. L. Brown's three-step monitoring technique, skill modeling reading texts, and comprehension exercises, whereas the Schema-Direct Monitoring Strategy (SDMS) used reading texts, comprehension exercises, and a monitoring strategy in flowchart form. The results of the study demonstrated significant differences in favor of the TDMS. Findings appear to confirm the literature that suggests that training in metacognitive strategies can enhance reading comprehension performance as well as reading comprehension skills. (Two tables of data are included, and 23 references are appended.) (MS)

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COMPUTER-ASSISTED METACOGNITIVE STRATEGIES AND THE READING COMPREHENSION SKILLS OF ESL ELEMENTARY SCHOOL STUDENTS

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Abstract

This article reports the results of a study on the effectiveness of two computer-assisted metacognitive strategies, the Tutorial-Direct Monitoring Strategy (TDMS) and the Schema-Direct Monitoring Strategy (SDMS), on the sequential reading skills and reading comprehension of ESL fourth grade students.

The population consisted of 68 randomly selected fourth grade Spanish-speaking students from a public school in a low socio-economic setting in Puerto Rico. Subjects were classified in combined language proficiency and reading ability levels and were randomly assigned to treatments.

Both treatment conditions used computer-mediated texts as the instructional materials. The Tutorial-Direct Monitoring (TDMS) Strategy consisted of Palincsar and Brown's three-step monitoring technique, skill modelling reading texts, and comprehension exercises, whereas the SDMS used reading texts, comprehension exercises and a monitoring strategy in flowchart form. Differences between treatments included embedded skill modelling and type of monitoring comprehension strategy. The results of the study demonstrated significant differences in favor of the TDMS.

INTRODUCTION

With the advent of the computer as an instructional tool, many curriculum specialists have been designing software for reading instruction. However, most of the software designed to help develop reading comprehension skills do not consider the inclusion of monitoring comprehension strategies, therefore limiting the instructional potential of the new technology as well as the availability of alternate teaching mediums and materials for ESL reading instruction.

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In addition, the type of text manipulations that have been included in reading computer programs are of the kind that decrease comprehension, such as inserted questions and adjacent to text glosses (Tierney & Cunningham, 1984).

ESL readers tend to exhibit the characteristics of poor first language readers because they are still acquiring reading comprehension skills and strategies in their first language (Bowden et al., 1985). In addition, the second language student cannot rely on previously acquired mastery of the structure of the language such as a native speaker would (Donoghue & Kunkle, 1979). Furthermore, most ESL students lack routine and fall-back strategies needed for self-correction during the reading comprehension process because they have not been trained to do so (Brown, Armbruster, & Baker, 1983). The use of fall-back and routine strategies for self correction has been called comprehension monitoring (Palincsar & Brown, 1984). Comprehension monitoring, in turn, is one aspect of metacognition.

Metacognition refers to the knowledge and self control that individuals have over their own thinking and learning activities (Baker & Brown, 1984; Brown & Deloache, 1978). It consists of two distinct components: awareness of the knowledge possessed in terms of the reading process; and the ability to use self-regulatory mechanisms to ensure text comprehension (Brown, Armbruster & Baker, 1986).

Researchers agree that metacognition plays a vital role in reading (Brown, 1984; Brown et al, 1983; Brown, Armbruster &

Baker, 1986; Flavell, 1986; Markman, 1981). Metacognition in reading comprehension involves the coordination and integration by the reader of four variables: (a) characteristic of text-difficulty, (b) task-goals and purposes of reading, (c) strategies-activities engaged in by learners to understand and recall information, and (d) schemata and prior knowledge (Brown, Armbruster & Baker; 1986; Brown, Bransford, Ferrara & Campione, 1983; Brown, Campione & Day, 1981). The knowledge readers have of each of the above variables will influence the degree to which the readers will be able to coordinate their plans and engage in monitoring strategies. Thus, training in specific comprehension monitoring strategies can improve students reading comprehension skills.

The research reported in this article attempted to investigate the effectiveness of two computer-assisted metacognitive strategies on the development of sequential reading skills of ESL fourth grade students. It also sought to study the interaction between experimental treatments and combined ESL language proficiency and reading levels. Furthermore, this study intended to employ the components that help the reader to interact and construct meaning from the text within a computer-assisted learning environment. The two metacognitive strategies studied were used to encourage the students to recognize specific reading cues, and to monitor their reading comprehension process. The use of the computer attempted to provide a motivating microworld

where students would feel confident and unthreatened when using the target language to learn.

The study sought to answer the following questions:

1. Were there significant differences between the test performance of Treatment A subjects and Treatment B subjects regarding sequential reading skills?

2. Were there significant differences between posttest performance on the Sequential Reading Skills Test when subjects were classified by combined reading and language proficiency levels?

3. Were there significant interactions between the pedagogical interventions in relation to test performance on the Sequential Reading Skills Test when subjects were classified by combined reading and language proficiency levels?

Reading comprehension and metacognition

Reading comprehension is currently viewed as a process by which the reader constructs meaning by interacting with the text (Anderson & Pearson, 1984; Baker & Brown, 1984; Brown, Armbruster & Baker, 1983). The understanding the reader achieves during reading comes from the accumulated experiences of the reader, experiences that are triggered as the reader decodes text. To comprehend the written word, the reader must be able to: (a) understand how the author has structured or organized the ideas and information presented in the text, and (b) relate the ideas and information from the text to information stored in the reader's mind (Anderson & Pearson, 1984; Orasanu & Penney; Palincsar & Brown, 1984). The meaning constructed by the reader

does not come from the text alone; it comes from the reader's own experiences which are activated by the ideas presented by the author (Cooper, 1986). The knowledge and control that readers may have over their own thinking and learning activities have been found to be an important aspect of reading comprehension (Baker & Brown, 1984; Flavell, 1979). The awareness of this knowledge and its control is referred to as metacognition. Flavell defines the term as "one's knowledge concerning one's own cognition process and products" (1979).

Recent emphasis on metacognition has introduced new analysis of the reading process. Awareness about the utility and appropriateness of various actions accompany improvement in reading and may be a causal factor in learning (Paris, et. al.,1981). Strategic behavior implies intentionality and purpose on the part of the reader. Consequently, metacognition, by making readers aware of their process strategies when reading, and helping them to regulate their cognitive activities, provides an active participatory view of the nature of reading and learning.

Cognitive Monitoring

Recent research poses the problem that young children are limited in their knowledge and cognition about cognitive phenomena or in their metacognition, and do little monitoring of their own memory, comprehension, and other cognitive tasks (Cooper, 1986, Flavell, 1979; Mackay & Palmer, 1979; Palincsar & Brown, 1980; Paris et al., 1981; Pressley, Borkowski & Sullivan, 1984). Metacognitive experiences are the conscious cognitive or affective experiences that accompany any intellectual enterprise. Tasks

refer to the objectives of a cognitive task and strategies to the cognition of other behaviors employed to achieve the objective.

In reading, metacognition or metacomprehension appears to include two basic components (Baker & Brown, 1984): (a) awareness of the processes and skills needed to complete a task correctly and to make corrections during the task if needed.

A student's ability to monitor comprehension can be envisioned as a developmental task. Beginning readers seem to be less aware of a lack of understanding when reading than are mature readers (Myers & Paris, 1978). At the same time, however, studies indicate that the ability to monitor comprehension can be taught (Palincsar & Brown, 1984). Cooper (1986) has indicated that much of the emphasis in helping students comprehend has focused on what to do before and after reading, such as using techniques similar to SQ3R. These strategies are helpful, but they do not account for the actual reading process, during which the bulk of a reader's comprehension activity takes place. The teacher cannot assume that comprehension has taken place automatically after reading.

Computer-assisted language learning

The computer is an advanced, sophisticated high technological tool, in itself incapable of action. Its role in education is that of a medium of instruction. In language teaching, the computer, instead of merely presenting material and questions, and processing students' responses, can actually make decisions about the shape and structure of the material to be presented to the student (Ahmad, Corbett, Rogers, & Sussex, 1985).

Furthermore, it guides the student to different parts of the computer-assisted language learning program, or to other activities which do not require the use of the computer. Some researchers consider the computer as an instrument that acts on the environment to produce change, and this change in turn affects the user's performance of a given task (Langer, 1986; Papert, 1980; Turkle, 1985). Papert (1980) believes that children can learn to use computers in a masterful way, and that this particular learning can change the way children learn everything else.

Computer technology is the raw material from which personal educational environments can be made (Lesgold & Perfetti, 1981; Papert, 1980; Boden, 1977; Turkle, 1985). Working with the computer as an expressive medium (such as paint) provides the excitement and feeling of achievement one gets from creating something new reading instruction for children, computers have a three-fold function: (a) as a learning tool, (b) as an educational toy, and as (c) a microworld (Geoffrion & Geoffrion, 1983).

A tool enables a person to perform tasks that otherwise can be awkward. Geoffrion and Geoffrion (1983) view the functionality of tools in terms of their helpfulness and convenience. They suggest that the computer as a learning tool in reading instruction can present text and definitions or other types of instruction simultaneously on the screen, thus eliminating other types of time consuming tasks for the learner such as having to consult the dictionary.

Computers also have the flexibility of becoming toys with which to play. Play is essential to child development as a vehicle for both social and cognitive learning (Turkle, 1985). Computers assume the role of toys by creating environments that allow children to manipulate text in a variety of ways the same manner a child manipulates blocks. A "toy" like the computer could accelerate reading acquisition by providing oppo-tunities to "play" with text.

According to Papert (1980), the computer can create motivating microworlds. Small worlds where children can freely explore are created and recreated by the computer. In reading instruction, children can rearrange topics to suit personal interests and needs by becoming one of the characters in the story and directly influencing its outcome. "In content area reading, students can select more detailed, or more cursory explanation of text segments, depending on their personal reading goal. At present, this type of evironment is nearly impossible to attain through conventional means" (Geoffrion & Geoffrion, 1983).

METHOD

Subjects

The population of the study consisted of 68 randomly selected 4th grade Spanish speaking students from a public school in a low socio-economic setting in Caguas, Puerto Rico. Students were randomly assigned to treatment condition after meeting the selection criteria. The selection criteria for participation in the study included the following: (a) previous participation in a

computer literacy program, (b) average or below average reading ability as measured by the InterAmerican Test of Reading Level I, and (c) average or below average language proficiency as measured by the Language Assessment Battery.

Instruments

The materials used to investigate the effects of the two metacognitive strategies on the reading comprehension performance of the subjects were: (a) the InterAmerican Test of Reading, (b) the Language Assessment Battery, (c) the Sequential Reading Skills Test, and (d) the computer-assisted reading lessons with embedded metacognitive strategies.

In order to control the variables of reading ability and language proficiency the investigator administered the InterAmerican Test of Reading and the Language Assessment Battery. The reading comprehension and language proficiency scores were used to classify students into four distinct subgroups: (a) subgroup 1 included average proficiency , average readers, (b) subgroup 2 included average proficiency below average readers, and (d) subgroup 4 included below average proficiency below average readers .

The Sequential Reading Skills Test was a research instrument constructed by the investigator to determine the student's ability to organize events in sequential order according to the narrative. The test consists of three sequential order exercises. The paragraphs were constructed following the linguistic patterns and the vocabulary from the book New Friends (1986). An item analysis on the SRST was performed to obtain information regarding

item difficulty and discrimination levels. In addition, an estimate of the internal consistency reliability of the test was made from a single administration of the test form using the Kuder-Richardson formula 20. The internal consistency reliability was found to be an estimate of .79 and a standard error of measurement of 1.59. An item analysis revealed an index of difficulty that ranged from .40 to .72 and an index of discriminability that ranges from .40 to 64.

Each experimental treatment consisted of two monitoring comprehension lessons that took five days of instruction to complete. It also included eight reading lessons programmed in the SuperPilot authoring language and used with the Apple IIe micro-computer. Each computer-assisted program lesson included exercises designed to practice sequential order skills. All materials were developed, written, and fieldtested by the investigator.

The software package prepared for Treatment A (Tutorial-Direct Monitoring Strategy) included an adapted version of Palincsar's and Brown's comprehension monitoring strategies. It also included a three-step technique used during the reading process: summarizing, clarifying, and questioning. This computer-assisted reading package also contained modelling of the reading comrehension skill and reminders of the monitoring comprehension strategy throughout the program.

The Schema-Direct Monitoring Strategy consisted of two monitoring comprehension lessons, eight reading comprehension

lessons programmed using the SuperPilot authoring language, and exercises to develop sequential order skills. The SDMS software did not include, in the program design, the modelling and the reminders of the monitoring strategy. Instead, the monitoring strategy was presented to the students in flowchart form. Students had to refer to the flowchart each time a comprehension failure occurred.

In both treatments, students had the final option of consulting with the teacher. The treatments of the study were developed in three phases: (a) an awareness training phase where the students discussed the goals of reading, developed vocabulary and schemata and practiced the monitoring strategy specified for each treatment; (b) the computer-assisted instruction phase where students went to the computer lab for five (50 minute) periods during four weeks; and (c) the computer-assisted postreading phase.

Experimental treatments and procedures

After careful screening of the subjects and sub-group classification, pretesting data were collected. Two structured teacher-training sessions were conducted by the investigator prior to the beginning of the experiment. Key vocabulary and schemata were developed. Pre-reading activities, such as stating the goals and purpose for reading, and presentation and modelling the monitoring skills, took place. Students then began receiving the treatment intervention. All students were scheduled to attend the computer lab in the afternoon. The intervention lasted four weeks totalling 20 fifty minute sessions. At the end of the instruction period, posttesting data were collected.

Analysis

Pre-test data were analyzed for each dependent measure in order to account for group equivalence. Since group differences were found between group means and standard deviations, the data were subjected to a Cochran test. Means and standard deviations for posttest data were obtained and analysis of covariance was used in order to a statistically adjust posttest mean scores for initial differences in pretest performance between groups.

The findings based on pretest data indicate that students under TDMS conditions obtained higher mean scores and standard deviations ($X = 4.09$, $SD = 2.02$). In order to determine whether there were significant mean differences between treatment conditions and subgroups classification. ($x = 4.091$, $SD = 2.58$) a two-way analysis of variance was performed.

A factorial analysis of variance design with two factors, instructional treatments and combined group classification of language proficiency and reading ability level was performed to test the relationships between the sequential reading skill performance and the interaction of treatment conditions. The results of the two way analysis of variance on the pretest scores of the SRST revealed significant differences between means. The results of the analysis of covariance with the SRS pretest scores as covariates are summarized on Table 2.

Examination of the $\underline{F}$ ratio for SRS posttest scores presented on Table 2 indicates a significant difference between treatments ($F = 69.72$ at the .001 level of significance). In addition, a

a closer study of Table 2 reveals an F ratio of 8.13 significant at the .001 level for the SRS posttest scores of subjects classified by subgroups. This indicates significant mean differences between subjects' posttest scores classified by a combination of language proficiency and reading ability levels.

Furthermore, the F ratio reported on Table 2 for the SRS posttest scores by treatment condition and subgroup classification demonstrates a significant difference between means (F = 2.89 at the .05 level of significance). Consequently, significant interaction between experimental treatments and group classification was found.

Table 1 summarizes the means and standard deviations of pretest and posttest data for all subgroups of students performance under both treatment conditions.

Table 1

Means and Standard Deviations of Pretest and Posttest Scores of the Sequential Reading Skills Test by Treatment Condition and Subgroup Classification.

Subgroups	N	Pretest		Posttest	
		X	SD	X	SD
TDMS	35	4.09	2.58	6.94	2.86
1	7	6.00	2.16	9.86	1.68
2	6	4.67	2.50	7.67	2.16
3	11	3.73	2.37	6.82	2.36
4	11	2.91	2.59	4.82	2.64
SDMS	33	3.70	2.02	4.94	1.84
1	13	4.46	2.50	5.85	2.04
2	6	4.17	1.83	5.17	1.83
3	7	3.14	1.35	4.57	1.13
4	7	2.43	.98	3.43	.98

Note 1 = average language proficiency and average reading ability; 2 = average language proficiency and low reading ability; 3 = below average language proficiency and average reading ability; 4 = below average language proficiency and below average reading ability.

Table 2

Summary of the Analysis of Covariance for the SRS Posttest Scores by Treatment Conditions and Subgroup Classification with the SRS Pretest Scores as Covariate

Source of Variation	Sum of Squares	df	Mean Squares	F
Covariate Pretest Scores	335.741	1	335.741	424.30
Main effects Treatments	55.170	1	55.170	69.72
Subgroup	19.303	3	6.434	8.13
Treatment x Subgroups	6.860	3	2.287	2.89
Explained	407.255	8	50.907	64.34
Residual	46.686	59	0.791	
Total	453.941	67	6.775	

Note: $p < .05$ $p < .001$

CONCLUSIONS

The findings of this study confirm the body of literature suggesting that training in metacognitive strategies can enhance reading comprehension performance (Baker & Brown, 1980; Baker & Stein, 1978; Brown et al., 1986; Brown & Campione, 1978) as well as reading comprehension skills such as recalling and sequentially organizing events in the narrative.

The findings of this study also substantiate Reinking's and Schreiner's (1986) contention that the unique techonological attributes of computers can combine to affect cognitive processes during reading. By using software to control the presentation of text and by providing greater interaction between reader and text, computer-mediated text may influence reading comprehension. Further support for the use of computer-assisted reading instruction stems from the finding of significant interaction between treatments and classification of subjects by combined levels of language proficiency and reading ability.

EDUCATIONAL IMPLICATIONS

The results of this study can have practical implications for ESL teachers, curriculum developers, and reading instructors.

1. The use of the computer as a medium of instruction enables students to work at their own pace while acquiring metacognitive skills. Students discover processes and ways in which to attain mastery of the reading skills.

2. The flexibility and adaptability of the computer technology allow students to recreate situations, repeat tasks and manipulate their own learning process.

3. Computer-aided reading instruction can promote comprehension when metacognitive strategies are programmed into software.

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