

Hypermedia CAI and Precision Teaching: An Exploratory Study

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The purpose of this study was to monitor the effect of a hypermedia computer-assisted instruction (CAI) software program on the development of letter recognition skills of kindergarten students. Experimental ($n = 18$) and control ($n = 19$) students participated in the ABC study and received group instruction on three target letters, one letter presented per week. In addition, experimental students worked with the hypermedia computer software letter recognition lessons. Student letter recognition performance was monitored through probe sheets administered across three phases. During baseline (A), students completed probes of animal figures and a letter previously taught. During intervention (B), students completed probes of the letter presented each week, and during maintenance (C), students were retested on probes presented during intervention. Although overlap in performance among experimental and control students existed, (a) experimental students demonstrated improved levels of letter recognition as compared to their control peers, (b) low performing students in the experimental classroom demonstrated greater gains in overall performance levels from intervention to maintenance as compared to their control peers, and (c) student and group changes in celeration rates were similar in degree across experimental and control classrooms.

Knowledge of letter names has been identified as a predictor of first year reading achievement (Bond & Dystra, 1967; Chall, 1983; Tunmer, Herriman, & Nesdale, 1988). Moreover, fluency in letter recognition skills has been cited as a predictor of the acquisition of reading skills among beginning readers (Blachman, 1984; Ehri & Wilce, 1979; Speer & Lamb, 1976). Students who are slow to recognize and name letters experience difficulty in learning letter sounds (Ehri & Wilce, 1979) and have difficulty in recognizing words (Mason, 1980).

One instructional approach that is receiving increased attention is computer-assisted instruction (CAI). CAI has been found to enhance literacy and prereading skills (Fein, 1987; Gore, Morrison, Maas & Anderson, 1989) and self-confidence (Hyson, 1985) in normally developing preschool and kindergarten children. Additionally, CAI offers the flexibility to individualize and pace instruction as needed and the ability to provide opportunities for repetitive practice in challenging formats (Allen-Watson, Chadwick, & Brinkley, 1986).

Hypermedia, a specially designed computer environment, provides a flexible format for adapting materials and allows children to access information by means of a simple selection process. When working with a program

developed through a hypermedia environment, children can select images or buttons on a screen to expose additional information in the form of pictures, letters, words, and sounds. (See Higgins & Boone, 1990, for a description of the hypermedia environment and its application to instructional practice.)

This study investigated the effect of the use of hypermedia CAI on the acquisition of letter recognition skills of kindergarten students. This study was part of an investigation centered on the development and testing of state of the art microcomputer software designed to aid students with disabilities and other students considered at-risk, in the acquisition of successful pre-reading skills in general education kindergarten settings. (See Higgins, Boone, Notari, and Stump (under review), for a complete description of that investigative study.) The purpose of this study was to monitor and compare experimental and control students' letter identification skills through the application of hypermedia software lessons and Precision Teaching techniques.

Method

Subjects

Students enrolled in two general education kindergarten classrooms located in a suburb of Seattle, Washington, were involved in the study:

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18 students in an experimental classroom and 19 in a control classroom. There were 10 boys and 8 girls in the experimental classroom and 10 boys and 9 girls in the control classroom. Most children were Caucasian, except for four students, two in each classroom, who were African-American. Socio-economic status and IQ information were not available from the school district.

Teachers classified students as high, medium, and low performers based on classroom observations. Additionally, the experimental teacher indicated that two of her students were considered at risk for referral to special education. The district defined students considered at risk for referral to special education, as those who scored at or below the 25th percentile on a district-developed prereading test. The teachers in both the experimental and control classrooms had been teaching kindergarten for five years.

Materials

Basal Reader

The *Macmillan Basal Reader Series-R* (1983) was the adopted text for the participating school district. This series provided a comprehensive curriculum in kindergarten for the instruction of letter identification. Hypermedia CAI lessons were developed for each letter of the alphabet based on the curriculum presented through the basal series. The hypermedia lessons made use of the same pictures and examples that were presented by the teacher using the Macmillan instructional materials.

Computer Equipment

Two Apple Macintosh Plus computers with external 3.5 inch disk drives were used in the experimental kindergarten classroom. Students operated all computer functions through the mouse, a hand-held input device. Keyboards were not attached to the computer.

HyperCard

HyperCard (Atkinson, 1987) from Apple Computer is a combination operating system and authoring environment for the Macintosh computer. It was the development system for the software used in this research.

Hypermedia CAI Lessons

Hypermedia allows students to access information through the selection or clicking on images or buttons on the screen. Through selection, additional information may be presented as digitized speech, graphic representations, animated sequences, text or a combination of these modes

Baseline Probe Sheets

Two sets of baseline probe sheets were created. One set consisted of an average of 100 drawings of animal figures familiar to the children randomly placed on a page. The target animal was a mouse, with pigs, giraffes, bears, and squirrels serving as distractors. Five forms of this sheet were created, one for each experimental day..

The second set of baseline probe sheets was composed of upper and lower case H. The letter H had been previously presented to students. These sheets were similar to a worksheet with which the students were already familiar and that was used regularly in the classroom. An average of 60 target letters and 70 distractor letters were randomly presented on a page. Distractor letters were selected using the following guidelines: one letter which looked like the target (e.g., K for target H), one that was less similar in appearance (e.g., E for target H), and one that was shaped significantly different from that of the target (e.g., S for target H). Five sheets, one per experimental day, were created.

Intervention and Maintenance Probe Sheets

Probe sheets similar to those used in baseline were created for the target letters (i.e., R, S, and T) introduced during intervention, one letter per week. Three forms of the probe sheets were created for each of these letters. The distractors letters were: (a) P, N, and A for R, (b) C, F, and M for S, and (c) B, C, and M for T. These same sheets were also used during the maintenance phase.

Design and Procedure

A single-subject ABC design was selected. The study began with a baseline phase (A), which

lasted two weeks. During the first week of baseline (A1), students responded to the animal probe sheets, and during the second (A2), students completed probe sheets presenting the letter H. Next, the intervention phase (B) was in effect for a period of three weeks, with one target letter introduced each week. Each week, students completed three probe sheets of the week's letter. The maintenance phase (C) lasted three weeks and reassessed the three letters that were introduced during the intervention phase. Students completed three probe sheets per letter, one letter per week. There was a one week break between the intervention and maintenance phases due to spring vacation at the school. In all, the study lasted for a period of nine weeks.

Baseline (A1): Animals

The objectives of this first week of baseline were to evaluate students' skill in identifying and circling a familiar image (i.e., a mouse), to assess motor ability, and to familiarize students with the probe activity. Students were shown an enlarged picture of the mouse figure and told that they had a short time (30 seconds) to circle as many as they could on their probe sheets. Papers were collected, with the number of correct and incorrect circled items counted and recorded. This activity was repeated each day, for a one-week period.

Baseline (A2): H

The objective of this second week of baseline was to assess students' skill in identifying and circling the letter H. The letter H had been previously presented to students. Administration and scoring procedures matched Baseline A1: Animals. This phase lasted five days with a different form of the probe sheet completed each day.

Intervention (B)

General procedures. During the next three weeks, the letters R, S, and T were introduced and presented by the control and experimental teachers, one letter per week. The purpose of this phase was to monitor students' skill in identifying and circling target letters before and after instruction. The teachers' existing instructional schedules were not altered during this phase. The letter of the week was introduced on Monday during group instruction which lasted approximately 10 to 20 minutes.

Teachers introduced the letter on the chalkboard and made its sound, followed by students naming words that contained that letter sound. These student-generated words were written on the board and the target letter highlighted. A chalkboard task, mirroring the format of the probe sheets, was completed with individual students circling the target letters found on the chalkboard. Worksheets of this same format were then completed individually by the students. During two days of the week, students worked at centers, one of which presented a letter-of-the-week activity. The letter probe sheets were added to this existing instructional sequence in the following manner.

Control classroom. In the control classroom, students completed a probe sheet on Friday for the letter that was to be presented during the upcoming week. On Monday before group instruction, another probe sheet was completed. Following group instruction, students completed the third and final probe of the week. Thirty seconds was provided each time for completing the probe sheets.

Experimental classroom. Students in the experimental classroom completed the same three probe sheets per letter. In addition, they worked on the hypermedia CAI lesson designed for each letter. Experimental students were assigned to two groups: *before-instruction* and *after-instruction*. The *before-instruction* group worked with the CAI lesson prior to group instruction and completed: (a) a probe before working on the computer (Friday), (b) another probe following work on the computer (Friday), and (c) the final probe following group instruction (Monday). The *after-instruction* group observed the following schedule: (a) a probe before instruction (Friday), (b) another probe following group instruction (Monday), and (c) the final probe after working with the computer (Monday).

Maintenance (C)

The maintenance phase was designed to assess any changes in fluency that occurred following a three-week lapse of instruction on the target letters. This phase began one week following the last intervention week due to spring break at the school. During the maintenance phase, teachers introduced new letters with no review

of the target letters. During the first week of maintenance, probes for the target letter R were re-administered in random order on Monday, Wednesday, and Friday, one probe per day. Students were allowed 30 seconds to complete the activity. Papers were collected and scored for the number of correct and incorrect responses. During the second week of maintenance, the probes for the target letter S were re-administered, and the probes for the target letter T were used on the third week of this phase.

Results

Outcomes from this intervention were analyzed in primarily three ways: visual inspection, level of performance, and celeration rates. Incorrect frequency data were dropped from all analyses because more than 90% of the students made zero errors when completing the probe sheets.

Visual Inspection

All student data were plotted on Standard Celeration Charts and inspected. Visual inspection of the Charts revealed: (a) great overlap between the performance of the two experimental groups (e.g., *before-instruction* and *after-instruction*), preventing drawing of conclusions associated with instructional sequences, and (b) variability in performance within and across letters in control and experimental groups. To illustrate these patterns, charts of the two experimental low performers identified as at-risk for special education referral and the charts of two randomly selected low-control group students are displayed in student Charts (4).

Control Student 1 demonstrated similar median levels of performance on the baseline probe sets and her greatest intervention change when working with the letter S. She demonstrated higher median levels during maintenance for letters S and T as compared to intervention levels. Control Student 2 demonstrated the overall lowest levels of performance of the group of students' whose Charts are displayed. His performance during the maintenance phase revealed more upward trends as compared to his intervention phase, although his median levels of performance during both the intervention and

maintenance phases did not exceed those of the baseline phases.

Experimental Student 1 generally demonstrated accelerating performance patterns across all phases. Her median intervention performance level for letter S and for all maintenance phases surpassed her baseline performance levels. This student also demonstrated improved median performance for intervention to maintenance. Experimental Student 2 demonstrated low levels of performance during the baseline phases and "bouncy" performance during the remaining phases. However, all of his maintenance median levels surpassed baseline levels of performance.

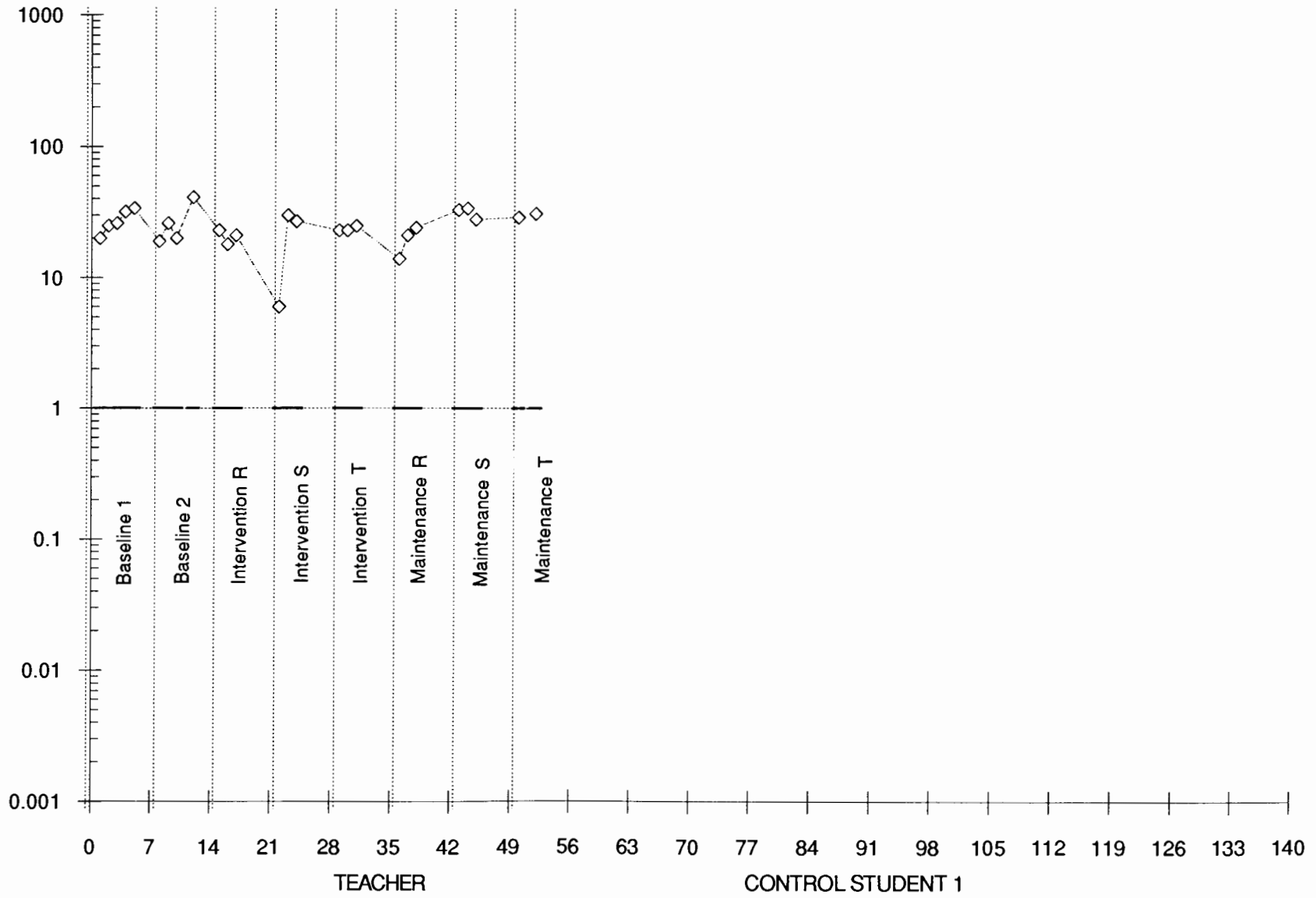
In order to discern patterns related to group performance, overall comparisons were made. Levels of performance and celeration rates were calculated and compared.

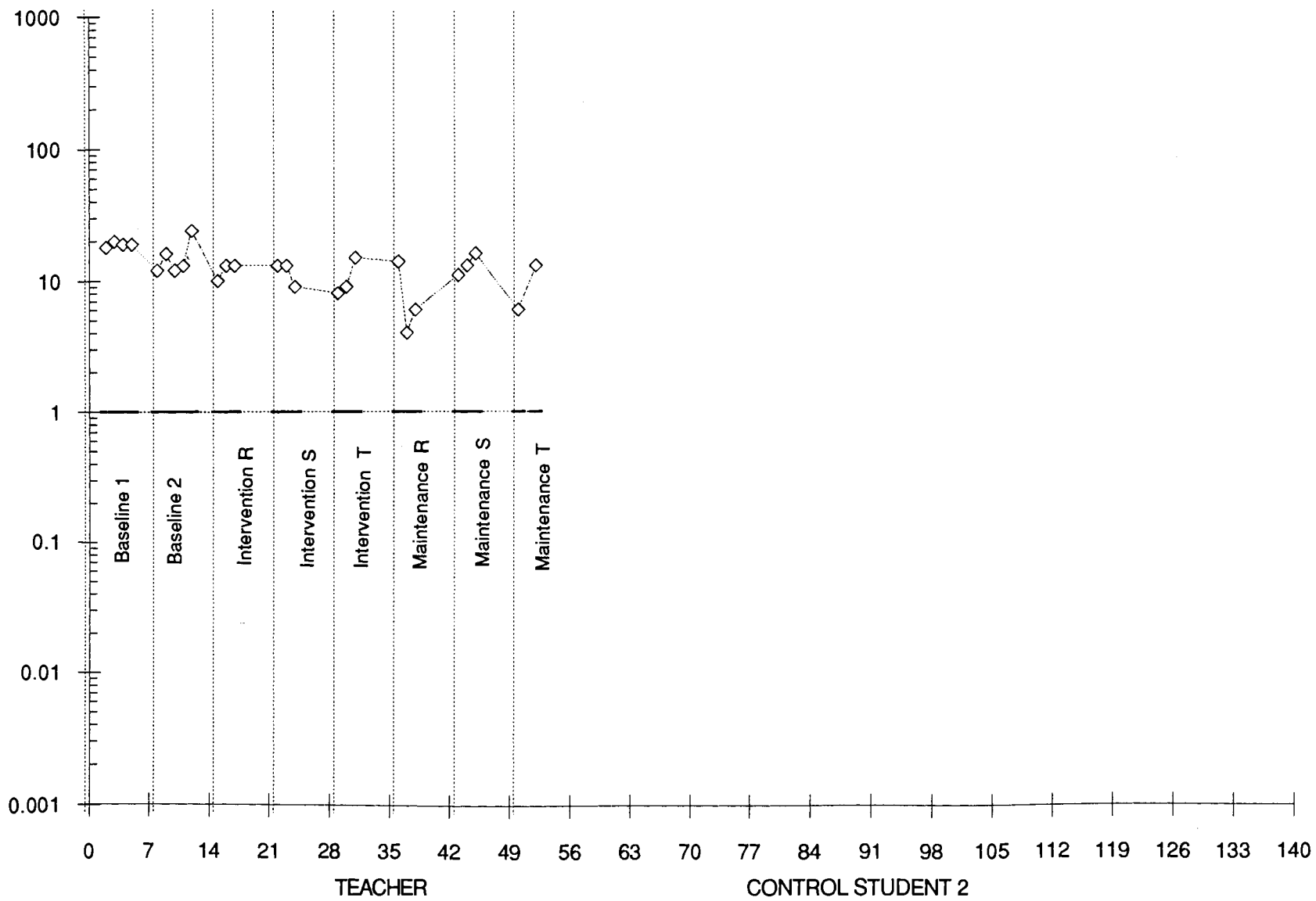
Level of Performance

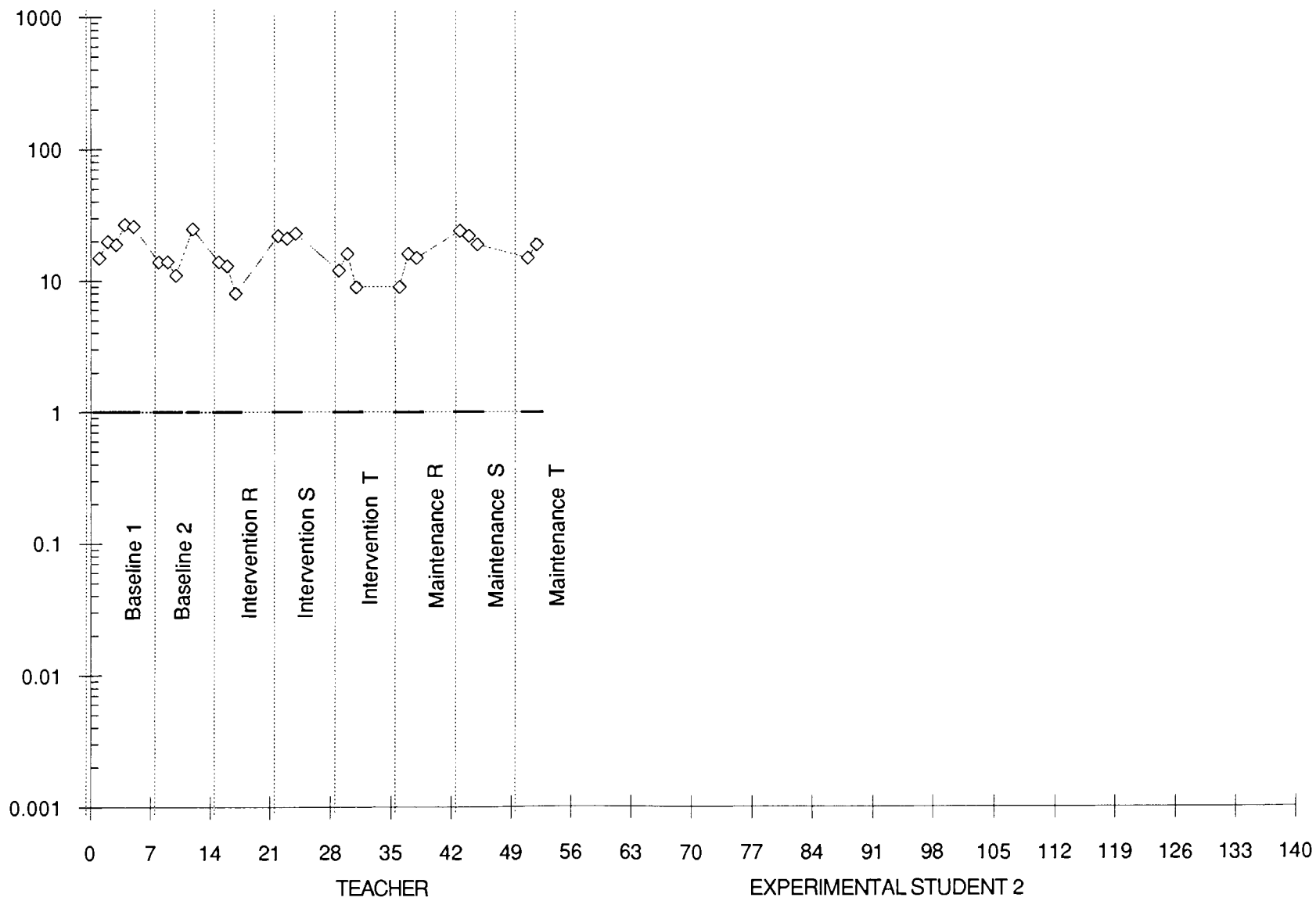
Performance levels compared to baseline.

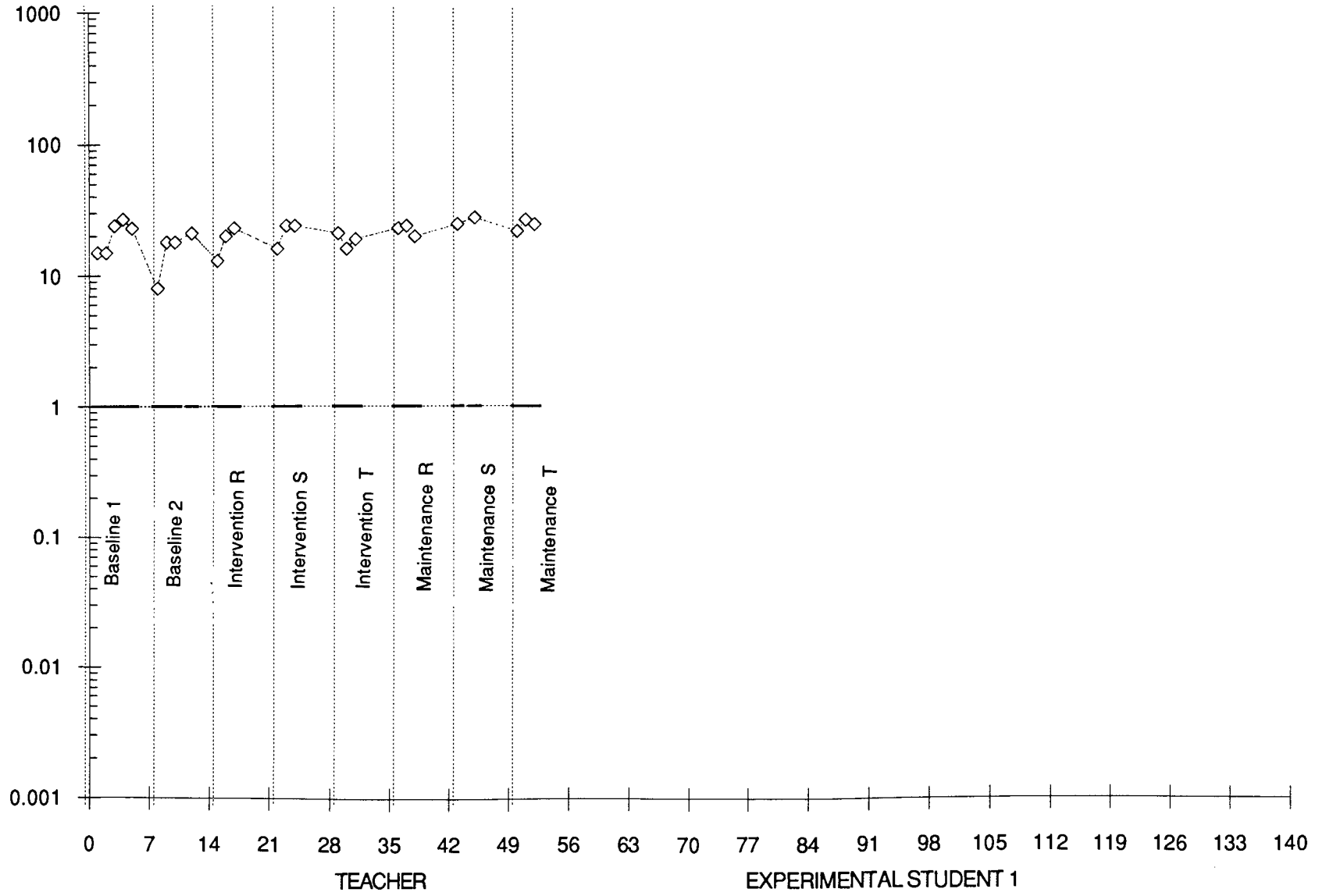
Median levels of performance were calculated for each student for each phase of the study. The median levels for the classes, and then for the three ability groups (i.e., high, medium, and low performers) were calculated per phase. Further, the mean of the median performance levels for the baseline phase components was found by averaging the levels indicated for A1 and A2. This average baseline performance level was used as a comparison point. As shown in Table 1, average group performances of 22 (experimental) and 25 (control) correct responses were indicated for baseline.

During intervention, the overall experimental group surpassed its average baseline level of performance for the letters S and T; the control group failed to reach or surpass its baseline level during intervention. As for maintenance, the overall experimental group reached or exceeded its baseline level for the letters S and T, as did the control group.









Subgroup performance also indicated changes in level. Medium and low group experimental students surpassed their baseline performance during intervention and maintenance phases: medium group for letters S and T during both

phases, and the low group for letter S during intervention and R, S, and T during maintenance. Low performers reached or surpassed their baseline performance levels for letters S and T during maintenance.

Table 1

Median (Range) Performance Levels per Phase

	Baseline			Intervention			Maintenance		
	Mean	A1	A2	R	S	T	R	S	T
Experimental									
Overall		24	20	20	24	23	20	27	28
N=18	22	(15-42)	(14-27)	(12-27)	(19-39)	(12-43)	(13-34)	(19-40)	(15-43)
High		28	25	21	28	26	22	31	35
N=6	27	(15-42)	(15-27)	(12-27)	(19-39)	(21-43)	(16-34)	(19-40)	(28-43)
Medium		26	20	20	24	26	20	27	27
N=7	23	(20-39)	(16-27)	(14-22)	(19-32)	(15-29)	(13-30)	(21-36)	(15-35)
Low		22	17	16	22	19	20	22	25
N=5	20	(18-24)	(14-21)	(13-20)	(19-24)	(12-25)	(15-23)	(20-30)	(16-29)
Control									
Overall		26	23	19	22	22	20	25	28
N=19	25	(13-41)	(13-32)	(8-26)	(7-36)	(9-37)	(5-31)	(7-41)	(10-40)
High		27	27	21	22	29	23	27	27
N=9	27	(17-41)	(15-32)	(13-26)	(18-36)	(21-37)	(23-41)	(16-31)	(23-40)
Medium		27	21	16	17	16	20	16	NA
N=5	24	(14-28)	(12-25)	(8-21)	(7-30)	(8-29)	(5-25)	(7-25)	
Low		21	21	13	22	20	18	21	22
N=5	21	(19-27)	(13-23)	(13-21)	(13-27)	(9-33)	(5-21)	(13-33)	(10-30)

Performance levels: Intervention to maintenance. Experimental and control group gain scores across intervention and maintenance phases were calculated for each letter to evaluate the level of letter recognition students maintained three weeks following instruction. This was completed by first determining the gain score of individual students for each letter from intervention to maintenance phases. This was found by subtracting the median intervention level of a letter from the median level for that letter during maintenance. For example, the median rate for letter R for an experimental student during intervention was 21 and 24 during maintenance. This resulted in a gain score of 3 for the letter R for that student. These individual gain scores per letter were then averaged for experimental and control groups and for the three subgroups within each classroom setting. Analyses for the medium-control group were limited due to lack of data for the letter T during the maintenance phase; only 1 of the 4 students completed the

maintenance probe sheets. Gain scores are reported in Table 2.

Group gain scores were: (a) 2.94 for experimental and 1.95 for control for the letter R, (b) 2.00 for experimental and 2.26 for control for the letter S, and (c) 3.56 for experimental and 1.64 for control for the letter T. For two of the three letters, the experimental group demonstrated greater gains from intervention to maintenance.

Differences were noted in subgroup performance. The most notable differences in gains were indicated for the low performing groups. Experimental low group students demonstrated greater gains for all three letters as compared to control students. Gain scores for the low performers were: (a) 3.60 for experimental and 0.80 for control for the letter R, (b) 2.40 for experimental and 0.50 for control for the letter S, and (c) 3.40 for experimental and 0.25 for control for the letter T.

Performance Level Gain Scores

	Experimental			Control			
	R	S	T	R	S	T	
Overall	+2.94	+2.00	+3.56	+1.95	+2.26	+1.64	
High	+4.17	+1.17	+4.10	+3.11	+5.22	+2.43	
Medium	+1.43	+2.43	+3.29	+1.00	-1.30	NA	
Low	+3.60	+2.40	+3.40	+0.80	+0.50	+0.25	

Celeration Rates

Celeration rates compared to baseline. As with performance levels, celeration rates were calculated for each phase (i.e., last correct data point divided by the first correct data point for A1 and A2, and for each letter during intervention and maintenance phases) for each student. Next, these were averaged across groups. Finally, mean celeration rates for the baseline phase were found by averaging performance across A1 and A2. These average celeration rates were then used as a comparison point. One outlier (x24.00) was noted in the

medium performing control group for letter S and resulted in analysis including and excluding the data point. Outcomes are presented in Table 3.

The baseline rate for the overall experimental group was not surpassed during any other phase of the study. The baseline rates for the overall control group were surpassed during the intervention phase for letter S when the outlier was included; when the outlier was removed, the overall celeration was x1.11 and therefore,

did not surpass the baseline average. For the subgroups, the experimental students surpassed their baseline rates during the intervention phase for letters R and S, and the medium group surpassed their baseline performance during intervention for letter T. The medium control group students surpassed their baseline performance during intervention for letter S when the outlier was included, but when the outlier was removed, the students achieved an average rate of $x1.19$ and did not surpass their baseline average. Low performing students surpassed their baseline performance during the intervention for letter S.

Celeration rates: Intervention to maintenance.

Individual student celeration rates between intervention and maintenance were calculated for each letter (i.e., last correct data point for the letter during intervention). These rates were then averaged across total groups and subgroups for experimental and control classrooms. As reported in Table 4, celeration rates per letter were: (a) $x1.41$ for experimental and $x1.19$ for control for letter R, (b) $x1.25$ for experimental and $x2.43$ ($x1.23$ excluding the one data point) for control for letter S, and (c) $x1.35$ for experimental and $x1.30$ for control for letter T.

Subgroup celeration rates per letter varied greatly among letters and performance groups. For high performers, the experimental group demonstrated similar, but somewhat higher rates for all three letters as compared to their control peers. Medium control performers achieved greater rates for the letter S as compared to their experimental peers. When excluding the outlier data point, however, the medium performing control group demonstrated a celeration rate of $+1.16$ for the letter S from intervention to maintenance, which was lower than the experimental group's rate of $x1.28$.

In an attempt to more clearly understand the patterns of celeration performance across intervention to maintenance, individual students' performance rates per letter were classified as indicating improved, same, or worsened performance. A celeration rate between $+1.24$ and $x1.24$ was considered as *same*, celeration rates of $+1.25$ or less as *worsened*, and celeration rates of $x1.25$ or greater as *improved*. Student performance status classification is reported in Table 4.

Overall, (a) 56% of the experimental and 37% of the control students were classified as *improved* for the letter R, (b) 44% of the experimental and 32% of the control were classified as *improved* for the letter S, and (c) 50% of each of the experimental and control groups were classified as *improved* for the letter T. A greater percentage of control students were classified as *worsened* for letters R and S as compared to the experimental students.

As for subgroups, one student in the high-experimental group was classified as *worsened* for the letter R; all other students were classified as either *improved* or as *same* for all letters. A range of 11 to 40% of control medium and low performing students were classified as *worsened* for the letters R and S. However, results indicated that the majority of students maintained or improved their fluency performance from intervention to maintenance.

Discussion

Outcomes from these analyses suggest that, although there was overlap in graphed patterns, there were differences in performance among experimental and control students. Differences were noted for both levels of performance and celeration rates.

Level of Performance

During the baseline phase, the control group demonstrated slightly higher levels compared to the experimental students. However, during intervention, the experimental students demonstrated similar or higher levels of performance as compared to the control students. Additionally, experimental students surpassed their baseline performance level in more instances than the control students.

In terms of overall gains in performance levels from intervention to maintenance, the experimental students generally demonstrated greater gains in performance as compared to their control peers. The most dramatic difference was noted for the low performing subgroups.

Table 3

Average 'Celcratation Rates (Range) per Phase

	Baseline			Intervention			Maintenance		
	Mean	A1	A2	R	S	T	R	S	T
Experimental									
Overall		x1.46	x1.21	x1.26	x1.20	x1.18	x1.17	x1.00	x1.12
N=18	x1.33	(+1.47/ x2.17)	(+1.35/ x2.63)	(+1.75/ x2.00)	(x1.00/ x1.56)	(+1.33/ x2.08)	(+1.32/ x1.62)	(+1.37/ x1.20)	(+1.20/ x1.36)
High		x1.41	+1.03	x1.27	x1.21	x1.07	x1.17	x1.04	x1.05
N=6	x1.19	(x1.12/ x1.63)	(+1.35/ x1.41)	(+1.25/ x1.56)	(x1.00/ x1.44)	(+1.09/ x1.19)	(+1.06/ x1.55)	(+1.20/ x1.16)	(+1.14/ x1.25)
Medium		x1.32	x1.47	x1.17	x1.17	x1.16	x1.39	x1.13	+1.01
N=7	x1.32	(+1.47/ x2.17)	(+1.05/ x1.65)	(+1.10/ x1.67)	(x1.04/ x1.56)	(x1.10/ x2.08)	(+1.32/ x1.33)	(+1.16/ x1.16)	(x1.20/ x1.36)
Low		x1.56	x1.51	x1.65	x1.38	x1.24	x1.03	x1.25	+1.04
N=5	x1.56	(x1.38/ x1.73)	(+1.06/ x2.63)	(+1.75/ x2.00)	(x1.05/ x1.50)	(+1.33/ x1.24)	(+1.25/ x1.62)	(+1.37/ x1.20)	(x1.07/ x1.27)
Control									
Overall		x1.42	x1.13	x1.71	x1.15	x2.44	x1.25	x1.25	x1.01
N=19	x1.42	(+2.63/ x1.70)	(+2.22/ x3.00)	(+1.82/ x1.56)	(+2.00/ x24.00)	(+1.22/ x1.88)	(+1.14/ x1.82)	(+1.54/ x1.45)	(+1.18/ x2.17)
High		x1.37	x1.18	1.55	x1.15	+1.06	x1.15	x1.22	x1.00
N=9	x1.37	(x1.00/ x1.52)	(+1.23/ x2.16)	(+1.19/ x1.47)	(+1.56/ x1.29)	(x1.00/ x1.29)	(x1.00/ x1.80)	(+1.56/ x1.21)	(+1.18/ x1.24)
Medium		x1.39	+1.06	x1.93	x1.14	5.75	x1.31	x1.18	+1.04
N=5	x1.39	(+2.63/ x1.33)	(+2.22/ x3.00)	(+1.82/ x1.56)	(+1.10/ x24.00)	(+1.22/ x1.71)	(+1.04/ x1.82)	(+1.56/ x1.17)	NA
Low		x1.52	x1.22	x1.77	x1.15	x1.70	x1.32	x1.36	x1.06
N=5	x1.52	(+1.08/ x1.70)	(x1.05/ x2.16)	(+1.10/ x1.38)	(+2.00/ x4.50)	(x1.09/ x1.88)	(+1.41/ x1.71)	(+1.54/ x1.45)	(x1.07/ x2.17)

Table 4

Acceleration Rates and Status

<i>Experimental</i>	<i>R</i>			<i>S</i>			<i>T</i>					
	Rate	I	S	W	Rate	I	S	W	Rate	I	S	W
Overall N=18	x1.41	10 56%	7 39%	1 6%	x1.25	8 44%	10 56%	0 0%	x1.35	9 50%	9 50%	0 0%
High N=6	x1.46	4 67%	1 17%	1 17%	x1.18	1 17%	5 83%	0 0%	x1.22	2 33%	4 67%	0 0%
Medium N=7	x1.25	3 43%	4 57%	0 0%	x1.28	4 57%	3 43%	0 0%	x1.50	4 57%	3 43%	0 0%
Low N=5	x1.57	3 60%	2 40%	0 0%	x1.31	3 60%	2 40%	0 0%	x1.30	3 60%	2 40%	0 0%
<i>Control</i>	<i>R</i>			<i>S</i>			<i>T</i>					
	Rate	I	S	W	Rate	I	S	W	Rate	I	S	W
Overall N=19	x1.19	7 37%	10 53%	2 11%	x2.43	6 32%	9 47%	4 21%	x1.30	7 50%	7 50%	0 0%
High N=9	x1.34	5 56%	4 44%	0 0%	x1.10	3 33%	5 56%	1 11%	x1.21	3 33%	6 67%	0 0%
Medium N=5	x1.03	1 20%	3 60%	1 20%	x4.57	1 20%	2 40%	2 40%	NA	NA	NA	NA
Low N=5	x1.09	1 20%	3 60%	1 20%	x1.77	2 40%	2 40%	1 20%	x1.46	4 80%	1 20%	0 0%

Note: I=Improved; S=Same; W=Worsened

Celeration Rates

Generally, celeration rates for the two groups of students failed to reach those levels established during baseline. This outcome may be linked with the fact that baseline data were collected on five consecutive days for each probe set (i.e., A1 and A2) and that the baseline probes presented familiar animal figures and a letter previously presented to students. It may be that students required more opportunities to work with the target letters and their related probe sheets to develop fluency; the students may have been at the acquisition level of learning during the study.

Comparisons across intervention and maintenance celeration rates were less clear than for levels of performance. The experimental students demonstrated greater, although modest, positive changes in celeration rates across intervention and maintenance for the individual letters as compared to their control peers.

Classification of celeration rates as *improved*, *same*, or *worsened* performance indicated that the majority of students in both classrooms either improved or maintained their performance rates from intervention to maintenance. However, a greater number of medium and low performing students in the control group were classified as worsening, when compared with their experimental peers.

Together, these outcomes provide support for the use of hypermedia CAI software lessons with students striving to gain letter recognition skills. Students who worked with the software lessons demonstrated similar or enhanced performance patterns compared with their control peers. Use of the CAI lessons appeared to most positively impact the level of performance achieved by students, especially that of the low performers. Low performing experimental group students demonstrated gains from intervention to maintenance, and the majority demonstrated improved performance patterns for letters S and T.

One unique feature of the arrangement of the CAI intervention was that student work with the computer did not require the teacher to restructure her existing instructional sequence or schedule. Students independently took turns

working on the computer during station time. The computer lessons provided students with one additional, and novel, means for interacting with the target letters. It may be that additional opportunities to work with the computer lessons would result in enhanced student performance; time was only allowed for experimental students to work through the computer lesson one time for each letter.

This study offers a beginning point for investigating the application of hypermedia CAI with students developing reading-readiness skills. The providing of CAI in the general education classroom may prove to be another viable tool in supporting low performing students and students with disabilities in general education settings. Data from this study indicate that the software lessons most dramatically impacted the performance of low performers.

Further research is needed to investigate the impact of the availability of technology on the performance patterns of young children. The inclusion of computer technology, and in this case, hypermedia CAI, offers a new avenue for assisting students in developing beginning reading skills.

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