The Effect of Active Student Responding during Computer-Assisted Instruction on Social Studies Learning by Students with Learning Disabilities

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An alternating treatments design with a best treatments phase was used to compare two active student response (ASR) conditions and one on-task (OT) condition on the acquisition and maintenance of social studies facts during computer-assisted instruction. Each week for six weeks, five students were provided daily computer-assisted instruction on 21 unknown facts divided randomly into Clicking-ASR (active responses with computer mouse), Repeating-ASR (active oral responses) or Listening-OT (on task or passive responses). For all five students, Repeating-ASR resulted in more facts correct on same-day, next-day, and one-and two-week maintenance tests. During weeks 7 and 8 with implementation of the best treatment condition, Repeating-ASR produced higher scores than all conditions (including Repeating-ASR) during the first 6 weeks.

Technology has established itself as an integral part of special education over the past several decades. With ongoing research on effective practices, technology holds great promise for contributing to the quality of education for students with disabilities. Some see technology as the great equalizer among students with and without disabilities (Roblyer & Edwards, 2000) because its use allows many students with disabilities increased access to the general-education curriculum.

Computer-assisted instruction (CAI), in particular, has potential for playing a critical role in the education of students with disabilities. Computer-assisted instruction can be defined as the use of the computer in the delivery of instruction including presenting new information and providing practice (Newby, Stepich, Lehman, & Russell, 1996). There exists a growing body of literature that documents the benefits of CAI use with students with disabilities (Irish, 2002; Raskind & Higgins, 1998; Smith, 2000). When used properly, CAI can create more opportunities for students to participate in learning, increase academic learning time, meet a wide range of student needs, and motivate student learning (Becker, 1992; Vockell, 1987). Computer-assisted instruction has been shown to yield higher motivation, produce fewer behavior problems, and increase attending behaviors (Chen & Bernard-Opitz, 1993; Ford, Poe, & Cox, 1993; MacArthur, Haynes, & Malouf, 1986; MacArthur, Haynes, Malouf, Harris, & Owings, 1990). Computer-assisted instruction has also been shown to increase academic achievement (e.g., Din, 1996; Koscinski & Gast, 1993; Ota & DuPaul, 2002; Shiah, Mastropieri, Scruggs, & Mushinski-Fulk, 1995). Multimedia-based CAI (i.e., interactive computer program, video captions, and still photographs) has also shown to increase fluency of skills learned (Lancaster, Schumaker, & Deshler, 2002; Mechling & Gast, 2003; Mechling, Gast, & Langone, 2002). Some suggest that CAI is effective when it is used as a supplement to traditional instruction, whereas the effects of CAI as a replacement to traditional instruction are equivocal (Hall, Hughes, & Filbert, 2000). These equivocal results suggest there is still much to be learned about CAI, in particular, the characteristics of effective instructional design.

This study was designed to investigate the role of a*ctive student response* (ASR) in the design of CAI. An active student response is an observable, measurable student response to an instructional antecedent (e.g., responding verbally to a question or a computer prompt, writing a sentence, reading aloud, clicking a mouse to select a response) (Barbetta, Heron, & Heward, 1993). There has been a consistent positive relation between ASR and student learning that comes from large-group correlational studies linking several instructional variables to student achievement (Berliner, 1980; Fischer, Berliner, Filby, Marliave, Cahen, & Dishaw, 1980; Rosenshine & Berliner, 1978) and experimental studies of high-ASR teacher-led and peer-mediated instruction (Barbetta et al., 1993; Barbetta &

Heward, 1993; Drevno, Kimball, Possi, Heward & Barbetta, 1994; Sterling, Barbetta, Heward, & Heron, 1997; Utley, Reddy, Delquadri, & Greenwood, 2001). However, limited research exists that demonstrates empirically the effects of ASR during CAI (e.g., Jerome, Barbetta, Rosenberg, & Brady, 2001; Shin, Deno, Robinson, & Marston, 2000; Tudor, 1995; Tudor & Bostow, 1991; Wilson, Majsterek, & Simmons, 1996).

Tudor and Bostow (1991) and Tudor (1995) evaluated the effects of ASR-CAI with college-level students. In Tudor and Bostow (1991), 75 undergraduate psychology students were randomly assigned to one of five groups who received different types of programmed instruction. Two groups made ASRs by typing their responses on computer frames (with one of the groups receiving feedback) and the other groups made on-task (OT) responses such as passive reading or instructions to think of the correct answers. After completing the programs, students completed a written posttest and developed two programmed instruction frames based on the knowledge they had gained from the program. Results showed that the two ASR groups performed significantly higher in the posttest. Also, they developed programmed instructional frames with higher accuracy than participants in the other groups.

Tudor (1995) conducted a similar study with four college-level students using an alternating treatments design. Text frames were presented one at a time. In one condition, the students filled in the correct responses on the text frames with blanks on it (i.e., an ASR). In the other condition, the students silently read the text frames without blanks on it (i.e., an OT response). Results indicated that students performed better on the items in which they constructed answers on the blank frames. The author concluded that active responding was functionally related to greater achievement.

Shin, Deno, Robinson, and Marston (2000) attempted to predict classroom achievement from ASR during CAI with 48 second graders. In this study, CAI was provided using a computer-based groupware system called Discourse GroupWare Classroom. With this system, the teacher sent instructions from her terminal to each of the students' monitors. Students provided responses to teacher's instructions and the teacher provided feedback to the student. Active student response during the CAI and initial performance were the two independent variables used to predict student's final performance using multiple linear regression analysis. Active responding was found to be a significant predictor and was found to be highly correlated with student final performance, thereby lending further support to the positive effects of ASR during CAI instruction.

A recent study used an alternating treatments design to compare ASR and OT instruction on the acquisition and maintenance of science facts among 4 students with mental retardation during CAI (Jerome et al., 2001) using the hypermedia program, Hyperstudio (Wagner, 1997). During ASR instruction, students were presented a science fact followed by a computer prompt to write the fact on a structured study guide. During OT instruction, students listened to the computer program reading the fact. Students learned science facts in both conditions, however, results from same-day tests show the mean number of ASR facts learned was higher than the mean number of OT facts (4.13 ASR facts and 3.2 OT facts). Individually, the mean number of ASR facts learned was slightly higher for three of the students (1-to-2 more facts scored correctly with ASR compared to OT instruction). Similar results were found on next-day tests. Maintenance tests showed that the group maintained a mean of 73.5 % of the 68 science facts learned in the ASR condition compared to 76.8 % of 56 facts learned with OT instruction. Although the difference was not considerable, the results do lend some credibility to the value of ASR during CAI with students with disabilities. The authors indicated that the narrow performance differences and intervariability may have been due to the study's limitations such as (a) the de-contextualized nature of computer-assisted instruction without any previous or additional content instruction, (b) the difficulty level of the instruction, and (c) a study guide design in which required students to make a limited active response in that they wrote only part of the fact (e.g., often just a word) with the remainder of the fact already completed on the guide.

The present study was designed to extend the results of Jerome et al. (2001) by comparing three types of student responses during CAI on the acquisition and maintenance of social studies facts by students with learning disabilities using the hypermedia program, Hyperstudio (Wagner, 1997). Two of the response conditions required students to make active student responses; *Clicking-ASR* and *Repeating-ASR*. During *Clicking-ASR*, students selected a response by clicking on the mouse. During *Repeating-ASR*, students orally repeated the correct response. The other response condition, *Listening-OT*, required the students to make an on-task response by listening as the fact was read on the computer.

Method

Participants and Setting

Participants were five fifth-grade students with learning disabilities, two females and three males, enrolled in a private school for students with learning disabilities. Parental permission, student consent, and availability during the time of the study were used as selection criteria. Participants were required to have basic computer skills such as using the mouse, and clicking on icons. In addition, participants were required to have a reading level of first grade or above to participate in the study. Full-scale IQ scores based on the *Wechsler's Intelligence Scale for Children* – Third Edition

Table 1.
Participant Characteristics

Student	Age	Gender	IQ			Grade level		
			Full Scale	Verbal	Performance	Spelling	Mathematics	Reading
1	11	M	*	*	*	2.5	3.3	3
2	11	M	76	57	102	1.9	2.3	1.6
3	10	M	126	111	139	2.1	2.9	7.0
4	12	F	*	*	*	2.1	4.0	1.4
5	10	F	109	113	104	2.8	3.8	1.6

Note. The Spelling, Mathematics and Reading grade levels were obtained by the WIAT *(Wechsler's Individual Achievement Test).* The IQ test scores were obtained from the *Wechsler's Intelligence Scale for Children* - Third Edition (WISC-III). *Information not available.

(WISC-III) ranged from 76 to 109. Reading levels ranged from 1st grade (Student 2) to 7th grade (Student 3) based on the Wechsler's Individual Achievement Test (WIAT).

The study was conducted in an assigned room, referred to as the study room. The same room was used for all the students each day of the study. Each one-to-one CAI practice session and test session occurred in the study room in the school at approximately the same time each day. The length of each session ranged approximately from 20 to 25 minutes per student. The first author served as the researcher.

A Dell personal computer with *Hyperstudio* (Wagner, 1997) was used for the study. Hyperstudio is a hypermedia authoring software program that can incorporate text, sounds, graphics, and animation to create customized lessons according to students needs. The researcher developed the hypermedia social studies lessons that consisted of a series of hypermedia screens. Each hypermedia screen had on it a social studies fact, an *ear icon* and a *next button* icon.

Procedures

General Procedures. For each of the first six weeks of instruction, the 21 unknown facts were randomly assigned to the Clicking-ASR, Repeating-ASR, or Listening-OT conditions using a standard procedure (i.e., 7 per condition). The condition presentation order for each week was determined prior to beginning that week's lesson and was randomly assigned and counterbalanced so that no condition was presented first more than twice a week. The presentation order of the hypermedia cards within each condition was also randomized to keep the students from memorizing facts in order. For the seventh and eighth week, seven unknown facts were identified and assigned only to the condition in which each student performed the best.

On each Monday of the study, the CAI instruction session began with the concept introduction lesson. Following the concept introduction lesson component, the practice sessions began. CAI practice sessions were held four days a week (Mondays through Thursdays) for eight weeks, resulting in 32 practice sessions. Same-day tests took place Mondays through Thursdays directly after the practice sessions. Next-day tests took place Tuesdays through Thursdays immediately prior to the practice sessions and on Fridays prior to the following week's pretest and/or the previous weeks' maintenance test.

Pretest. To develop individualized sets of unknown facts, the researcher pretested each student individually. Pretesting occurred on Fridays and involved the presentation of 30 social studies questions obtained from the two fifth grade social studies textbooks identified by the classroom teacher (Hart, 1999a, 1999b). None of the content from the selected chapters was taught prior to or during the study.

Each student was escorted to the study room individually for pretesting and was seated at a desk across from the researcher. The researcher then proceeded to verbally ask the student social studies questions. Each question was asked twice before the student was permitted to answer. For example, the researcher asked twice, "Who was the first president of the United States?" The student's oral response was recorded verbatim on the pretesting form. For a response to be scored as correct, an accurate oral response had to be made within five seconds. An incorrect response was scored when the student gave an incorrect response or made no response within five seconds. During the first six weeks of the study, the first 21 social studies facts scored as incorrect during each Friday's pretest were included in the next week's CAI.

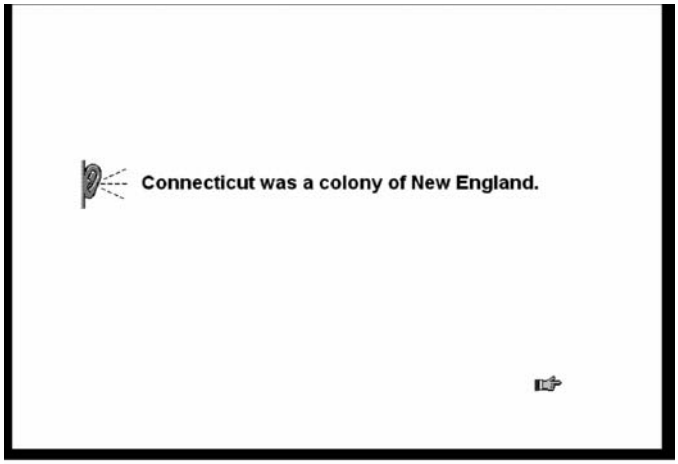
During weeks seven and eight, each pretest consisted of the presentation of 15 social studies questions using the procedures and criteria for selection identical to those used during the first six weeks.

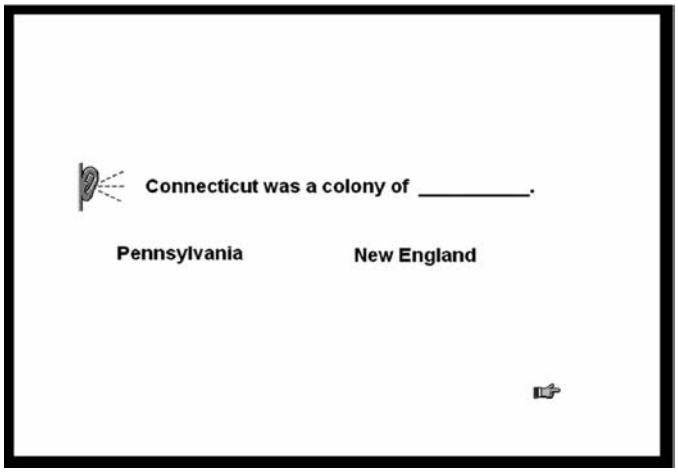
Concept Introduction Lessons. The concept introduction lesson consisted of a hypermedia screen with lesson background information and an introduction to the lesson for the week. Each student navigated through the lesson independently. Content material for the introduction was presented as text. Each concept introduction screen had an ear icon on it. When the student clicked on the ear icon, the computer orally read the text presented on the screen. The information on the concept introduction screen was related to the social studies facts to be presented during the practice sessions. However, the specific practice session facts (i.e., those to be tested) were not included on the concept introduction screen.

Practice Sessions. The practice sessions began after the concept introduction lesson component. For the first six

Figure 1. Concept Introduction card. This card presented background information prior to practice.

Figure 2. Clicking–ASR cards. Required students to click on the right response.





weeks practice consisted of the presentation of 21 unknown facts (i.e., 7 per condition) using one of the three different student response conditions (i.e., either Clicking-ASR, Repeating-ASR, or Listening-OT). A hypermedia screen was presented prior to each condition to indicate to the student what condition was in place. The student progressed through the practice session providing one of the three types of responses. Then he or she progressed to the next screen by clicking on the next button icon. Each condition included seven facts presented twice, providing students with two response opportunities per fact.

After the student completed the seven facts presented twice under the first condition, a prompt was given that the next condition was to be used. The seven facts from the second condition were presented twice in a random fashion, followed by the seven facts from the third condition.

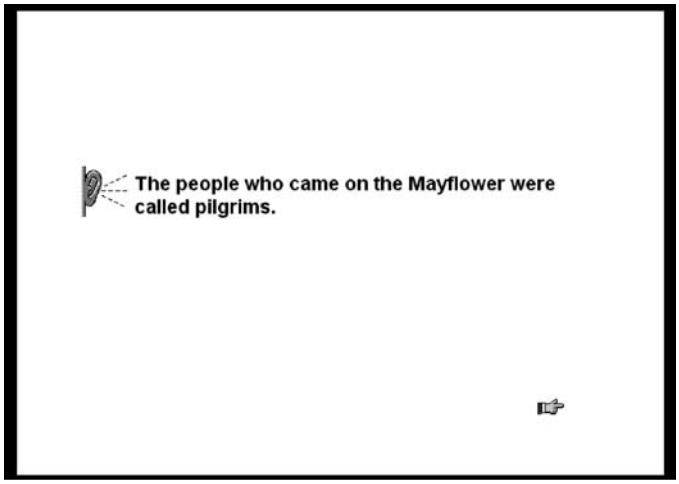
The researcher monitored the students as they progressed through the practice session. When the student reached the last card on the stack, he or she was given stickers on a behavioral chart for cooperative participation and then escorted back to the classroom. At the end of the week, each student was given a small reward (e.g., photo frame, small toy) based on the number of stickers earned.

Conditions. During Clicking-ASR, the student was required to make an active response by clicking on the correct response. The social studies fact was presented in print on a hypermedia screen and was orally read by the computer after the student clicked on the ear icon. The student then moved to the next screen by clicking on the next icon and was directed to click on the correct response. For example, printed on the first screen was "Connecticut was a colony of New England." The student then moved to the next screen with this same fact printed on it in a fill-in-the-blank form with two choices to complete the response. In this example, "Connecticut was a colony of _____" was followed by the two choices, " Pennsylvania" and "New England." On this screen, the computer read the fact aloud, and the student then clicked on one of the two responses ("Pennsylvania" or "New England"). If the student clicked on the correct response (in this case "New England"), the computer read it aloud. If the student clicked on the incorrect response, a *breaking glass* sound was produced. The student then moved to the next screen.

During Repeating-ASR, the student made an active response by orally repeating the fact that was presented in print on the card and orally read by the computer. For example, after the student clicked on the ear icon, the computer read, "The people who came on the Mayflower were called pilgrims. Repeat." The student orally repeated the fact. The student then moved to the next card.

During Listening-OT, the student listened to the social studies fact that was printed on the card as it was read aloud

Figure 3. Repeating-ASR card. Required students to repeat the fact being presented.

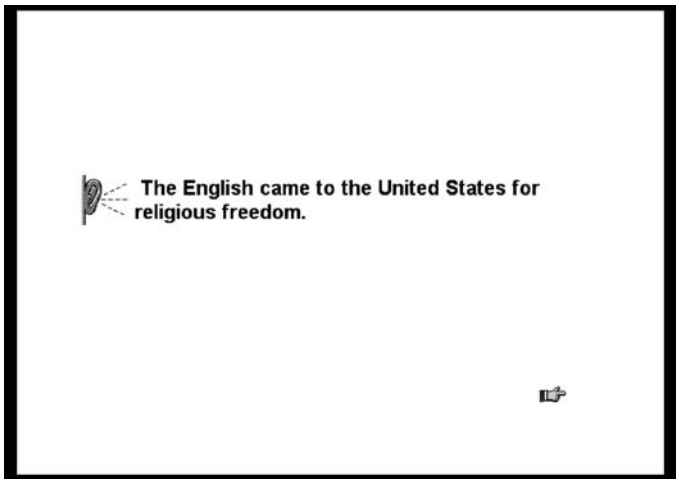


by the computer. The student was then prompted by the computer to listen as it was read again. For example, when the student clicked on the ear icon, the computer read the social studies fact, "The English came to the United States for religious freedom. Listen. The English came to the USA for religious freedom." The student then moved to the next card. During weeks seven and eight, instruction occurred with seven unknown facts using only the best treatment.

Test Sessions. Same-day tests took place Mondays through Thursdays drectly after the practice sessions. Next-day tests took place Tuesdays through Thursdays immediately prior to the practice sessions and on Fridays prior to the following week's pretest and/or the previous weeks' maintenance test.

The researcher orally administered the tests to each student individually. The student sat directly across from the researcher while she read questions two times consecutively for each of the 21 social studies facts. The researcher then waited 5 seconds for the student's response. The response given by the student was written verbatim on the scoring sheet by the researcher. If the student responded correctly within 5 seconds, the item was scored as correct. If the student did not respond within 5 seconds or responded incorrectly, the item was scored as an incorrect response. The researcher then presented the next question. No feedback was provided to the student for correct or incorrect responses.

Figure 4. Listening-ASR card. Required students to listen to the fact being read.



Maintenance tests were conducted 1 and 2 weeks after instruction ended on each set using similar procedures. Only those facts considered learned were included in the maintenance tests. For the purpose of this study, *learned* was defined as those facts stated correctly on the fourth and last day of next-day tests. Two maintenance tests were given for each of the eight sets resulting in eight 1-week and eight 2-week maintenance tests given per student.

Dependent Measures

Data were collected on three major dependent measures: same-day tests, next-day tests, and one and 2-week maintenance tests. The number of correct responses and percentage of correct responses were recorded.

Interobserver Agreement

An independent second observer was trained to score the same-day, next-day, maintenance, and pre-tests according to the criteria presented. The observer was randomly present for observations on 33% of the same and next-day tests and 38% of maintenance tests. Agreements and disagreements between the researcher and the second observer were recorded. The interobserver agreement on same-day, next-day, and maintenance tests for the five students was 100%.

Treatment Integrity

The second observer collected data on treatment integrity to help ensure procedural reliability of the practice and test procedures. The observer was randomly present for observations on 32.5% of the sessions. Data show that all the practice session and test procedures were implemented with 100% accuracy during the observed sessions.

Experimental Design

An alternating treatments design with final best-treatment phase was used to determine the effects of Clicking-ASR, Repeating-ASR, and Listening-OT computer-assisted instruction on the acquisition and maintenance of social studies facts. Each week, seven social studies facts were taught with Clicking-ASR, seven with Repeating-ASR, and seven with Listening-OT. The presentation order of the three conditions was randomized and counterbalanced (no

condition was presented first for more than two consecutive sessions) across sessions.

During the last 2 weeks of the study, only the condition determined to be most effective was administered to establish the relative effectiveness of the best condition in isolation and to demonstrate a much stronger functional relation (Tawney & Gast, 1984).

Results

Same-Day Tests

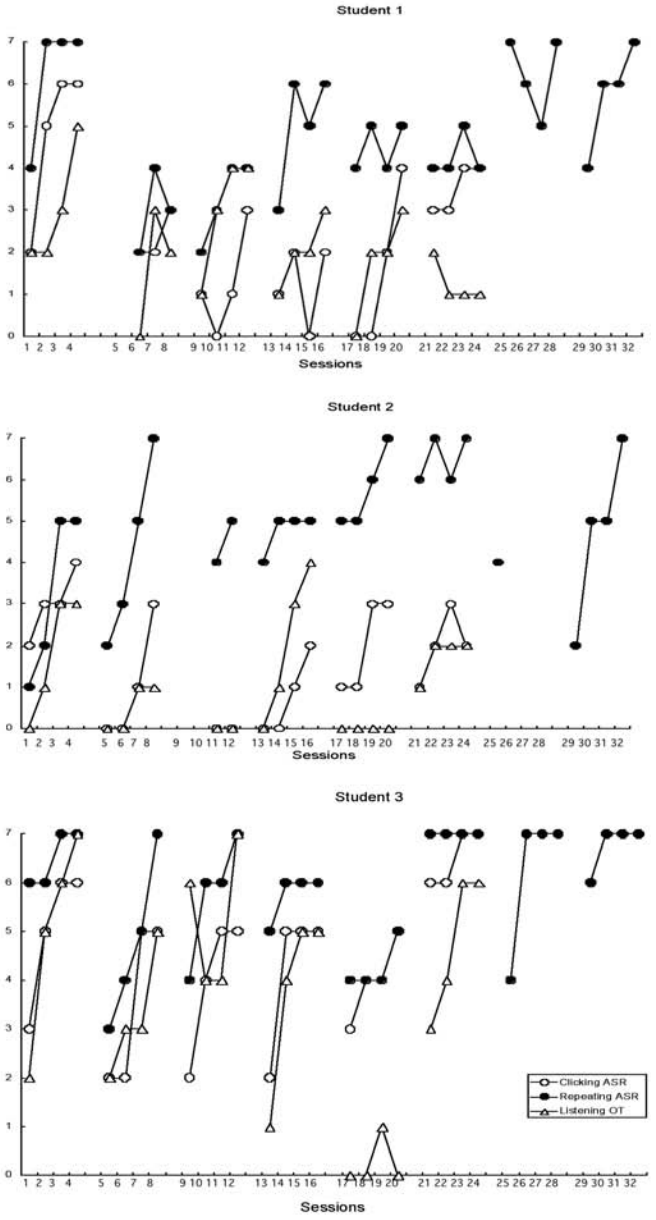
Figures 5 and 6 show each student's performance on same-day tests given immediately after instruction. The mean same-day test scores were highest in the Repeating-ASR condition for all five students on each of the 4 days of instruction individually, as well as across all 4 days (grand mean). For students 2, 3, 4, and 5, mean scores were highest in the Repeating-ASR condition followed by the Clicking-ASR condition on all 4 instructional days, as well as across the four days. Student 2 demonstrated the most considerable performance difference with an average of 3.7 and 4.3 more facts answered correctly on Repeating-ASR fourth day same-day tests than the Clicking-ASR and Listening-OT respectively. Mean scores for Student 1 were highest in the Repeating-ASR condition on all 4 instructional days followed by Listening-OT.

As a group, the mean same-day test scores on each of the 4 successive days of instruction across all sets in the Repeating-ASR condition were 3.9, 5.1, 5.6, 6.0, the mean scores for the Clicking-ASR condition were 1.8, 2.6, 3.3, 4.1, and the mean scores for Listening-OT condition were 1.0, 1.9, 2.8, 3.3.

Of the 124 same-day tests taken by Students 1 through 5, Repeating-ASR same-day test scores were highest on 89 (72%) of the tests, Repeating-ASR results were identical to Clicking-ASR results on 26 (21%) of the tests, and identical to Listening-OT on 5 (4%) of the tests. Scores were highest on three Clicking-ASR same-day tests and one Listening-OT same-day test. In sum, Repeating-ASR instruction resulted in the highest or identical scores on 97% of the same-day tests.

During the seventh and eighth weeks of instruction when only the Repeating-ASR condition (best practice condition) was implemented, Repeating-ASR instruction produced higher scores than all conditions (including Repeating-ASR) during the first 6 weeks of the study.

Figure 5. Number of facts answered correctly on same-day tests (based on 7 facts per condition) given after the practice session for Students 1, 2, and 3. Breaks in data points represent new fact sets.

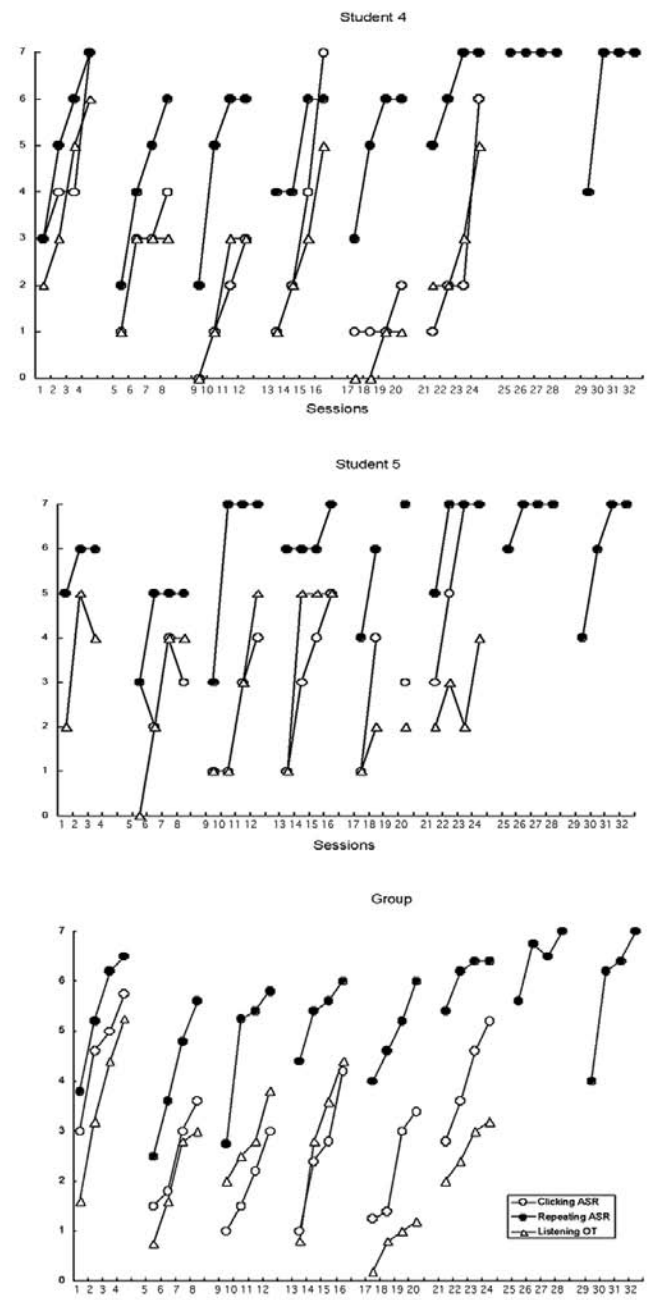


Next-Day Tests

Figures 7 and 8 show each student's performance on next-day tests given the day after instruction. The mean next-day test scores were highest in the Repeating-ASR condition for all five students on each of the four days of instruction individually, as well as across all 4 days (grand mean). Scores were highest for all the five students in the Repeating-ASR condition followed by the Clicking-ASR and the Listening-OT conditions on all 4 instructional days, as well as across the 4 days. Student 2 demonstrated the most considerable difference with an average of 2.9 and 3.5 more facts answered correctly on Repeating-ASR fourth day next-day tests than the Clicking-ASR and the Listening-OT respectively.

As a group, the mean next-day test scores on each of the 4 successive days of instruction across all sets in the Repeating-ASR condition were 3, 4.5, 4.9, 5.8, the mean

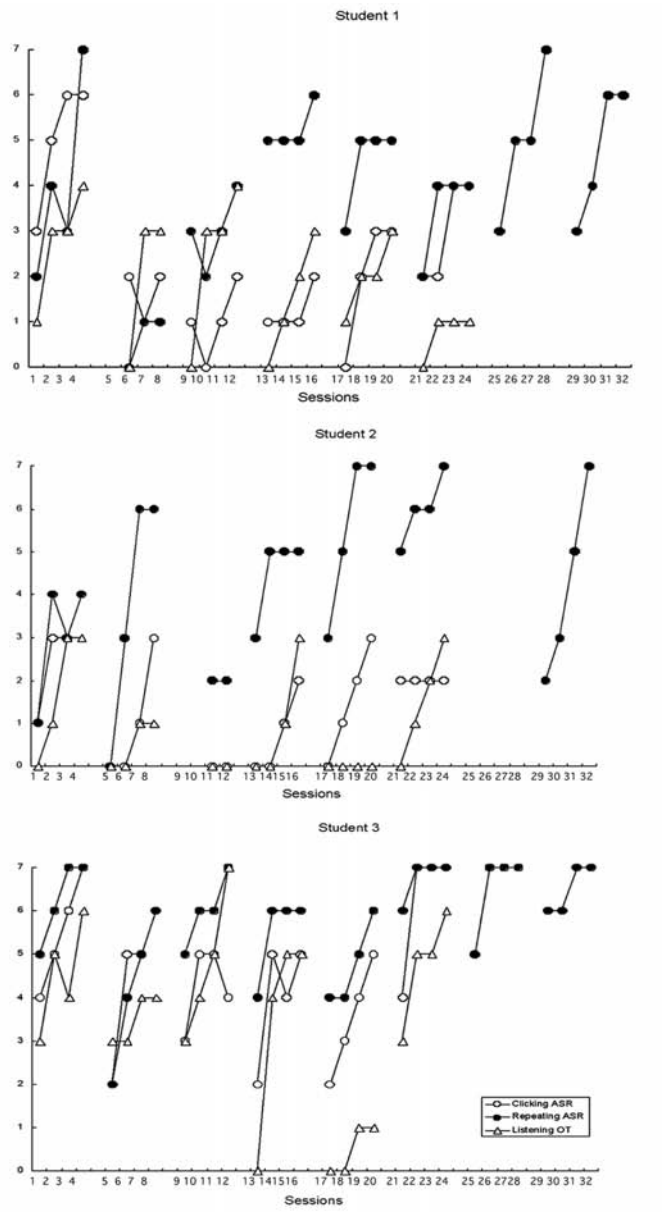
Figure 6. Number of facts answered correctly on same-day tests (based on 7 facts per condition) given after the practice session for Students 4, 5, and the group. Breaks in data points represent new fact sets.



scores for the Clicking-ASR condition were 1.3, 2.1, 2.7, 3.4, and the mean scores for Listening-OT condition were .8, 1.6, 2.4, 3.0.

Of the 124 next-day tests taken by Students 1 through 5, Repeating-ASR next-day test scores were highest on 81 (65%)

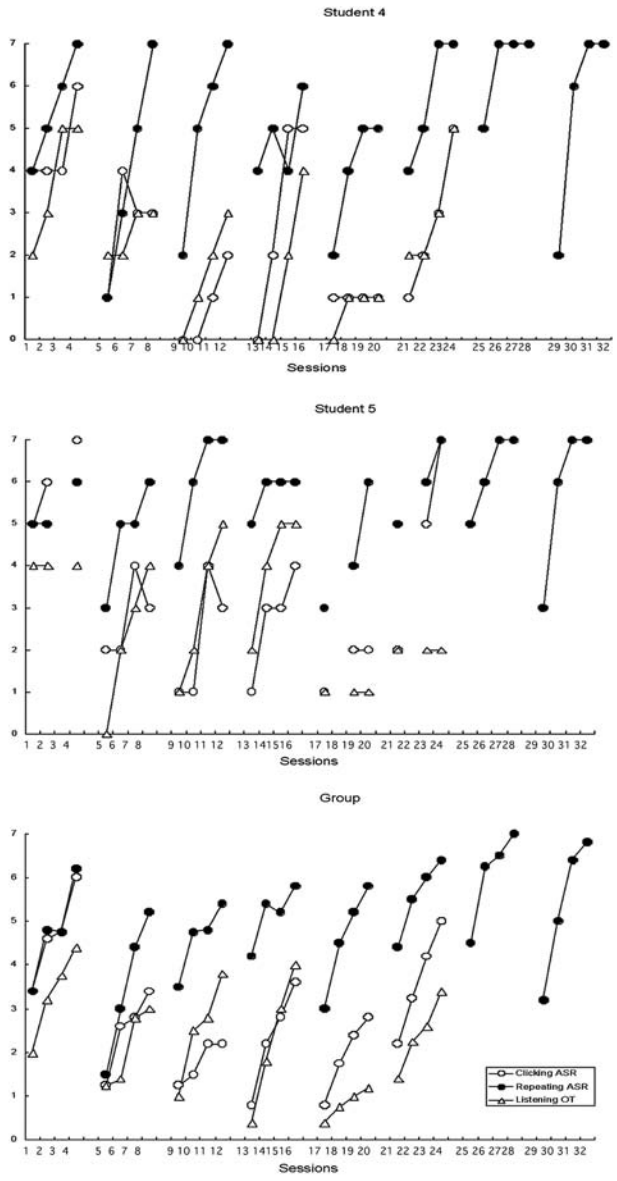
Figure 7. Number of facts answered correctly on next-day tests (based on 7 facts per condition) given prior to each practice sessions for Students 1, 2, and 3. Breaks in data points represent new fact sets.



of the tests, and Repeating-ASR was identical to Clicking-ASR on 14 (11%) and to Listening-OT on 3 (3%) of the tests. Clicking-ASR next-day test scores were highest on nine tests, and Listening-OT next-day test scores were highest on five tests. In sum, Repeating-ASR instruction resulted in the highest or identical scores on 76% of the next-day tests.

During the seventh and eighth weeks of instruction when only the Repeating-ASR condition (best practice condition)

Figure 8. Number of facts answered correctly on next-day tests (based on 7 facts per condition) given prior to each practice sessions for Students 4, 5, and the group. Breaks in data points represent new fact sets.



was implemented, Repeating-ASR instruction produced higher scores than all conditions (including Repeating-ASR) during the first six weeks of the study.

Maintenance Test

Repeating-ASR resulted in more social studies facts correctly answered on tests conducted 1 and 2 weeks after instruction (see Table 2). On 1-week maintenance tests, the Group maintained the highest mean percentage of facts learned in the Repeating-ASR condition (91.6%), followed by the Clicking-ASR (79.4%) and the Listening-OT (75.1%) conditions. Two-week maintenance tests also showed that the Group maintained a highest percentage of facts in the Repeating-ASR condition (93.2%), followed by the Clicking-ASR condition (82.2%) and the Listening-OT condition (74.3%).

Discussion

Students learned and maintained more social studies facts taught with Repeating-ASR followed by Clicking-ASR and Listening-OT. This study lends further support to the research demonstrating the positive relation between active student responding (ASR) and student achievement (e.g., Barbetta et al., 1993; Brophy, 1987; Sterling et al., 1997). This study focused on the effects of ASR during CAI. Thereby adding a dimension to the ASR literature that has focused primarily on the effects of increased ASR during teacher-led or peer mediated instruction. A limited number of studies exist that directly investigated the effects of ASR during CAI (e.g., Jerome, et al., 2001; Shin, Deno, Robinson, & Marston, 2000; Tudor, 1995; Tudor & Bostow, 1991; Wilson, Majsterek, & Simmons, 1996) and only one of these studies (Jerome, et al., 2001) was conducted was with students with disabilities.

This study extended the findings of Jerome et al. (2001) in which a written active student response was found to be slightly more effective than a listening on-task response during CAI for students with mental retardation. Although most students learned more in the ASR condition in Jerome et al. (2001), the authors suggested that the study's curricular limitations (e.g., lack of background knowledge, curricular content that was too difficult, design of the study guide) resulted in limited evidence of differential effects. In this study, different ASR conditions were used and background knowledge was provided through the concept introduction lesson components.

Existing CAI literature generally supports the use of technology in the delivery of instruction for both general and special education students. However, empirical evidence of its effectiveness is only beginning to emerge (Hitchcock & Noonan, 2000; Jimenez, Oritz, Rodrigo, & Hernandez-Valle, 2003; Mastropieri, Scruggs, & Shiah, 1997) and much remains to be learned about the characteristics of effective CAI instruction. This study provided empirical evidence of a functional relation between ASR and student achievement during CAI, as with other types of instruction (e.g., teacher-led, peer mediated). Further, this study suggests that one type of ASR (an oral repeating response) can be more effective than the more traditional clicking response that is required of most CAI.

The results have several implications for classroom practice. To improve the effectiveness of instruction, teachers

Table 2.
Mean Number and Range of Facts Answered Correctly on Fourth Day Next-Day Tests, and One and Two-Week Maintenance Tests.

	Clicking			Repeating			Listening		
Student	4th Next – Day Test	1-Wk MT	2-Wk MT	4th Next – Day Test	1-Wk MT	2-Wk MT	4th Next – Day Test	1-Wk MT	2-Wk MT
1	3.2	2.3	2.5	5	4.2	4.5	3	2.6	2.5
		63.9%	72.2%		86.6%	90.9%		90.3%	84.7%
	(2-6)	(0-6)	(0-6)	(1-7)	(1-7)	(1-7)	(1-4)	(1-4)	(1-4)
2	2.3	1.8	1.8	5.4	4.8	4.8	1.7	1.2	1
		63.9%	63.9%		86.7%	86.7%		38.9%	33.4%
	(0-4)	(0-4)	(0-4)	(2-7)	(1-7)	(1-7)	(0-3)	(0-3)	(0-2)
3	5.7	5.3	5.7	6.6	6.5	6.6	4.8	4.7	4.7
		94.3%	100%		97.9%	100%		83.3%	83.3%
	(4-7)	(4-7)	(4-7)	(6-7)	(5-7)	(6-7)	(1-7)	(0-7)	(0-7)
4	3.7	3.3	3.3	6.6	6.1	6	3.7	2.8	3.2
		93.9%	88.3%		92.3%	90.5%		81.4%	90.3%
	(1-6)	(1-5)	(1-6)	(5-7)	(4-7)	(4-7)	(1-6)	(1-4)	(1-5)
5	5	4	4.2	6.5	6.1	6.4	3.8	3	3
		80.9%	86.5%		94.3%	97.9%		81.7%	80%
	(3-7)	(2-7)	(2-7)	(6-7)	(5-7)	(5-7)	(1-5)	(1-5)	(1-5)
Total	19.9	16.7	17.5	30.1	27.7	28.3	17	14.3	14.4
Mean	3.9	3.3	3.5	6	5.5	5.7	3.4	2.9	2.9
%		79.4%	82.2%		91.6%	93.2%		75.1%	74.3%
Range	(0-7)	(0-7)	(0-7)	(1-7)	(1-7)	(1-7)	(0-7)	(0-7)	(0-7)

Note. *The top numbers indicate mean performance. The percentage figures indicate the percent of facts maintained on one-and two-week maintenance tests. The numbers in parentheses indicate range of performance.*

should select or design CAI that promotes high rates of ASR rather than those that require only passive attention or on-task performances from their students. Further, the type of ASR required is critical. Teachers should require students to make an oral response during CAI rather than simply a clicking response. Most commercially-developed CAI instruction, however, does not require students to make an oral response similar to the one used in the Repeating-ASR condition. Although preliminary, these results suggest that teachers should add an oral component to their CAI assignments. Students could be required to say the critical information (e.g., facts, numbers, concepts, names) as they select or click with the computer mouse. CAI that includes whole group active student responding should be considered for instruction. Information and questions could be presented using the computer and an LCD projector or TV connection. Students could actively respond by chorally responding (i.e., responding in unison) and occasionally responding individually. Students who miss a teacher-led CAI lesson could review the lesson independently at the computer at a later time.

Parents should be made aware of the importance of ASR while choosing educational software for their children. First and foremost, a parent should purchase software that requires their child to be actively engaged in the lesson. When their child uses the instructional software, he or she should be encouraged to make oral active responses in addition to the required clicking responses. Also, special education university faculty should emphasize and demonstrate the importance of ASR based CAI in the training of future teachers.

Rigorous research methodologies were used to control for the study's internal validity which gave confidence to the results and set the groundwork for future research. However, the results of this study are preliminary and should be viewed as such. In addition, the nature of single-subject design research limits the generalization of findings. Generalization of the findings must be established through direct and systematic experimental replication which can be accomplished in multiple ways. For example in this study, social studies was the subject area and the participants were students with learning disabilities. A similar study could be replicated among students with other disabilities, typical learners, students of other ages, and across other curricular areas. Future research might include modifying various methodological variables, such as the number of facts per condition, and modifying the design of the hypermedia cards.

More comprehensive use of the components of hypermedia instruction (e.g., sound, animation, video-segments, and non-linear progression) should be included in future research.

Much more research is needed to identify other characteristics of effective computer assisted instruction including, presentation style, screen design, interaction and feedback, ease of navigation, learner control, and use of multimedia features such as color, graphics, animation, audio and video (Roblyer & Edwards, 2000). Also future research should investigate the effects of ASR-CAI on higher-order thinking skills such as drawing inferences or synthesizing information rather than basic recognition or recall responses as was the case in the present study. In this study, the opportunity for students to make an ASR or OT response immediately followed the presentation of the concept to be practiced. Further research is needed to determine if each condition's effectiveness would differ if the opportunity to make an active student response occurred after the presentation of all the facts rather than immediately after each fact was presented. The implementation of these study variations would add considerably to the knowledge of effective computer-assisted instruction.

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