Effects of Computer-Based Practice on the Acquisition and Maintenance of Basic Academic Skills for Children with Moderate to Intensive Educational Needs

Julie M. Everhart
Westerville City Schools
Sheila R. Alber-Morgan
The Ohio State University
Ju Hee Park
Wheelock College

Abstract: This study investigated the effects of computer-based practice on the acquisition and maintenance of basic academic skills for two children with moderate to intensive disabilities. The special education teacher created individualized computer games that enabled the participants to independently practice academic skills that corresponded with their IEP objectives (e.g., letter-sound correspondence, word identification, number identification). The computer games provided discrete learning trials with immediate feedback for each response. A multiple baseline across skills design demonstrated that computer-based practice resulted in the successful acquisition of basic academic skills for both participants. Additionally, both participants maintained at least two mastered skills for two to four weeks.

In this dynamic age of technology, the use of computers permeates many facets of our daily living, learning, working, and entertainment. The pervasiveness of rapidly changing technology and the corresponding need for computer literacy has required schools to embed technology into academic instruction in order to prepare students to live and work in a high tech society. In fact, the National Educational Technology Plan (2004) developed by the U.S. Department of Education as part of the No Child Left Behind Act recommends that states and districts “encourage ubiquitous access to computers and connectivity for each student” (p. 43).

In addition to preparing students for the requirements of the real world, student engagement with computer technology has been effective for increasing academic skills (e.g., Fitzgerald, Koury, & Mitchum, 2008; Hall, Hughes, & Filbert, 2000). For example, computer assisted instruction (CAI) has been demonstrated to increase reading skills for at risk first graders (Chambers et al. 2008), oral reading fluency for children with attention deficit/hyperactivity disorder (Clarfield & Stoner, 2005), social studies content knowledge for fifth graders with learning disabilities (Jerome & Barbeta, 2005), comprehension of history text by high school students (Twyman & Tindal, 2006), sight word recognition for children with developmental disabilities (Lee & Vail, 2005), and basic academic skills (shape, color, and number identification) for preschoolers (Hitchcock & Noonan, 2000).

CAI may be effective because it utilizes active student responding with immediate feedback and/or reinforcement for each response (e.g., Hall et al., 2000; Macaruso & Walker, 2008; Sorrell, Bell, & McCallum, 2007). Research demonstrates that students with more intensive disabilities can benefit a great deal from frequent opportunities for active student responding (e.g., Barbeta, Heron, & Heward, 1993). Although CAI has substantial research support for increasing academic skills, most CAI research has focused on typically developing students or students with mild to moderate disabilities. Students with moderate to intensive disabilities can also benefit from CAI of academic skills, but most of the technology
research for this population has focused on functional skills and communication skills (e.g., Calculator, 2009; Gihak, Kessler, & Alberto, 2008; Lancioni et al., 2009; Mechling, 2008). Therefore, to better substantiate the effectiveness of CAI, it is necessary to further investigate the effects of CAI on academic skills for students with moderate to intensive disabilities. The purpose of this study was to examine the effects of computer assisted instruction on the acquisition and maintenance of basic skills for children with moderate to intensive disabilities.

Method

Participants and Setting

Participants were two students with moderate to intensive educational needs, Joe and Nate, who received individualized instruction in a self-contained special education classroom. Both participants also received speech therapy, occupational therapy, physical therapy, and adapted physical education. They each qualified for alternative assessments because of their cognitive and fine motor needs. Joe was a 9-year-old African American boy who was diagnosed with traumatic brain injury (TBI). He participated in a general education second grade class for approximately 15 minutes per day. Nate was a 6-year-old Caucasian boy who was diagnosed with Down syndrome and participated in a general education kindergarten class for approximately 30–40 minutes each day. Joe and Nate were selected to participate in this study because both students had basic academic skill needs identified in their individual education programs and both children had severe learning challenges. Additionally, Joe and Nate had the following prerequisite skills needed to participate in this study: (a) the ability to focus attention on a computer screen, (b) the ability to visually discriminate between three different academic stimuli on the computer screen (e.g., letters), and (c) the ability to use a computer mouse to select an item on the screen.

Experimental sessions were conducted in a self-contained special education classroom in a suburban public elementary school. The classroom consisted of seven K-2 students with multiple disabilities, four paraprofessionals, and one special education teacher (i.e., the first author). Computer practice took place during breaks in the morning or afternoon when students were typically engaged in individualized activities. During these sessions, two to six other students were present working with paraprofessionals in other areas of the classroom away from the computers. The paraprofessionals also served as observers who collected IOA and procedural reliability data.

Definition and Measurement of Dependent Variable

The dependent variable was acquisition of basic academic skills, which was measured by the number of correct academic responses from 10 response prompts per session presented on flashcards. Flashcard probes were used to assess academic skill acquisition and maintenance because the participants were accustomed to this form of assessment in their daily routine. The flashcards also provided a consistent visual cue for the participants throughout the study.

For Joe, a correct response was scored each time he stated the correct answer within 5-s of the flashcard presentation and verbal prompt. For example, the special education teacher showed Joe a flashcard with a number printed on it and said “What number?” A correct response was scored when Joe stated the correct response within 5-s. An incorrect response was scored when Joe stated an answer that did not correspond to the item presented or made no response within 5-s. If Joe responded incorrectly and then self-corrected, the response was scored as incorrect.

Because of Nate’s difficulties producing oral language, his responses were measured by observing his gestures. Specifically, Nate’s special education teacher showed him two flashcards and verbally prompted him to touch or point to the correct response. For example, one flashcard showed the number “11” and the other flashcard showed the number “15.” The special education teacher verbally prompted, “Touch 15.” A correct response was counted when Nate touched or pointed to the correct flashcard within 5-s. An incorrect response was recorded when Nate touched the wrong card, touched both cards
at the same time, or did not respond within 5-s.

The experimenters identified three target academic skills for each participant based on their IEP objectives. For each target skill, 10 items (i.e., letters, numbers, or words) were selected and used as response prompts for computer practice and flashcards. The following basic skills were selected for each participant in order of when the intervention was introduced.

Joe: number identification (11–20), lettersound identification (K-T), and color word identification (e.g., red, blue).
Nate: color word identification (e.g., red, blue), letter identification (A-J), and number identification (11–20).

Flashcard probes were always conducted one day after computer practice prior to the next computer practice, and flashcards were presented in random order during each assessment.

Independent Variable

The independent variable was independent practice of the target skills using computer games that were designed by the teacher using the Microsoft PowerPoint® program. With this program, the teacher digitally recorded and embedded her voice into each game in the form of verbal prompts, feedback, and praise. The materials used in this experiment included a computer, a computer mouse, individualized computer games, a digital timer, and flashcards.

When each participant began the game, he was presented with a digital verbal prompt to select a specific item from a choice of three items (e.g., A, B, C). The games provided visual and auditory praise for correct responses. When the student responded correctly, a written praise statement appeared on the computer screen (e.g., “Great job”) accompanied by the teacher’s voice enthusiastically saying the praise statement. The praise screen was immediately followed by animations and sound effects (e.g., a car going across the screen with the sound of the engine, a fish swimming across the screen with a gurgling noise and bubbles). After presenting praise and reinforcement for correct responses, the game advanced to the next learning trial.

When a student emitted an incorrect response, the next screen showed the words “Try again,” accompanied by the teacher’s monotone voice saying “Try again.” No additional sound effects or animations were provided for incorrect responses. The student was then presented with another opportunity to attempt the learning trial. The computer program did not advance to a new learning trial until the student emitted the correct response. For each session, the computer response prompts were presented in random order.

During computer practice sessions, the participants were provided one trial for each of 10 items with a maximum of 3-min to play each game. For example, for letter identification, the participant was given one opportunity to identify each of the 10 selected letters. After three minutes of computer practice, whether or not the participant finished all 10 learning trials, the practice session ended for that game and the participant was directed to another computer game (e.g., number identification) or a different classroom activity. If the participant finished the 10 trials before three minutes had elapsed, he or she was also directed to the next task.

Experimental Design and Procedure

A multiple-baseline across skills design was used to examine the effects of computer practice on acquisition and maintenance of basic skills. The experimental conditions consisted of baseline, training, computer practice, and maintenance. For each student, each tier of the multiple baseline design shows the data for one of three different target skills. Baseline data were collected for all three target skills. Intervention began with the skill that showed the lowest and most stable baseline data. When the participants attained 60% accuracy on three consecutive sessions for the first skill, intervention began with the next skill on the second tier. When 60% accuracy was attained on three consecutive sessions for the second skill, intervention began for the third skill on the final tier. The intervention continued for each target skill until the par-
participant attained 80% accuracy on three consecutive sessions. Then the maintenance condition was implemented.

Baseline. During baseline, the special education teacher sat across from the participant at a table and presented three sets of flashcards, one set for each skill. The teacher held up each flashcard and provided a verbal prompt (e.g., “What word?”), and recorded correct and incorrect responses. Joe was expected to provide verbal responses. Nate was presented with two flashcards and asked to point to the correct response (e.g., “Touch red.”). When the student responded correctly, the teacher delivered a praise statement (e.g., “Good! You got it!”). Feedback was not provided for incorrect responses. If the student responded incorrectly, the teacher said nothing and presented the next flashcard. If the participant became distracted or off-task (e.g., looking around, attempting to leave the table), the teacher used prompts to re-direct him back to the task (e.g., “Almost done,” “Three more,” “We’re working now.”).

Training. Prior to beginning the intervention, the teacher provided the participants with training for using the computer mouse to select items on the computer screen. Training sessions were about three minutes in duration and included verbal directions, modeling, least-to-most prompting, guided practice, and systematic error correction. Once the participants were observed using the mouse independently to move the cursor to an object on the screen and click on a selection, they began the computer practice condition. Nate received this training on two consecutive days and Joe received training on six consecutive days.

Computer practice. During computer practice, the teacher set up the game and prompted the participant to go to the computer and play the game. The participants completed the games independently, receiving feedback only from the computer game itself. Each computer game ended with an audible signal and a blank screen after the 10 trials had been completed or after the three minutes had elapsed, whichever occurred first. An observer monitored the participants to make sure they did not leave the computer before they were finished with the game. If the participants had attempted to leave the task, the observer would have redirected the participant back to the computer, however, no students attempted to leave the computer during any of the practice sessions. The flashcard probes used to assess acquisition were administered the following day prior to the next computer practice session.

Maintenance. After the participants attained 80% mastery on three consecutive sessions for one skill, computer practice was discontinued for that skill. For example, if a student achieved 80% accuracy on three consecutive sessions with letter-sound identification, but did not meet the 80% criteria for number and sight word recognition, computer practice was discontinued for letter-sound recognition only. Maintenance probes were administered using the same flashcard procedures used throughout the study and were administered approximately two days each week.

Interobserver Agreement (IOA) and Procedural Reliability

IOA was assessed on 20% of the sessions. A second observer was present to record the participant’s responses to the flashcard prompts. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100.

Procedural reliability was assessed on 20% of the sessions for computer practice and flashcard probes. Procedural reliability checklists were used to determine the extent to which the intervention was implemented as planned. A second observer checked off the steps that were completed correctly and in the correct sequence. The number of steps completed correctly was divided by the total number of steps and then multiplied by 100 to calculate the percentage of procedural reliability.

Results

Figure 1 shows the number of correct responses across skills and conditions for Joe, and Figure 2 shows the number of correct responses across skills and conditions for Nate. During baseline, Joe’s data were stable, ranging between zero and four correct re-
Figure 1. Correct responses for Joe for number identification, letter-sound identification, and color word identification.
Figure 2. Correct responses for Nate for color word identification, letter identification, and number identification.
sponses for each skill. No trends were apparent during baseline for Joe. Nate’s baseline data were more variable, ranging between zero and six correct responses across skills. Additionally, Nate’s second tier (letter identification) shows a slight upward trend during baseline. When the intervention was introduced, both students showed a clear upward trend of correct responding for each skill. Joe’s second tier (letter-sound identification) shows a delayed upward trend beginning on the fifth intervention session followed by rapid progress to mastery (i.e., 4 sessions). Both participants also demonstrated maintenance. Nate demonstrated maintenance for all three skills and Joe demonstrated maintenance for letters and numbers. Although Joe’s color word proficiency increased, he was unable to reach the criteria for beginning the maintenance phase for color words in the time available for data collection.

Interobserver Agreement and Procedural Reliability

Interobserver agreement (IOA) was assessed in each condition for each participant on 20% of the sessions. Across all phases, skills, and participants, mean IOA was 99.4% (ranging from 80% to 100%). Procedural reliability was assessed on 20% of the sessions for the computer practice procedures and the flashcard assessment procedures. Procedural reliability was 100% for computer practice and 97% for the flashcard assessment procedures.

Discussion

Results of this study demonstrate that computer-based practice was functionally related to acquisition and maintenance of basic skills by two children with moderate to intensive disabilities. Although each participant showed variations in rate and pattern of responding, they both achieved substantial improvement of basic academic skills over the course of 12–14 weeks. Both participants also demonstrated maintenance for at least two academic skills over two to four weeks.

Joe’s correct responding was low and stable in baseline. When computer practice was introduced, Joe’s data show upward trends for each skill (see Figure 1). For letter sounds, Joe did not begin to show improvement until the fifth intervention session when his pattern of correct responding increased substantially. The experimenters were unable to determine the reason for the delayed, then substantial, increase in correct responding for letter sounds. During maintenance, Joe consistently attained 90–100% accuracy for number identification and letter sounds. He was unable to begin the maintenance phase for color words due to the limited time for data collection, but based on his data trend on the third tier, he probably would have met mastery for color words if given more time.

Nate’s data were highly variable throughout the study until he began the maintenance phase (see Figure 2). Because he selected the correct answer from two flashcards, Nate had a 50% chance of getting the answer correct. This may have inflated his percent of correct responses and produced increased variability throughout the experiment. However, during maintenance, similar to Joe, Nate demonstrated consistently accurate responding at 90–100%. The findings of this study support previous research that computer assisted instruction is an effective tool for increasing academic performance (e.g., Chambers et al., 2008; Clarfield & Stoner, 2005; Jerome & Barbetta, 2005) and extends the findings of computer assisted instruction to children with moderate to intensive disabilities. Aspects of computer practice that likely increased the effectiveness of the intervention include consistent visual and auditory response prompts, frequent opportunities for active responding, and immediate feedback for each response. The results of this study are also consistent with previous research demonstrating the effectiveness of active student responding with immediate feedback for students with more intensive disabilities (e.g., Barbetta et al., 1993).

Limitations and Future Research

While this study provides evidence of a functional relationship between computer practice and basic skills acquisition and maintenance, several limitations should be considered. First, each student attended a general education classroom for 15 to 40 minutes each day to increase their social interactions with typically developing peers. The experimenters were
unable to control the amount of exposure to the target skills outside of the special education classroom (including home and community settings). Future research should attempt to control for exposure to the target skills in other settings.

A limitation that may have influenced the students’ rate of learning is the amount of practice they received. Due to time restraints and the participants’ limited attention spans, each game was confined to three minutes which only allowed for one practice trial for each item. The students’ rates of learning may have been faster if they spent more time practicing. Future research should attempt to determine the optimum number of learning trials needed to promote mastery of basic academic skills for students with moderate to intensive disabilities.

Throughout the study, flashcard probes were administered to assess progress of basic skills. Repeated exposure as well as feedback for correct responses during the flashcard probes may have contributed to the participants’ increased proficiency with basic skills. Consequently, the participants’ performance may have been the result of the combined effects of computer practice and flashcard probes as opposed to computer practice alone. The upward trend during baseline in the second tier of Figure 2 indicates this possibility for Nate. However, Joe’s baseline data for each skill displays hardly any change in responding until computer practice was implemented. Future research should attempt to identify a way to assess the outcomes of computer practice without introducing possible confounding variables associated with assessment.

Another limitation of this study is that the experimenters did not assess generalization of the target skills to other settings or situations. Future research would be strengthened by measures of skill generalization to other classrooms or settings, with different teachers or peers, in different instructional arrangements, or with different application activities. One type of generalization, response maintenance, was measured in this study. However, the end of the school year limited the amount of maintenance data collected to only a few weeks. Future research should attempt to implement longer maintenance phases or collect follow-up data.

The research on academic interventions for children with moderate to intensive disabilities is an important area of need in the field of special education. Future research should continue to investigate and identify effective strategies for teaching a range of academic and functional skills to individuals moderate to intensive educational needs.

Implications for Practice

Students with moderate to intensive disabilities need individualized instruction, repeated practice with immediate feedback, and frequent opportunities to increase their independent functioning. Customized computer games can provide a means for meeting these student needs. The flexibility of programming instruction with computers allows for a wide range of possibilities. Computer games can be customized to each student’s IEP objectives, modes of responding, and reinforcer preferences (e.g., animated characters, colors, sound effects).

In this study, the special education teacher created individualized computer games that the participants could play independently. The results demonstrated that computer practice enables students with moderate to intensive disabilities to work independently for at least brief periods of time. While the participants were only playing each game for a maximum of three minutes (totaling nine minutes if they reached criteria to play the games for all three skills), none of the participants attempted to leave the computer area while playing. Anecdotally, the classroom staff observed the participants smiling, giggling, clapping their hands, and repeating sounds while they were engaged in computer practice; and both participants requested to play the computer games when it was not their designated time to play. Additionally, using the teacher’s voice for auditory prompts and feedback may have promoted student motivation as well as generalized responding.

Creating customized computer games for this study required a little creativity, a basic understanding of Microsoft PowerPoint®, and time to construct the games. The first game can take up to an hour to create, but could
then be used as a template for quicker creation of additional games. Once the teacher creates the games, she can use them throughout the school year and modify them as needed for individual students. In addition, Microsoft PowerPoint® is a standard feature on most school computers, so teachers can create their own games for free. In fact, one of the reasons that the teacher in this study designed the customized games using Microsoft PowerPoint® was that appropriate computer software was unavailable for her students. Equipment and materials for students with significant disabilities tends to be expensive, however, Microsoft PowerPoint® was already available throughout the school district at no additional cost. Considering the potential for increased academic achievement and opportunities to work independently, this intervention can have an excellent cost-benefit ratio. Teachers of students with moderate to intensive disabilities can learn to make customized computer games designed to meet each of their students’ unique academic learning needs.

References


Received: 27 July 2010
Initial Acceptance: 20 September 2010
Final Acceptance: 20 November 2010