Evaluation of Manual Spelling, Observational and Incidental Learning Using Computer-Based Instruction with a Tablet PC, Large Screen Projection, and a Forward Chaining Procedure

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Abstract: The study employed a multiple probe design to investigate the effects of computer-based instruction (CBI) and a forward chaining procedure to teach manual spelling of words to three young adults with moderate intellectual disability in a small group arrangement. The computer-based program included a tablet PC whereby students wrote words directly onto a multi-touch screen. Words were projected onto a large screen in order to measure observational learning of other students’ words. The study further evaluated acquisition of incidental information (reading target and observational spelling words) within the small group arrangement. Results indicated that students improved their spelling performance using the CBI package as well as their ability to read the grocery store words. Findings are discussed in the context of providing instruction in small group arrangements using commercially available technologies.

Literacy skills, including reading, writing, and vocabulary development (Ramdoss et al. (2011) have been shown to support the independent functioning of persons with disabilities across settings. Writing skills can provide persons with disabilities greater participation and independence in social, academic, and employment environments (Sturm & Koppenhaver, 2000). Writing skills include: originating ideas, organizing thoughts, capitalization, punctuation, and spelling (Alber-Morgan, Hessler, & Konrad, 2007) in addition to use of grammatical rules for constructing sentences (Yamamoto & Miya, 1999). Students with disabilities, including those with intellectual disability (ID) and those with a diagnosis of autism spectrum disorders (ASD) have been shown to have the ability to learn various forms of spelling (Coleman-Martin & Heller, 2004; Cuvo, Ashley, Marso, Zhang, & Fry, 1995; Dude, McDonald, McIlvane, & Mackay, 1991; Kinney, Vedora, & Stromer, 2003; Schlosser & Blischak, 2004; Stromer & Mackay, 1993; Stromer, Mackay, Howell, McVay, & Flusser, 1996) and writing (Joseph & Konrad, 2009) including constructing sentences (Prest, Mirenda, & Mercier, 2010a; 2010b; Rousseau, Krantz, Poulsen, Kitson, & McClannahan, 1994; Yamamoto & Miya).

Writing skills, which may be handwritten or word processed on a computer or other electronic device, are important for: completing academic tasks in school and demonstrating knowledge across content areas (Alber-Morgan et al., 2007; Joseph & Konrad, 2009); increasing communication through technology (i.e., emails, text messaging; Joseph & Konrad); providing a means of communication for persons with limited or no speech (Alber-Morgan et al.; Naughton & Tawney, 1993; Vedora & Stromer, 2007), increasing functional skills (i.e., writing a grocery or “to do” list); and improving social skills (i.e., writing a message in a greeting card; writing one’s own daily schedule) (Vedora & Stromer). Nonetheless, students with disabilities continue to struggle with writing skills (Konrad & Trela, 2007) and often fail to receive adequate instruction in this area (Joseph & Konrad). Researchers report that there is minimal research and resources available for instructing basic writing skills to students with intellectual disability (Joseph & Konrad) and recog-
nize the need for research-based writing interventions for students with disabilities (Konrad & Trela). These recommendations seem even more critical when referring to students in the moderate range of ID whose cognitive and fine motor constraints may impede their writing and spelling skills (Bird, Cleave, White, Pike, & Helmkay, 2008).

One avenue for addressing these shortfalls is exploration of features of commercially available, mainstream technologies which are ever evolving. In their review of the literature, Ramdoss et al. (2011) suggest that computer based instruction (CBI) is a promising practice for improving the literacy skills of children with ASD. They also recommend further research to determine the variables associated with effective CBI when instructing literacy skills with students with autism and to determine if there is a difference in instruction delivered through the computer versus person delivered instruction. Vedora and Stromer (2007) further state that learning to spell using a computer may lead to functionally useful writing skills.

Although small in number, studies do exist evaluating the use of CBI to teach spelling to students with disabilities. These studies appear to maximize on the ability of CBI to: provide information visually; incorporate auditory feedback and cuing when needed; and individualize programs to students’ ability levels. In an early study, Dube et al. (1991) used a desktop computer to present words and pictures on the computer screen to two students with intellectual disability. Students initially copied the word by touching letters from an available array on the screen followed by fading of letter prompts in a backward chaining format.

Blishak and Schlosser (2003) taught spelling to children with autism using a talking word processing software program while Schlosser and Blishak (2004) taught four students, ages 8 to 12 years with a diagnosis of autism and mild intellectual disability to spell words with a speech-generating device. Kinney et al. (2003) further taught a young girl with ASD to write words using video models of her teacher writing target words presented on a computer and generative spelling (recombining initial consonants and word endings to spell novel words).

Stromer et al. (1996) instructed two adults with hearing impairments and intellectual disability to construct words (spelling) corresponding to pictures using a computer. Students also learned to write words on index cards and to use written lists to obtain objects from a shelf following CBI. Vedora and Stromer (2007) were able to increase the spelling performance of two students ages 14 and 17 years with a diagnosis of intellectual disability using a touch-sensitive computer screen and Boardmaker software program (Experiment 1) and PowerPoint (Experiment 2). Students selected letters (touched or used the computer mouse) to construct words corresponding to dictation and pictures on the computer. Similar to the Stromer et al. study, students also wrote names of words on index cards and used the lists to retrieve objects following dictation with the computer program.

The purpose of the current study was to evaluate the use of CBI to teach manual spelling to students with moderate intellectual disability. Spelling, for the purpose of this study was defined as the correct arrangement of letters in written or oral form (Graham & Miller, 1979; Heron, Okyere, & Miller, 1991). Examination of the literature indicated a noticeable void in this research area. As technology continues to advance and to become commercially available and more affordable, it may be time to re-examine CBI while utilizing such technologies as multi-touch screen tablets, touch pads, interactive whiteboards, and portable handheld devices. The components of CBI in the current study were a multi touch tablet PC, PowerPoint software program, and large screen projection. The instructional package also used a teacher-directed procedure, forward chaining, which systematically taught letters in words in a left to right format, one letter at a time, and gradually fading letter prompts on the screen (Westling & Fox, 2009). Students were provided instruction and opportunities to practice correct responses using the CBI program until they independently and consistently spelled a word.

In addition to effectiveness, the current study examined the efficiency of this delivery mode of instruction through measures of observational and incidental learning of non-target information presented in a small group instructional arrangement. Students with
moderate ID have been shown to be able to learn additional, non-target information by observing other group members’ acquisition of their target information (observational learning; Farmer, Gast, Wolery, & Winterling, 1991; Schoen & Ogden, 1995; Schuster, Morse, Griffen, & Wolery, 1996) and through exposure to additional information not directly taught or reinforced to the student or group members (incidental learning; Schuster et al.). Incidental information may be presented as part of: (a) the antecedent prior to delivery of a task direction (i.e., spelling a word before reading it; Keel & Gast, 1992); (b) the antecedent within the task direction (i.e., asking “What vegetable?” rather than “What word?”; Roark, Collins, Hemmeter, & Kleinert, 2002); or (c) in the form of instructional feedback delivered as a consequent statement (i.e., “Good reading and a potato is a vegetable.”; Schuster et al.). It appears important to examine these forms of learning within the realm of CBI and small group instruction. As identified by Campbell and Mechling (2009), Mechling, Gast, and Krupa (2007), and Mechling, Gast, and Thompson (2008) the ability to observe another student’s information when using a traditional desk top or laptop computer may be impeded by the size of a smaller computer screen. Similar to these three studies which used a SMARTBoard with a large interactive screen, the current study presented target information of other students on a large screen. The current study evaluated observational learning through students’ abilities to manually spell other students’ target words and incidental learning through presentation of antecedent information [pairing of the target spelling word with the corresponding photograph along with delivery of the task direction, “Spell _____ (e.g., syrup)”] prior to student’s manual spelling of a word shown on the large screen.

Finally, the current study attempted to add to the literature by measuring students’ abilities to generalize spelling of words from the CBI program to a written list. In order to be functional, it is important for students to generalize writing skills across tasks (Alber-Morgan et al., 2007). Stromer et al. (1996) demonstrated that students with intellectual disability and hearing impairments could transfer stimulus control from a computerized program to handwritten spelling, however only one student with intellectual disability was included in that study. The multi touch tablet PC used in the current study allowed students to input spelling words onto the computer program by handwriting on the horizontal screen using a digitized pen. This input closely simulated a handwriting task while utilizing the features of CBI. Along with determining whether CBI is an effective and efficient means for delivering instruction, it appears important to determine whether these skills can be generalized to real life materials and activities outside the confines of a computer and formal instruction. In the current study generalization was assessed through the writing of a list.

In summary, the study addressed the following research questions: Would the use of CBI (multi touch tablet PC, PowerPoint, and large screen projection) and a forward chaining procedure taught within a small group arrangement, result in students with moderate ID: (a) manually spelling target grocery store words; (b) manually spelling non-target spelling words of other students through observational learning; (c) reading their target spelling words and the spelling words of others presented as antecedent information (incidental learning); and (d) manually spelling target words across a functional list (generalization).

Method

Participants

One male and two females participated in the study. The students were enrolled in a Transition Program for Young Adults, which was a high school program in the local school system. The three participants in the study were selected based on IEP objectives for increasing literacy skills (reading and writing), their ability to read and write simple words prior to the study, and their need to increase community skills such as grocery shopping by using literacy skills. Students were able to write all lower case letters of the alphabet and copy (write) letters when presented with visual text.

Emeril was 20 years and 7 months of age at the end of the study. He was diagnosed with mild/moderate autism [score 31 on the Child-
hood Autism Rating Scale (CARS): Schopler, Reichler, & Renner, 1988] and a moderate intellectual disability. His full scale IQ score was 49 on the Wechsler Intelligence Scale for Children—Third Edition (WISC-III: Wechsler, 1991) and his composite score on Vineland Adaptive Behavior Scale (Sparrow, Balla, & Cicchetti, 1984] was 51. He enjoyed reading for leisure as well as academic tasks and was using a modified Wilson Reading program for decoding and encoding words. He knew all consonant and short vowel sounds when presented in a C-V-C pattern. His needs included breaking down two syllable words for decoding and encoding and to read base words when suffix s was added. He read and answered “wh” questions on a 2.5 grade level. He was working on identifying the main idea from stories and answering why and how questions. He wrote daily journal assignments with up to five sentences using a paragraph web and personal word bank. He completely wrote all of his personal information in addition to the date and days of the week. He wrote in the past, present and future tense with minimal assistance. He used capitalization and punctuation appropriately.

Emeril could tell time and was working on telling elapsed time. He counted money using TouchMath, subtracted multiple digit numbers using regrouping with minimal assistance, and needed to increase counting back denominations of coins and bills. He was proficient at using a calculator for adding and subtracting.

He understood where to catch the city bus for one route, but needed to learn additional routes, times, and how to make transfers. He could order and pay for food at restaurants and access community buildings such as the YMCA and library and could locate items in grocery stores and most departments of stores. He was independent with his personal care and was learning to operate a washer and dryer. He could follow simple recipes and was working on reading and setting temperatures and cooking times based on package directions as well as to prepare a healthy snack, breakfast, and lunch.

Emeril participated in physical education daily and swam once a week. He enjoyed interacting with peers and adults, initiated conversations, and demonstrated a sense of humor. His needs included using the correct volume when speaking, taking time to formulate his thoughts before speaking, and to remain on topic. He gave out imaginary “crystals” to show affection to others.

Wynona was 20 years and 10 months of age at the end of the study. She was diagnosed with a moderate intellectual disability (IQ 44, Stanford-Binet Intelligence Scales—Fourth Edition: Thorndike, Hagan, & Sattler, 1986; Adaptive Behavior Composite Score 58, Vineland Adaptive Behavior Scales: Sparrow et al., 1984]. She was able to read and follow a daily written checklist as well as functional words in the categories of safety, meal preparation, and restaurants. Her needs included increasing her sight word vocabulary on a primer level and to read new functional words. She was able to shop from a written list and make purchases. She was able to write her first and last name and was working on writing her middle name. She also wrote her address and phone number and some simple words such as “ice” and “milk.” She could formulate grocery lists with additional words with assistance. She recognized coins and values and counted basic combinations with the same coin values. She also used the “next dollar strategy” when making purchases. She could tell time on the hour and half hour using an analog clock and therefore used digital watches and clocks.

She required supervision when cooking, but could enter the times on a microwave when verbally prompted or given a written cue. She was learning to sort clothing and to use a washer and dryer. She took care of her personal needs, but wore a jacket or coat in hot weather and required reminders for completing hygiene tasks. She frequently walked ahead of the group and needed reminders to look for traffic before crossing the street and was learning to state what bus was needed for a specific destination and the appropriate behaviors while waiting for and riding on public transportation. Wynona was previously employed at the YMCA cleaning exercise machines. She was very social and communicated effectively, but needed reminders for using an appropriate tone of voice and positive attitude with teachers and peers. She enjoyed playing...
basketball, shopping, using the computer to locate favorite animal sites and watching movies about animals.

Terah was 18 years and 10 months of age at the end of the study and had a diagnosis of cerebral palsy with left hemiplegia and a moderate intellectual disability. Her full scale IQ score on the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV; Wechsler, 2003) was 45. No information was available regarding her adaptive behavior skills. She read using a sight word approach and cues from the initial sounds in words, but struggled with decoding. She was able to answer simple comprehension questions from material read to her or which she read. She had legible handwriting and needed prompting to slow down with writing and to write larger letters. She was able to write basic demographic information and sign her name. She could write 3–4 word sentences with assistance for spelling words exceeding one syllable and used inventive spelling. She could identify both the subject and verbs in most sentences and was using capital letters and ending punctuation.

She was able to add two and three digit numbers using counters and two digit subtraction with simple regrouping. She used a calculator to add purchases and to figure change. She knew the values of coins and was learning to count coin combinations. She could also use the “Next Dollar Strategy” for making purchases. She could tell time using a digital clock, but only recognized the hour and half hour when using an analog clock.

She cared for her own laundry, cooked simple dishes (i.e., Ramen noodles, toast, eggs, and microwave dinners), and cleaned her own room. Her needs included selecting suitable clothing for occasions and weather and improving her selection of nutritional foods. She worked at McDonald’s cleaning the lobby and restrooms and was learning to use community resources such as a pharmacy for refilling her prescriptions, locating items and shopping independently in stores, riding the public bus, and opening a bank account. She was described as being eager to please, very social, and enjoyed “hanging out” with friends in the community and riding her bicycle.

**Materials and Equipment**

Age appropriate, functional reading words were targeted for the study. These words were selected from the software program *Grocery Words* by Attainment, Inc. Students were screened individually prior to the start of the study on their ability to read and manually spell words selected from this program. Words included those with and without multi-syllables, compound words, and multiple words ranging from 4 to 10 letters. During the screening, reading words were presented, one at a time on a PowerPoint slide in 32 point Calibri font on a Dell Latitude XT2 XFR Tablet PC (Figure 1) and students wrote spelling words using a pencil and an 8.5 in. × 11 in. piece of unlined paper.

From the screening list, 18 words were selected that the three students were unable to read or manually spell across three sessions (Table 1). The final 18 words were also selected from the pool of unknown words by showing students pictures of the items (i.e., photograph of paper towels) and asking, “What is this?” in order to identify items that were familiar to students and to test comprehension (Schlosser & Blischak, 2004). Finally, from this list of known photographs, students were asked to select photographs of items they or their families purchased in the grocery store. The words were divided into three sets of two words per student (6 total words per student). Set 1 contained words with 4–5 letters while Set 2 contained words with 5–7 letters and Set 3 contained words with 7–9 letters including multiple words. During pre and
post testing of generalization spelling, students wrote words with a pencil on the same type of 8.5 in. × 11 in. piece of unlined paper used during screening. Incidental reading of target and other students’ words were measured using words presented on the tablet PC computer using PowerPoint slides with individual words printed in 32 pt. Calibri font. During written spelling (intervention and measures of observational learning) students wrote words using a 5 in. long, 3/8 in. diameter digital pen on the flat screen of the tablet PC. During all spelling trials students were also shown the photograph of the corresponding target word on a single PowerPoint slide.

The multi-touch, tablet PC was selected because it allowed students to hand write on the screen rather than typing on a keyboard or onscreen keyboard or selecting words on a screen. Handwriting on the screen more closely replicated handwriting skills which could be used across environments. The tablet PC used in the study was described as a multi-touch convertible tablet PC by which the screen could be rotated into an upright, vertical position or flat, horizontal position resting above the keyboard (Figure 1). Students read words on the upright screen and wrote words in the horizontal position. Functions of the tablet PC allowed students to handwrite their spelling words onto the screen using the digital pen and drawing tool (Figure 2). PowerPoint slides presented the discriminative stimuli to students during CBI and CBI and observational probe sessions. Each slide contained a photograph corresponding to the student’s target word in the upper left hand corner and word/letter prompts, appropriate for the level of forward chaining being used by the student, next to the photograph (Figure 2). Each session included three trials for each student’s target words and three different photograph exemplars were provided per word on three separate slides. Photographs were obtained from the Google Images website. During small group CBI, photographs, word/letter prompts, and words written by students, were projected onto a large screen.

**TABLE 1**

<table>
<thead>
<tr>
<th>Target Spelling Words*</th>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emeril</td>
<td>tuna, syrup</td>
<td>celery, tissue</td>
<td>sausage, beef stew</td>
</tr>
<tr>
<td>Wynona</td>
<td>soda, bacon</td>
<td>razor, bagels</td>
<td>pudding, bar soap</td>
</tr>
<tr>
<td>Terah</td>
<td>chili, steak</td>
<td>shrimp, pickles</td>
<td>ravioli, sour cream</td>
</tr>
</tbody>
</table>

* Target spelling words of each student served as observational spelling words for other students

Figure 2. PowerPoint slide with drawing tool, digital pen, and example of student's written spelling word.

Figure 3. Example of image projected onto the large screen.
using a Sony digital projector mounted on the ceiling (Figure 3).

**General Procedure and Setting**

The forward chaining procedure was implemented to systematically teach spelling, letter by letter, of each word when using CBI. Each word was introduced during the first session of a new set of words whereby the student copied all letters, left to right. Criteria for fading letters, in a forward chaining format, was set at 100% correct, for one session. Letters were faded, one letter at a time and replaced by a single underscore (_) line. Figure 4 provides an example of six PowerPoint slides using the forward chaining procedure.

All pre and post-test and probe sessions were conducted individually with each student in a segregated classroom or faculty office in the education building on the university campus. The Transition Program for Young Adults was housed in a first floor classroom of the building. For these individual sessions the tablet PC was positioned in front of the student on a table or desk and the instructor sat to the left of the student. When present, the reliability data collector sat behind and to the right of the student. During generalization sessions, the pencil and paper were placed in front of the tablet PC closer to the student. All CBI sessions were conducted in a small group arrangement in the segregated classroom. The students sat next to each other, on the same side of the table facing the large screen on the wall. The tablet PC was placed on the table in front of the students and moved closer to the student whose turn it was to write (spell) a word. The instructor sat or stood behind the students, moving as needed between students to position the tablet PC in front of students. The reliability data collector sat behind and to the left of the group facing the screen.

**Response Definition and Data Collection**

**Spelling.** Data were collected on a student’s written response for each letter of each word during spelling probes and CBI sessions. The percentage of correct letters written in the correct sequence before the letter prompt was the dependent measure used to determine the effectiveness of the CBI package. Similar to the Constant Time Delay Procedure (Westling & Fox, 2009) the forward chaining procedure began with a 0 second delay whereby the first session for each set of new words contained the complete spelling of the word (see Slide 1, Figure 4). Therefore, the percent of letters written correctly, before the letter prompt, was always zero for the first session of each new set of words. Likewise, because only one subsequent letter prompt could be removed each session, only a gradual change in correct responding before the prompt could be obtained.

Responses for written spelling were measured across pre and post-test generalization probe sessions, probe sessions for observational learning of other students’ spelling words, probe sessions of target spelling words, and during CBI with target spelling words. Correct responses were defined as initiating writing a letter within 5 s of completion of a previous letter or presentation of the photograph and task direction (i.e., “spell ravioli”) and writing the correct letter within 5 s. An incorrect response was defined as failure to initiate writing a letter within 5 s of completion of a previous letter or presentation of the photograph and task direction; failure to write the correct letter within 5 s of initiation; or initiating within 5 s, but writing an incorrect letter. CBI errors were corrected by the instructor by providing a direct verbal cue (letter name).

**Reading.** Responses for reading words were measured across probe sessions for incidental learning of target spelling words and the target spelling words of other students. Correct responses were defined as reading a word correctly within 5 s of the word appearing on a PowerPoint slide and the task direction, “What word?” An incorrect response was defined as saying an incorrect word within 5 s of the word being presented on a slide or failure to say a word (no response) within 5 s of seeing the word on the slide.

**Experimental Design**

A multiple probe design across three sets of spelling words and replicated across three students (Gast, 2010) was used to evaluate the effects of a CBI package on the ability of stu-
Figure 4. Example of slide progression using the forward chaining procedure.
dents to: (a) manually spell target words; (b) learn to spell other students’ words through observation; (c) learn to read their target spelling words and the spelling words of other students (incidental learning); and (d) generalize spelling of target words to a medium of pencil and paper. The package included: (a) CBI using PowerPoint, multi-touch tablet PC, and a large screen presentation; and (b) forward chaining procedure. The forward chaining procedure teaches the first steps in the chain (i.e., first letter of a word) of a multi-step task (i.e., writing multiple letters in a word) by providing prompts or cues until the first step (i.e., letter) is mastered. The instructor then adds the next step (i.e., second letter) and provides instruction on the next step (i.e., second letter of the word) while the first step (i.e., first letter of the word) is performed independently and so forth until the entire chain of steps (spelling word) is mastered (Westling & Fox, 2009). The order of the conditions of the study was:

- Pre-test: Generalized spelling of target words and spelling words of other students;
- Probe 1: Target spelling words all sets; observation spelling of other students’ words; Incidental reading of target spelling words and spelling words of other students;
- CBI: Set 1;
- Probe 2: Target spelling words all sets; observation spelling of other students’ words; Incidental reading of target spelling words and spelling words of other students;
- CBI: Set 2;
- Probe 3: Target spelling words all sets; observation spelling of other students’ words; Incidental reading of target spelling words and spelling words of other students;
- CBI: Set 3;
- Probe 4: Target spelling words all sets; observation spelling of other students’ words; Incidental reading of target spelling words and spelling words of other students;
- Post-test: Generalized spelling of target words and spelling words of other students.

Pre/Post Test Procedures: Generalized Spelling of Target Spelling Words and Spelling Words of Other Students

Instructional spelling sessions in the current study occurred using a computer-based program. The multi-touch, convertible tablet PC was selected because it allowed students to hand write on the screen rather than typing or selecting words on a screen in order to more closely replicate handwriting skills which could be used across environments. The purpose of the generalization condition was to determine if the CBI program promoted generalization of spelling words to handwritten lists using a pencil and paper. Students were presented with their six target spelling words, the 12 spelling words of the other two students, and three known words, in an intermixed fashion (21 total words). Known words were included to encourage attention to task and motivation. Pictures corresponding to words were presented in random order one at a time, on a PowerPoint slide presented on the tablet PC. The instructor controlled progression of the slides and delivered the task direction, “Write the word ___” while the picture appeared on the screen. Correctly spelled words were verbally reinforced and general verbal reinforcement was provided for attempts to spell words. Each word was tested one time per session and testing was conducted for one session during the pre-test condition prior to the first probe condition and one session during the post-test condition following the last probe condition.

Probe Procedures

Target and observational spelling word probe procedures. Probe sessions to measure each student’s ability to spell their six words and the 12 words of the other students were conducted using the tablet PC with a multi-touch screen. All sessions were conducted individually with each student and during each session six target words and 12 observational words were presented in random order for three trials for each word. A picture, corresponding to the word to be spelled was presented on a PowerPoint slide and the instructor provided the task direction, “Write the word ___. Students were verbally reinforced for words spelled correctly and for general attempts to spell words. Three known words were also included to encourage attention and to provide reinforcement and motivation for spelling words. One session was conducted per day with three probe sessions being conducted
prior to the introduction of CBI with each new set of words and during the final Probe 4 session.

**Incidental reading of target and observational spelling words procedure.** In order to test incidental learning (reading) of words, students were presented with their six target spelling words, the 12 spelling words of the other two students, and three known words, in an intermixed fashion (21 total words). Known words were included to encourage attention to task and motivation. Words were presented in random order, one at a time, on a PowerPoint slide presented on the tablet PC. The instructor controlled progression of the slides and delivered the task direction, “What word?” when each word appeared on the screen. Correctly read words were verbally reinforced as well as verbal reinforcement for general attending to the task. Each word was presented three times per session and testing was conducted for three sessions during each of the four probe conditions.

**CBI Procedures**

Instructional sessions using the CBI program, with the tablet PC and large screen projection, were conducted in a small group arrangement after a minimum of three probe sessions with each student. Each session consisted of three trials per each student’s word plus one review trial for words of previously mastered sets. Each student completed his/her trial in sequence, one student at a time, moving left to right around the seating arrangement at the table. The instructor advanced the program to the next slide, secured the student’s attention, and delivered the task direction, “Write the word __.” Students were given 5 s to initiate and 5 s to write each letter of their word in sequence. Using the forward chaining procedure, students either copied a letter or wrote a letter on the tablet PC screen using the digital pen. Students were required to write all letters of each word during each trial in a left to right sequence. If students made an error, the instructor delivered a direct verbal cue (letter name) and the student then wrote the letter. If an incorrect letter was written on the screen the instructor used the “erase” function while delivering the verbal cue. Correct responses were followed by the instructor delivering verbal reinforcement after the entire word was written in order to not interrupt students’ writing of each letter. Students were also intermittently reinforced for attending to each other’s turns. Two students were required to be present in order for a session to be conducted and the instructor spelled the words of the student who was absent. Group criteria level of performance was used for moving from CBI to probe sessions of untaught spelling words. The group criteria was 100% correct (without letter prompts) for each student’s target word by all three students. Students who reached criterion before the other group members continued to spell their target words until all students reached criterion.

**Reliability**

Interobserver reliability data and procedural fidelity were collected during 27% of all probe and CBI sessions across participants. Interobserver reliability was determined by dividing the number of agreements (by the instructor and reliability data collector) on correct responses by the number of agreements plus disagreements and multiplying by 100. Percentage of agreement for all probe sessions was 98.9% (range = 98.5–100) and 99.6% for all CBI sessions (range = 97.6–100).

Procedural fidelity was collected on the instructor’s ability to follow the set procedures of the study across all conditions. Behaviors measured by the reliability data collector were: (a) gaining attention before delivering task directions; (b) advancing PowerPoint slides and delivering task directions; (c) providing appropriate latency and duration times for responding; and (d) correcting errors. Data were calculated by dividing the number of observed instructor behaviors by the number of planned behaviors and multiplying by 100. Mean procedural agreement was 99.6% (range = 98.3–100). Procedural errors occurred when the tablet PC ran out of power, an incorrect set of slides was shown, and when a letter was not faded on a slide. In addition, Terah provided verbal prompts to Wynona within 5 seconds before she wrote a letter.
Results

Spelling Target Words

Figures 5–7 show the percentage of correct responding (manual writing of letters) for each student during CBI. Data across all sets and students indicate that the CBI package was effective in teaching manual spelling of target words. All students reached criteria for each of their target set of spelling words and maintained their level of performance when using review trials of mastered words. While levels of responding remained low during probe sessions for Wynona across all sets, Emeril was able to manually write 31.3% of the letters in Set 3 prior to instruction and Terah wrote 46.2% of the letters of her target words in Set 2 (with an upward trend) prior to CBI instruction. All students were able to “sound out” some of the initial letters in words and Emeril learned to write “beef” in his third set following screening and before the first probe session. It appears that through repetitive exposure to reading words during multiple probe sessions or other inadvertent exposure to her target words, Terah began to learn to spell the word “shrimp” in Set 2 and “sour” in Set 3. Although students were able to write some of the letters, performance dropped to 0% during the first session of each new set due to the forward chaining procedure in which all letters of each word were visually provided on the PowerPoint slide. In addition, with the exception of Set 3, sessions to criteria and correct responses before the prompt, were also influenced by only fading one letter per session when following the procedure and pre-set criteria for fading letters. After five sessions using CBI in Set 3, two letters were faded per session.

Observational Learning of Other Students’ Words

Table 2 provides information concerning the effects of the CBI package in teaching students to manually spell the target words of other students which they observed on the large screen, but were not directly taught. The percentage of correct responding is provided across each probe condition prior to and following CBI with other students’ target words. As with their target words, students were able to sound out some of the initial letters in words prior to introduction of the words during CBI. In addition, correct spelling of non-target words also increased with subsequent probe sessions. In particular, Emeril and Terah began to correctly spell the words “pudding” and “soap” in Set 3 while Terah began to spell “beef stew” and Emeril began to spell “sour cream” in the third set of words.

Through observation, students learned to spell letters in other students’ target words with Emeril and Terah demonstrating the most noticeable change in correct spelling of other students’ words across all sets. Terah spelled over 90% of the target words of other students across all three sets immediately following CBI and Emeril spelled 74.7–93.1% of the target words of other students immediately following CBI. Wynona showed some improvement in spelling other students’ words in Sets 1 and 2 and over 50% of the target words of other students in Set 3 immediately following CBI. Of the three students she demonstrated the greatest level of distractibility and often talked to the other students during their turns. Her performance continued to improve over time and subsequent probe sessions with spelling words of other students from Sets 1 and 2 as did Emeril for spelling other students’ words from Set 1. Students continued to be exposed to the words of others during review trials of mastered words using CBI. Terah’s ability to continue spelling other’s words decreased slightly across Sets 1 and 2 during subsequent probe sessions as did Emeril’s performance across Set 2.

Incidental Learning of Reading Words

Data regarding students’ abilities to acquire information (reading of words) not directly taught or reinforced are presented in Table 2. Noticeable gains were made by each student following CBI to teach spelling of grocery related words. Prior to the introduction of CBI with the first set of words, students were unable to read any of the 18 words and showed visible improvements in performance for the first set of words following CBI. In subsequent probe sessions, students were able to correctly read some of their target words and the words of other students prior to introduction of CBI for each set of words. Improvement may have
been influenced by repeated exposure to words and pictures of words during these probe sessions. Levels remained low however, and increases in correct responding were evident following CBI to teach spelling of each set of words. During probe sessions immediately following CBI with a set of words, Terah read 100% of the words, Emeril read 98.1–
100% of the words, and Wynona read 79.6–100% of the words.

**Discussion**

The purposes of this study were to evaluate the effectiveness of CBI (multi touch tablet PC, PowerPoint, and large screen projection) combined with a forward chaining procedure to teach manual spelling of grocery store words and to measure students’ abilities to learn observational and incidental information within a small group arrangement using these technologies. At present, little is available in the research literature concerning effective spelling instruction for students with...
moderate intellectual disability and even less information on the use of CBI to teach this important skill to these students. It seems unclear whether poor spelling performance of students with moderate intellectual disability is due to inappropriate or inadequate instruction or to learning characteristics associated with their disability. Results of the current

Figure 7. Percentage of letters in words manually spelled correctly by Terah across three sets during probe and small group CBI sessions.
study demonstrate that students can learn to spell and retain correct spelling of words which would suggest that poor spelling performance may be a result of inappropriate instruction and perhaps under-utilization of currently available technologies.

Results also suggest that CBI can promote generalized use of learned information to non-technical or computerized materials. Students wrote 100% of their target words using paper and pencil during the post-test condition and errors committed with non-target words were comparable to those committed when using the tablet PC. These results may be important when students do not have access to a computer or printer. While students demonstrated no difficulty in writing words on paper, functionally, effects of the study should be measured by evaluating students’ abilities to compose an actual grocery list and use it to shop for items in a store.

Other findings from the study support earlier outcomes on the use of a large screen to promote observational learning of information by students with disabilities (Campbell & Mechling, 2009; Mechling et al., 2007, 2008) whereby two of the students in the current study learned to spell most of the words of other students and one student learned over 50% of the letters in other students’ words when using a small group arrangement with words projected onto a large screen. Although students did not spell these non-target words with 100% accuracy, research suggests that students will learn to spell words more quickly if they have already learned some of the letter sequences (Morris, Nelson, & Perry, 1986). In the current study students further learned to read grocery words presented incidentally as antecedent information through photographs corresponding to the target words and instructor delivered task directions (e.g., “spell bacon”) while the word was present on the tablet PC and large screen. These results further extend the literature suggesting that spelling instruction facilitates oral reading (De Rose, De Souza, & Hanna, 1996; Kinney et al., 2003; Vedora & Stromer, 2007).

It should be recognized, however, that learning was occurring prior to direct exposure to spelling words. One of the purposes of the multiple probe design, used in the current study, is to reduce the potential for effects on dependent variables through repeated measurements under non-treatment conditions. Nevertheless, it appears that even with fewer probe trials, learning did occur. Through repeated exposure during probe trials or perhaps environmental print, students learned to spell and read words such as pudding, sour cream, bar soap, and beef stew before the words were introduced.

**TABLE 2**
Percent Correct for Observational Spelling Words and Incidental Reading of Words

<table>
<thead>
<tr>
<th></th>
<th>Spelling Words</th>
<th></th>
<th></th>
<th></th>
<th>Reading Words</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probe 1</td>
<td>Probe 2</td>
<td>Probe 3</td>
<td>Probe 4</td>
<td>Probe 1</td>
<td>Probe 2</td>
<td>Probe 3</td>
<td>Probe 4</td>
</tr>
<tr>
<td>Emeril</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 1</td>
<td>10.5</td>
<td>89.5</td>
<td>89.5</td>
<td>93</td>
<td>0</td>
<td>98.1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Set 2</td>
<td>11.1</td>
<td>25.9</td>
<td>93.1</td>
<td>71.7</td>
<td>0</td>
<td>25.9</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Set 3</td>
<td>12.5</td>
<td>53.8</td>
<td>35.8</td>
<td>74.7</td>
<td>0</td>
<td>35.2</td>
<td>48.1</td>
<td>98.1</td>
</tr>
<tr>
<td>Wynona</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 1</td>
<td>10.5</td>
<td>49.7</td>
<td>87.7</td>
<td>83.6</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Set 2</td>
<td>5.3</td>
<td>7.6</td>
<td>23.1</td>
<td>64.9</td>
<td>0</td>
<td>22.2</td>
<td>79.6</td>
<td>98.1</td>
</tr>
<tr>
<td>Set 3</td>
<td>1.7</td>
<td>2.0</td>
<td>15.2</td>
<td>58.2</td>
<td>0</td>
<td>0</td>
<td>11.1</td>
<td>98.1</td>
</tr>
<tr>
<td>Terah</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 1</td>
<td>22.2</td>
<td>98.1</td>
<td>94.4</td>
<td>97.5</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Set 2</td>
<td>1.4</td>
<td>2.9</td>
<td>90.3</td>
<td>88.9</td>
<td>0</td>
<td>33.3</td>
<td>100</td>
<td>98.1</td>
</tr>
<tr>
<td>Set 3</td>
<td>17.9</td>
<td>26.9</td>
<td>49.5</td>
<td>94.6</td>
<td>0</td>
<td>13</td>
<td>31.5</td>
<td>100</td>
</tr>
</tbody>
</table>

Bold indicates performance immediately following CBI.
An additional consideration when examining the results is that the effects of the components parts of the CBI package cannot be separated out. One possible explanation for the results was the application of the forward chaining procedure which has long been used to teach multi-step skills. The current study provided a unique application of this procedure to spelling although efficiency of the program may have been compromised, in terms of sessions to criteria, by minimizing the number of new letters introduced at one time. Practitioners may find that students will maintain high levels of correct responding even when more than one letter is faded at a time, allowing acquisition of more words in a shorter amount of time while not negatively affecting the observational learning of other students. Other components of CBI, in combination with appropriate instructional procedures, may have contributed to the results. While word processing without writing may be used to ease the physical process involved in writing (MacArthur, 2000), the current study explored use of a multi-touch screen tablet which allowed students to directly write on the tablet (rather than touching letters or using a mouse) in order to assist with generalization to a written list. Use and availability of multi-touch screen tablets which use touch input through a finger or pen continue to increase, and their features, which may reduce the input and output demands of tasks for persons with disabilities, should continue to be explored.

Combining traditional procedures such as forward chaining with current technologies provide encouraging new approaches to instruction. Ease of development (e.g., downloading multiple photographs from Google Images) and modification of materials (e.g., deleting a letter in a word on a PowerPoint screen) to meet instructional needs of students were appreciated in the current application. One limitation of the study is that only six words per student were taught. Future applications may wish to further evaluate the procedure with a larger number of target words.

Whereas future research may wish to isolate variables of the current CBI program, the program package was designed to teach young adults with moderate intellectual disability to manually spell six words along with the acquisition of non-target information (spelling other students’ words and increasing reading of words). Despite the fact that most literacy instruction for persons with disabilities focuses on reading rather than spelling (Vedora & Stromer 2007) and students often fail to receive adequate instruction in this area (Joseph & Konrad, 2009), results of the current study indicate that high school age students can increase their ability to manually spell words using technology aids. In addition to functional use of spelling for activities such as shopping, in the world of technology based access, persons with disabilities can apply their knowledge of spelling to such activities as: (a) typing the initial letters in words and selecting from a drop down menu of words in order to access a website or YouTube video or; (b) using invented spelling (i.e., “r” for “are”; “u” for “you”) to text a message to a friend. Further evaluation of technology applications to support independent spelling of learners with moderate intellectual disability, should be considered in light of the increase in text based technology such as texting, social media (i.e., Facebook and Twitter), and internet access.

References
Cuvo, A. J., Ashley, K. M., Marso, K. J., Zhang, B. L.,


Stromer, R., & Mackay, H. A. (1993). Delayed iden-
tity matching to complex samples: Teaching Students with mental retardation spelling and the prerequisites of equivalence classes. Research in Developmental Disabilities, 14, 19–38.


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