Teaching Number Identification to Students with Severe Disabilities using Response Cards

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Abstract: Active student responding (ASR) has been shown to be an effective way to improve the mathematical skills of students. One specific method of ASR is the use of response cards. In this study, a system of least prompts combined with response cards was used to increase mathematical knowledge, and number identification, of three elementary students with significant disabilities (age range, 7–10 years, IQ range, >20–44) via a multiple probe design across participants. A functional relationship was demonstrated between student responding (increased number identification) and the implementation of the least to most prompting system. Maintenance checks, after the intervention was concluded, demonstrated that the skill level was sustained. Limitations and future research are discussed.

Students’ learning academic skills is a priority among all populations of students. Finding the educational experiences that are appropriate for each student is very important for educators (National Commission on Excellence in Education, 1983). In fact, Spooner, Dymond, Smith, and Kennedy (2006) suggest that over the past decade, accessing the general curriculum has become a major focus of investigators trying to build more effective educational systems for students with significant cognitive disabilities. Historically, students with severe disabilities have attended school with an emphasis on learning functional living skills (Browder et al., 2003; Brown, Nietupski, & Hamre-Nietupski, 1976). Until recently, the need for students to learn academic skills was not considered an important part of the curriculum (Browder et al.; Browder & Spooner, 2003; Browder, Spooner, Wakeman, Trela, & Baker, 2006). With the reauthorization of the Individuals with Disabilities Act (IDEA, 2004) all students with disabilities, no matter the severity of their disability, are required to have access to the general curriculum (IDEA). Not only is access required, but also students with severe disabilities must be assessed in grade level extensions of reading, mathematics, and science. Mathematics skills can often be complex to learn and for educators it is important that the right method of teaching be used. One way that teachers attempt to increase a student’s knowledge in mathematical skills is through active student responding (ASR).

Active student responding involves participating in class by asking and answering questions (Maheady, Michielli-Pendl, Harper, & Mallette, 2006). Jerome and Barbetta (2005) consider an “active student response as an observable, measurable student response to an instructional antecedent” (p. 13). This is a method of teaching that is used mostly by the general education teachers, but has started to be used by others. It is used to increase student learning in the general education classroom and has started to carry over to the special education classroom setting. Berrong, Schuster, Morse, and Collins (2007) demonstrated this by using response cards in self-contained special education to increase ASR. This is an easy method for the teachers to engage students in their learning. It also allows for an alternative form of answering for students that may be less inclined to respond when answering in front of groups. Having students to actively respond to questions opens many doors of learning for all students in the setting. During active student respond-
ing, it is important to look at methods of responding to include all students. The method in which a student responds also will play a key role in their academic success (Horn, Schuster, & Collins, 2006). One method of increasing ASR in students who are either nonverbal or who are severely limited in this regard is response cards (Berrong et al.).

Response cards are a teaching strategy that creates a non-judgmental learning environment for students. Heward et al. (1996) describe response cards as cards, signs, or other low tech items that are simultaneously held up by students in the class to display their response to questions presented by the teacher. Several studies have been conducted using response cards to increase ASR (Cavanaugh, Heward, & Donelson, 1996; Gardner, Heward, & Grossi, 1994; Heward et al.; Narayn, Heward, Gardner, Courson, & Omness, 1990). These studies report on the effects of response card use in the classroom. In addition, response cards have been used to increase academic responding for students with disabilities (Berrong et al., 2007).

One study that examined using response cards with individuals with disabilities was conducted by Horn et al. (2006). Specifically, the authors looked at using response cards to teach telling time to students with moderate and severe disabilities. The study was conducted with three middle school participants and took place in the student’s self-contained classroom where each student was given a laminated flip board that resembled a clock. The authors used an ABAB design to report the effectiveness of the students’ use of response cards. The results showed that response cards greatly influenced active student responding and also increased the student’s acquisition of telling time. Increasing ASR through response cards is one effective way to teach math skills, although investigators indicate the need to teach items systematically to students with severe disabilities.

One way to systematically teach students with severe disabilities is to use a system of least prompts. This strategy is beneficial when teaching concepts or skills. System of least prompts is a strategy that consists of a target stimulus, hierarchy of at least two prompts, and an opportunity for the student to respond independently (Ault, Wolery, Doyle, & Gast, 1989; Collins, 2007; Doyle, Wolery, Ault, & Gast, 1988). System of least prompts has been used to teach chained and discrete task to students with severe disabilities (Ault et al.; Collins; Doyle et al.).

One study conducted by Taber-Doughty (2005) focused on using a system of least prompts to teach the skills needed to use a copy machine and a debit machine. Participants included five high school students with mild to moderate mental retardation, although student attrition occurred with two students during the pre-training phase for various reasons. The study took place in the student’s domestic living area of their high school. Dependent variables in the study were student use of a debit machine to make a purchase and students ability to operate a large copy machine. The independent variable used to complete the purchasing and coping tasks were the system of least prompts, a self operated picture prompting system, and a self-operate auditory prompting system. An alternating treatment design was used to report the effectiveness of the prompting systems on skill acquisition. Results of the study indicated that all prompting systems were effective and efficient in the student’s ability to complete the two novel task and all students increased independence. In addition, outcomes showed that when the student had a choice they also increased in acquisition and decreased in duration for time to complete the task. Although this study used a system of least prompts to teach a functional skill, the system of least prompts also has been used to teach academic skills in the area of mathematics.

In another study, Colyer and Collins (1996) used natural cues within a system of least prompts to effectively teach using the next dollar strategy to four students with mild to moderate intellectual disabilities ages 12 to 15. The study took place in the coaches office of the students’ high school gym, with some sessions conducted in the classroom. The authors used a multiple probe across participants design to report the percentage of student’s correct response using the next dollar method. The method was taught using the system of least prompts by natural cues for prompting. The results of the study show that
there was a functional relationship between the system of least prompts and acquisition of the next dollar strategy for three of the four students. The three students were also able to generalize and maintain the next dollar skill. This study helps to effectively show that the system of least prompts can be used to increase money skills in a student with cognitive disabilities.

Even with all of the studies conducted on the effectiveness of response cards with students and the use of a system of least prompts when teaching a skill, research is limited in using a system of least prompts to teach using response cards for academic skills in students with severe disabilities. The majority of studies completed on response cards to increase active student responding have been with general education students. For example, Gardner et al. (1994) and Narayn et al. (1990) looked at using response cards in the general education classroom to increase the student’s participation and knowledge of a subject on the student’s daily quizzes. Currently, there is a lack of research using response cards specifically targeted to increasing math skills with students with severe disabilities. There are many studies looking at the effectiveness of using the system of least prompts to increase a students learning in academic areas; however, not many have focused specifically on math. For example, Karsh, Repp, and Lenz (1990) looked at using a system of least prompts to teach a word recognition skill to students with considerable cognitive deficits. In addition, Colyer and Collins (1996) did look at using a system of least prompts to increase math skills; however, it was with middle school age students and did not employ the use of response cards. To date, no research has combined the use of system of least prompts and response cards to increase mathematics skills in elementary students with significant cognitive disabilities. Therefore, the purpose of this study will be to address the paucity of research in this area by examining effects of response cards and a system of least prompts on numeral identification with elementary grade students with severe disabilities.

**Method**

**Participants**

Participants were three students with severe disabilities. Allison and Vicki attended the same class in one classroom for students with severe disabilities. The teacher of this classroom was appropriately licensed to teach students with significant disabilities. Two teacher assistants are also assigned to this classroom. Josh attended class in a similar classroom in the same school. This classroom also had a teacher with a license in severe disabilities and two teacher assistants. Classrooms are housed in a separate educational environment at a separate public school for students with severe disabilities. Allison was a 10 year old female with severe intellectual disabilities, and has an IQ of less than 20 with scattered skills. Josh was a 7 year old male student with multiple disabilities that has an IQ of 44. Vicki was an 8 year old female with multiple disabilities that has an IQ of less than 20. Students were aware that the numerals were numbers but could not independently identify the numerals presented on a consistent basis before the study took place. All students were able to make a distinct choice of two cards for answering of questions.

**Setting**

The setting was a separate public school in an urban area in the Southeastern United States. The intervention took place in the each student’s separate learning environment classroom. Allison and Vicki were in the same classrooms that consisted of small class setting with eight students. There were teacher assistants in each classroom to assist during the intervention. There was a section in each room with a table separate from other learning areas. This area of the rooms was set up to be less distracting than play areas in the room.

**Materials**

Materials used in the study consisted of response cards and were the same in the baseline and the intervention. Response cards for the students were preprinted. They were made on 5 in. × 7 in. cardstock paper. Numbers on the cards were printed in large black ink with nothing else on the card. They were laminated for durability during the study. The presenter’s cards were printed on a white 8.5 in. x 11 in. sheet of cardstock paper. Cards were also printed in large black ink in the
same font type as on the student’s cards. They also had symbols on them to represent numbers (e.g., three balloons, two hearts, etc) in addition to the number. These cards were also laminated for durability during the study.

**Experimenters**

Both classroom teachers served as the two experimenters that conducted this study. Both experimenters are highly qualified classroom teachers of each of the participants involved. Each teacher holds a teaching licensure in Special Education. The experimenters have had seven or more years of experience working with students with significant cognitive disabilities. Each experimenter was trained to mastery in the prompting system used in the intervention.

**Data Collection Procedures**

**Dependent variable.** The dependent variable was the number of correct response using response cards to answer mathematics questions on number identification for numerals 1–5. The participants had three cards each with a different numeral lying in front of them. The teacher said “show me number X (e.g., 4)” (the teacher did not hold up the card until the students have had a chance to respond). An independent response was coded as an “I” on the data sheet. The dependent variable was counted as incorrect if the student did not make a choice or picked the wrong number. In addition the prompting level required was recorded on the data sheet (i.e., $V$= verbal prompt, $M$= model prompt, $PP$= partial physical prompt, and $FP$= full physical prompt). Any prompt required was considered a prompted correct response and was not counted in the final total of correct responses. There was no prompting or assistance offered to the student in baseline as the prompting system used is the independent variable. The dependent variable was measured by using an event recording procedure. The experimenter marked the correct and incorrect responses for each session. The dependent variable was measured across all participants (see Table 1).

**Inter-observer reliability.** Inter-observer reliability took place during the baseline and the intervention phases. One of the researchers recorded participants performance every third session. The observers were trained to mastery in understanding what a correct, prompted, and incorrect response looked like and how to code each. Inter-observer reliability will be set at 90% or above. The gross method was used to calculate the reliability by dividing the number of agreements in a session by the number of agreements plus disagreements and multiplying by 100% (Tawney & Gast, 1984).

**Social validity data.** Social validity data were collected to measure the sound acceptability of the procedures and outcomes of the intervention. It was measured by a teacher and student survey. The teachers completed a questionnaire based on a rating scale at the completion of the study. The student also answered a very simple questionnaire by responding yes or no to each question in method that is familiar to the student (e.g., yes and no response cards on slant board).

**Experimental Design**

The experimental design was a multiple probe across participants (Horner & Baer, 1978; Tawney & Gast, 1984). Participants all started in baseline at the same time. Baseline data were collected for three sessions for Allison, with probes after the third session for Josh and Vicki. A session consisted of 3 trials; each trial presented the numbers 1–5 in random orders each time. There was a short wait time of 2 to 5 seconds depending on participants in between each trial. The participant who had the lowest amount of responses given and a stable baseline was the first one to receive the intervention. The intervention did not begin on the second participant until the first participant, already in the intervention, completed 3 consecutive sessions of at least 9 out of 15 correct responses. This was repeated for the next participant, and so on, until all participants were in the intervention stage. Students stayed in the intervention stage until they had successfully had four sessions of 11 out of 15 correct responses. Maintenance data was collected two weeks after the intervention phase ends. This was done by asking the student to use response cards to identify a number without any prompting.
Procedure

Baseline. During baseline, data were taken every day for a minimum of three days. All participants entered baseline at the same time. Each teacher conducted two teaching groups in two separate environments consisting of 2 to 3 students each. Data was only taken on the participants. Allison was in group one with teacher one and 1 to 2 other students not participating in the study. Josh was in group two with teacher two and 1 to 2 other students also in room two who were not par-

| TABLE 1  |
| Data Collection for Math Response Cards |

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Assessor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prompt level used: Verbal Model Physical and number presented</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Independently identifies first number after number is presented (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Independently identifies second number after number is presented (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Independently identifies third number after number is presented (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Independently identifies fourth number after number is presented (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Independently identifies fifth number after number is presented (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
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<tr>
<td></td>
<td>6. Independently identifies sixth number after number is presented for a second time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Independently identifies seventh number after number is presented for a second time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
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<tr>
<td></td>
<td>8. Independently identifies eighth number after number is presented for a second time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Independently identifies ninth number after number is presented for a second time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
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<tr>
<td></td>
<td>10. Independently identifies tenth number after number is presented for a second time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
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<tr>
<td></td>
<td>11. Independently identifies 11th number after number is presented for a third time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
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</tr>
<tr>
<td></td>
<td>12. Independently identifies 12th number after number is presented for a third time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. Independently identifies 13th number after number is presented for a third time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14. Independently identifies 14th number after number is presented for a third time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15. Independently identifies 15th number after number is presented for a third time (+ = correctly identifies; - = does not correctly identify, NO=no opportunity)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prompt level used: Verbal Model Physical and number presented</td>
<td></td>
</tr>
</tbody>
</table>
ticipating in the study. Vicki was in group one
with teacher one and 1 to 2 students in room
one who were not participating in the study.
The participants were asked to come to a table
and sit down with their group or taken by the
teacher to the table. Each group participant
had three response cards lying on the table in
front of them. The teacher was directly in
front of the students. The teacher informed
the students that they would be asked to iden-
tify a number by holding up the card with the
 corresponding number, said by the teacher.
The teacher said, “Show me number 4.” The
 students were given no more than five seconds
to attempt an answer. No prompt or corrective
 feedback was given during baseline. Praise was
offered after 5 seconds for any effort made
during the trials. Baseline continued for all
students until student one had stable data for
3 consecutive sessions. Each session consisted
of 15 trials offering numerals 1–5 three times
each to the targeted student.

Intervention. The intervention was the use
of a least-to-most prompting system to teach
students to make the correct response with
the response cards. The teacher told them, “I
will tell you a number and you need to hold
up the card with a correct number 1–5 on it.
The teacher would ask all of the students in
the group “show me number 4.” The target
student was given 5 seconds to make an at-
tempt to answer the question by raising the
correct card with the same number as the
teacher has presented. When a student an-
swered the question correctly the teacher
would praise the target student. If the student
started heading to a wrong response the
teacher would block student’s response and
redirect the student to the correct answer. If
the student offered no response within the 5
seconds the teacher would move to a verbal
prompt of “find the number that matches
mine” and again wait another 5 seconds. If the
student indicated the correct response after
the verbal prompt the student was praised. If
the student still provided no response the
teacher would model “Which number
matches mine?” and point to the correct an-
swer and again wait five seconds for the
students to respond. If there was still no answer
from the student than the teacher would give
the student a full physical prompt while saying
“The number that matches mine is this one”
while providing a descriptive response about
the correct answer (e.g., “see my card has two
balloons, one, two, and this card you have the
number two, so this is the correct answer”).
The wait time between each trail varied for
each student. The intervention continued un-
til the students have 11 out of 15 correct re-
sponses for 4 consecutive sessions.

Maintenance. Maintenance data were
gathered two weeks after the students in the
intervention phase had consecutive sessions of
11 out of 15 correct responses. The students
were asked to respond to math questions of
identifying numbers using response cards.
They were not given any verbal or physical
refreshers to help them recall the informa-
tion.

Procedural fidelity. Procedural fidelity was
gathered by one of the researchers each time
inter-rater reliability was collected. A proce-
dural reliability checklist was used to collect
data on the exact steps the teacher used to
teach the intervention in order to monitor the
teacher’s steps in the intervention. In addi-
tion, procedural reliability was taken during
the teacher training for the least-to-most
prompt system.

Results

Agreement. Procedural fidelity for the im-
plementation of the teacher training session
was 100%. Teacher 1 had 95% procedural
fidelity for implementation of the system of
least prompts. Teacher 2 had 97% procedural
fidelity for implementation of the system of
least prompts of 97%. Interobserver agree-
ment for the students’ responding was 95% for
Allison, 97% for Josh, and 97% for Vicki.

Student data. Figure 1 shows each stu-
dent’s independent correct responses for the
numerical identification. During baseline, Al-
\[ M = 8.4, \text{ range of 5 to 13} \] . During
baseline, Vicki correctly responded indepen-

Figure 1. Independent responses across students.
dently to the numerical identification with a mean of 4 correct responses and a range of 1 to 6. After intervention, the responses increased \((M = 9, \text{ range of 4 to 12; see Figure 1})\).

**Maintenance.** Figure 1 shows each participant’s maintenance for the numeral identification. All three participants maintained their data during maintenance (i.e., \(M = 11.5\) for Allison, \(M = 12\) for Josh, and \(M = 11\) for Vicki).

**Social validity.** The classroom teachers completed a social validity questionnaire. Results indicated that all teachers strongly agreed the teaching strategy improved the participant’s ability to answer without having a verbal response. In addition, teachers reported the study offered adequate preparation of presentation materials to students which created more consistent and correct answers. Finally, both teachers indicated that they would use this teaching strategy for other students in their class. One suggestion mentioned the desire for the response cards to be colorful and exciting to students.

Participants also contributed to the social validity outcomes. Overall participants reported that they enjoyed using the response cards. They all stated that they would enjoy using the response cards in other subject areas being taught.

**Discussion**

Participant data compiled from this study indicated that the effect of response cards and a system of least prompts increased overall numeral identification among students with severe disabilities. This is the first study to combine the method of ASR and the system of least prompts to exhibit increased numeral identification. In addition, this is one of the few studies to look at using a response card method with students with severe disabilities (e.g., Horn et al., 2006). Although, investigations of the effects of response cards on student responding are abundant, students with severe disabilities have been largely left out of this research. Additionally, this is one of the few studies to look at teaching a specific math skill to elementary students using both methods.

The findings of this study could be explained by the fact that the students were systematically taught the numeral identification through a system of least prompts while responding through the use of response cards. Colyer and Collins (1996) demonstrated in their study that students could effectively be taught mathematics skills through a system of least prompts. They successfully taught money skills to students by focusing on the system of prompts. As in this study, students were given the opportunity to answer with prompting when needed until the student could independently answer the task direction (i.e., presentation of the numeral and command to “find the one that looks like mine”) and the prompts were systematically faded over teaching trials resulting in skill acquisition. Students also demonstrated improvement in answering with the response cards, which is consistent with Berrong et al. (2007) when the authors suggest “response cards have positive effects not only in terms of increased students’ responding and accuracy of student’s responding, but also in an increased student academic learning” (p. 189).

It is important to note the possible limitations of the study. First, it only focused on a limited amount of numerals being taught. Students were only given the numerals 1 to 5 to learn with no addition of other numerals during the study. Teachers stated that students became satiated with exposure to the numerals after a period of time, which resulted in a decreased interest in the activity. During a teaching session, typically the students would be actively engaged in the activity, but engagement decreased after the fourth or fifth presentation of the teaching trail. Future research is needed that looks at the effects of this teaching strategy on additional numerals (e.g., 1–10) being presented to the students. Research is also needed on the use of this teaching strategy in other areas of math (e.g., greater than, less than; decimals) and other content areas such as sight words and sentence building.

A second limitation of the study was that there were only a limited number of students and, therefore, additional replications are necessary. Third, Allison had an extended absence due to illness and all students had a school production that interfered with consistent teaching of numerals. Fourth, the study...
only took place in one particular setting of the student’s classroom. Future research is needed that allows for generalization of the skills that are being targeted to other instructors, other settings, and other types of response cards. In addition, this study also could be replicated using students with severe disabilities in grades other than elementary, focusing on the combination of response cards and a system of least prompts.

In conclusion this study adds to the limited research on the use response cards and systems of least prompts for students with significant cognitive disabilities. It offers insight to teaching students with severe disabilities specific academic skills through a system of least prompts. It also offers support to practitioners by providing a method of instruction that allowed students a new way of displaying their knowledge through active student responding (i.e., response cards). As more research is needed to sustain the strategy of combining the two methods to teach academic skills to students with significant cognitive disabilities, the results of this study should provide practitioners the information needed to use a system of least prompts combined with response cards in their classrooms to teach a variety of academic skills.

References


Karsh, K. G., Repp, A. C., & Lenz, M. W. (1990). A comparison of the task demonstration model and the standard prompting hierarchy in teaching word identification to persons with moderate re-

Received: 15 September 2009
Initial Acceptance: 28 November 2009
Final Acceptance: 2 March 2010