Learning Channel Intervention to Develop and Generalize Fluency in Multiplication Facts

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Abstract

This study demonstrates that the learning channel intervention, utilizing a continuous assessment system, enabled 3 students with special needs to build and generalize fluency in multiplication facts. This study contrasts generalization of 2 learning channels- “see-say” and “hear-say”- to see if either of the 2 channels has an advantage over the other. The data from this study suggests that the particular learning channel was influential in generalization to application. The findings of this study indicate the “hear-say” learning channel has an advantage in the generalization of learning over the “see-say” learning channel. However, this preliminary finding suggests further studies employing a design in which two intervention modes can be alternated in 2 groups of participants.
KEYWORDS: learning channels, fluency, generalization, continuous assessment, multiplication facts, SAFMEDS.

Many students lack fluency in basic math skills, thus their performance requiring applications of those skills become slow, tedious, and erroneous. Dysfluent basic math skills may even limit and prevent acquisition of advanced math skills that depend on those skills (Binder, 1996; Haughton, 1972; Starlin, 1972). For example, those students not fluent in the multiplication tables will have recurring failures with multiplication and division facts.

Fluency can be defined as the ability to perform skills and demonstrate knowledge both accurately and speedily without hesitation (Binder, 1990, 1996; Haughton, 1980). Skinner (1986) indicated the school, especially at the elementary level, has some responsibility for developing fluency in the basic skills that students will need for more complex learning at later levels. The National Council of Teachers of Mathematics (NCTM, 2000, p.32) also signifies the importance of fluency in its standards, “understanding number and operations, developing number sense, and gaining fluency in arithmetic computation form the core of mathematics education for the elementary grades.”

In a typical education system, however, mastery is measured in terms of accuracy rate and students move to a next level when they acquire a certain rate of accuracy (e.g., 80%) without ensuring a fluency level. In this situation, students are usually not challenged to learn mental calculation but to be dependent on less efficient calculation methods. Particularly students with mild disabilities are often found using counting strategies (e.g., finger counting) to solve basic math facts (Casey, McLaughlin, Weber, & Everson, 2003; Skinner, Turco, Beatty, & Rasavage, 1989). NCTM (2000, p.32) recommends that mental computation in basic number skills be fluent to enhance the problem-solving process. While collecting data, it was observed that most students, who were severed in a pull-out special education program, depended on their finger-counting strategy to solve multiplication facts.

Students with disabilities, especially those with mental retardation and learning disabilities, have difficulty generalizing their learning to settings or situations that differ from the context in which they first learned those skills (Heward, 2006, p.147; Binder, 1996; DuVall, McLaughlin, & Sederstrom, 2003). Lin and Kubina (2004) described a particular problem related with learning channel where a student learned to answer addition problems visually, a “see-write” channel, but when teacher asked the student to answer orally, a “hear-say” channel, the student could not respond correctly. Such transfer or generalization of learning can be improved with a specific intervention involving ongoing measurements monitoring how students are making progress in one channel and how they transfer the learning to other learning channels.

A learning channel represents the "input" sensory modality involved with a stimulus and the "output" sensory modality or behavior contained in the response (Haughton, 1980; Lindsley, 1998, p.181). One advantage of using learning channels is to provide precise information about how learners learn and respond in terms of input and output sensory modality (Haughton, 1980; Lindsley, 1998; Lin & Kubina, 2004).

In math curriculum, the learning channels, "see-say," "see-write," "hear-say," and "hear-write" are the ones utilized most often in the classroom (Binder, 1996). Unfortunately, in most classrooms, students are instructed in a see-say or a hear-say learning channel, but then they are required to demonstrate learning through another channel. Often students are asked to read a multiplication fact on paper and expected to write the answer, a see-write learning channel. Little is known about how well students generalize learning when the channel for assessment is different from the channel of instruction. It is also unknown if any one learning channel has an advantage over other channels for generalization of learning.

A learning channel intervention, utilizing a continuous assessment system of response to instruction, was implemented to help students with special needs in the development and generalization of their fluency in multiplication facts. This study examined generalization of two learning channels- "see-say" and "hear-say"- to see if either of the two channels has an advantage over the other.

Method

Participants

The participants of this study were three students with special needs served in a resource/pull-out special education program. A pre-test was given to each of the six children initially recommended for the study to determine their proficiency with multiplication tables. The three students who scored less than 80% accuracy or took more than 2 minutes to complete any of the multiplication tables were selected for the study.

Rick is an 11-year-old male in 4th grade. According to the Stanford-Binet Intelligence Scales, he has an IQ of 64 and qualifies for services under the exceptionality of mental retardation. His teachers describe him as weak in both visual and auditory memory and as having difficulty in remembering learned information. Rick specifically demonstrated difficulty in performing multiplication tables while in class.

Jamie is a 10-year-old female in the 3rd grade. She has an IQ of 70 using the Stanford-Binet Intelligence Scales. She has been identified as a student with a specific learning disability in the areas of reading, writing, spelling, and math. She displays difficulty in learning and remembering basic math facts.

The last student is Lenny, a 12-year old male in the 4th grade. The school system has identified him as having a primary exceptionality of mental retardation and a secondary disability of emotional behavior disorder. According to the Stanford-Binet Intelligence Scales, he has an IQ of 68. His records indicate that his math skills are on 3rd grade level, but he is struggling to learn the multiplication facts. He has a tendency to do his work fast but he makes a lot of mistakes.

Procedures

The procedures of this study were decided by student response during the intervention and not predetermined by the researchers. The students' response to instruction was monitored through daily charting of individual performance and written tests. The procedures resulted in the following sequence: a pre-test, see-say intervention, post-test #1, hear-say intervention, post-test #2, and a follow-up test.

Pre-Test

A pre-test was given to the students the day before introducing the learning channel intervention to examine the effects of the intervention on the post-tests. The pre-test also determined the participants' proficiency level with the multiplication tables included for the intervention. A pre-test consisted of five sheets, one each for the 2, 3, 4, 5, and 6 multiplication tables. Each sheet contained 20 single-digit multiplication questions for each of the multiplication tables.

See-Say Channel Intervention

The see-say channel intervention involved the SAFMEDS strategy that has been effective in building accurate and fluent performance in basic academic skills with diverse populations (Byrnes, Macfarlane, Young, & West, 1990; Casey et al., 2003; Eshleman, 2000; Johnson & Layng, 1992, 1994). Dr. Ogden Lindsley developed the SAFMEDS strategy in the 1970's and 1980's. The acronym, SAFMEDS, stands for "Say All Fast a Minute Every Day Shuffle". Since students' performance is measured in a brief timed session (30 seconds or 1 minute), SAFMEDS facilitates the collection and analysis of daily performance data, which gives the teacher immediate feedback on the effectiveness of instruction (Byrnes, et al, 1990).

The day after the pre-test, the first author began the see-say channel intervention with the students. The instruction was conducted three times a week in a resource classroom used for pull-out special education services. These were individualized, one-on-one sessions that lasted about 20 minutes. The multiplication facts were divided into two phases of learning. During phase 1, students worked on the facts of the 3, 4, and 5 multiplication tables. The times 2 multiplication table was not included in the intervention because all participants showed a proficient level of performance on it. During phase 2, students worked on the facts of the 4, 5, and 6 multiplication tables. Phase 2 was introduced after students achieved a goal fluency with the 3, 4, and 5 multiplication tables. The goal fluency for the see-say learning channel was defined as answering 30 facts correctly in 1 minute.

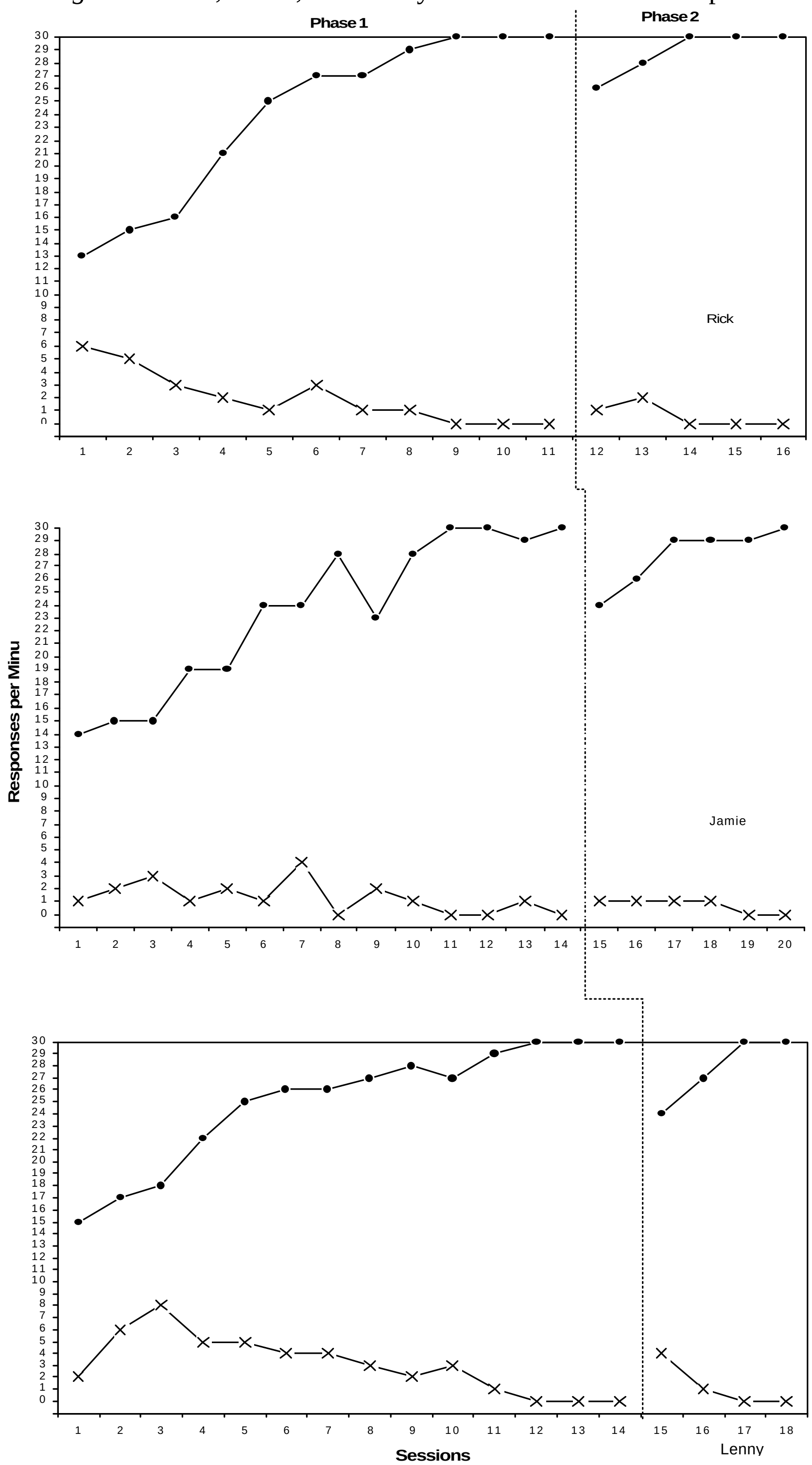
During phase 1 and 2 of the intervention period, the students practiced the cards in the see-say channel. This means that the students "see" the question on the front side and "say" aloud the answer on the back of the card. Then they turn the card to check the answer he or she just said.

During the practice session the students received three timed tests. In the timed tests, the student held a whole stack of 30 cards (i.e., mixing the 3's, 4's and 5's) and moved through them as fast as he could, but only for 1 minute. The performance was recorded in terms of "correctly read cards," "error/skipped cards," and "total cards read" out of the 30 cards. The timed test was administered at the beginning, at about half way through, and at the end of the session. Since three timed tests were given each session, the median score was used for graph data entry.

Hear-Say Channel Intervention

After the completion of the see-say learning intervention and followed by a post-test, the researcher introduced a learning channel of "hear-say" to the students. In this learning channel, students were encouraged to use their "memory" capacity where hearing of questions served as auditory prompts to say the answers. The students were encouraged to respond quickly when they heard the question. If they hesitated more than 3 seconds to a question, the researcher said the answer and moved to next fact. This is in contrast to the see-say channel, where they saw the question, responded orally, and received the feedback visually. The goal fluency for the hear-say

Figure 1. Rick, Jamie, and Lenny's Performance on Multiplication Facts



learning channel was defined as answering 30 facts correctly within 3 seconds to each fact. The intervention continued until each student reached the goal fluency.

Post-Tests

Two post-tests were administered in the study. The first post-test was given to the students upon the completion of the see-say intervention and the second one was given once they completed the hear-say intervention.

The post-test contained the same sheets as the pre-test, one each for the 3, 4, 5, and 6 multiplication tables. Students were not allowed to use any assistance, such as a multiplication chart to complete the pre- or post-test. Both tests were given in a paper/pencil format or in the see-write learning channel. This see-write channel was used because it is the same mode of assessment used by the school district to decide end-of-year promotion for students.

Results

See-Say Learning Channel Intervention

After receiving 9-12 sessions of the see-say channel intervention, the three students reached the goal fluency of phase 1 (answer 30 cards correctly in 1 minute). They achieved the goal fluency of phase 2 after receiving an additional 3-6 sessions. Individual student's performance on timed tests was recorded on a line graph and presented in Figure 1.

The first graph represents Rick's performance. Rick reached the goal fluency for phase 1 in 9 intervention sessions. During the first session, he answered 13 cards correctly and 6 cards incorrectly. By the 9^{th} session, he attained the goal fluency and maintained it for two more sessions. As phase 2 was introduced, his accuracy and speed dropped (26 corrects, 27 total). This occurred as the 10 facts of the 3 multiplication table were dropped, and the10 new facts of the 6 multiplication table were added to the stack. He had difficulty with 4-5 cards from the newly introduced 6 multiplication table. He went on to recover the goal fluency with three additional sessions.

The second graph shows Jamie's performance. She achieved the goal fluency after receiving 11 intervention sessions. She showed some regression at session 9, and again at session 13.

The last graph shows Lenny's performance. He reached the goal fluency of phase 1 with 12 intervention sessions. In phase 2, he regained his goal fluency with 3 additional sessions. The phase 2 period functioned as a baseline to check for effects of any uncontrolled variables. When the new cards were first introduced in phase 2, the accuracy and speed rates of the students decreased (accuracy alone 13%-20%).

Format Change

The SAFMEDS cards that students used for the see-say learning channel contained math facts in a horizontal format (e.g., 3X4=12). After they attained the goal fluency in the horizontal format, they were tested on the facts in a vertical format. One student had a particularly difficult time reading facts in a vertical format. In Jamie's case, her performance decreased by 30% when the format changed. Another student, Lenny, however did not show any difficulty converting between the two formats. Rick made mistakes on 1-2 cards when the vertical format was introduced.

Pre-Test

Table 1 shows the test score for each of the multiplication tables and the time taken for each student to complete the pre-test.

Table 1

Pre-and Post-Test Results

		Facts of 3		Facts of 4		Facts of 5		Facts of 6	
		Score	Time	Score	Time	Score	Time	Score	Time
Rick	Pre-test	6	1’05”	3	2’15”	3	1’20”	4	50”
	Post-test #2	20	40”	20	59”	20	1’06”	20	1’31”
Jamie	Pre-test	20	1’50”	17	1’50”	20	58”	20	2’15”
	Post-test #2	20	1’23”	20	1’07”	20	56”	20	1’13”
Lenny	Pre-test	19	1’57”	13	1’34”	20	1’	13	1’36”
	Post-test #2	20	31”	20	35”	20	50”	20	59”

’ denotes minute; ” denotes second

Student competency level on the pre-test varied individually. Rick started this program with a lower competency level than the other two students. He scored 30% on 3’s facts (6 out of 20 questions); 15% on 4’s facts (3 out of 20); 15% on 5’s facts (3 out of 20); 20 % on 6’s facts (4 out of 20). All three students, however, were found using their fingers for computation. Jamie was particularly dependent on the finger-counting strategy for the 3, 4, and 6 times facts.

Post-Test #1

Upon the completion of the see-say learning intervention, the first post-test was administered. It was unexpected to see that there was no difference between the pre-test and the first post-test scores. The three students’ scores on the first post-test were the same or a little less than that of the pre-test.

Performance during Hear-Say Channel Intervention

The students’ performance during the hear-say learning intervention was also monitored. For the first test in the hear-say channel, Rick’s accuracy rate decreased by 47% compared to his rate in the see-say intervention. Jamie’s accuracy rate also decreased by 20%. In contrast, Lenny was the least affected among the three students. He had difficulty with only 1-2 facts. Rick and Jamie both received five sessions of the hear-say intervention to master the same facts as learned in the see-say learning channel. Lenny became fluent in this mode by the end of the first session.

Post-Test #2

Upon the students reaching the goal fluency for the hear-say learning channel, the second post-test was administered. The post-test results are presented in Table 1. All three students made gains in their accuracy and speed in comparison with their performance on the pre-test. Rick improved his accuracy rate by 500%. Lenny improved his speed rate and reduced his error rate. Jamie made gains in her speed rate. The most visible difference was that the students no longer relied on their finger-counting method.

Findings and Implications

The results of this study demonstrate that the learning channel intervention with continuous response to instruction assessment, enabled students with special needs to build and generalize fluency in multiplication facts. This study investigated how students with special needs transfer their fluent performance from one channel to another channel. The results from this study indicate that the students' fluent performance on the multiplication facts acquired through the see-say learning channel had no effect on their see-write channel test performance. In contrast, after the students learned the same information in the hear-say learning channel, they did improve their performance on the see-write channel test. It is a commonly held premise in precision teaching that performance produced by fluency training results in greater generalization to application and longer retention (Binder, 1988; 1990, 1996, Lindsley, 1992; Haughton, 1972). However, the results of this study indicate the need for further investigation into this premise.

The data from this study suggests that the particular learning channel was influential in generalization to application. When using the second post-test results to compare the generalization of learning, the hear-say learning channel showed an advantage over the see-say learning channel in the generalization of learning. However, this preliminary finding suggests further studies employing a design in which two intervention modes can be alternated in two groups of participants. In other words, one group of participants should receive a reversed order of the interventions to control any compounding variables.

An implication from this study indicates a caution for teachers working with the special education population. Teachers should not assume that students, who can perform fluently in one learning channel, can go on to perform fluently in other modes. It further cautions teachers to be attentive to the individual strengths and weaknesses of their students. Each of these three students did not learn at the same rate, nor were they all able to easily adapt to different learning channels and formats (horizontal/vertical). After the intervention was individually-paced and adapted with a frequent assessment system, all of the students did demonstrate significant improvement on their performance of multiplication facts.

For these students, this was the first time they could achieve a perfect score for a multiplication fact test. The students expressed satisfaction and confidence when they could experience the ease of doing the calculations with their mind. Improving speed allowed the students to confidently rely on their mind, instead of being slowed down by the finger-counting strategy.

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