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The Effect of Direct Instruction Math Curriculum on Higher-Order Problem Solving

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The Effect of Direct Instruction Math Curriculum on Higher-Order
Problem Solving

by

Pamela Christofori

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Applied Behavior Analysis
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ABSTRACT

Previous research has examined the effectiveness of Direct Instruction Curriculum over the past thirty years in a variety of areas including rate of learning, effectiveness on different types of learners, and comparisons to other types of instruction. This study attempted to determine the effects of the use of a direct instruction math curriculum on higher-order problem solving. Two groups of 3 – 5 students each participated. The procedures included administering the Kauffman Achievement test to determine current grade level in math and reading. The Saxon Math Second Grade Curriculum was used to instruct the participants. The effects on higher-order problem solving with the Corrective Math Curriculum were assessed on two different dependent measures: solution of word problems consisting of both addition and subtraction operations, and performance of the students within the curriculum. Results were assessed using the delayed multiple baseline design.

Chapter One Introduction

This is a time of crisis in American education. Critics of current educational practices and outcomes are abundant, and their concerns do not appear to be unfounded. For example, the 1996 *Mathematics Report Card* reports that 75% of the nation's 8th graders do not take algebra by the end of 8th grade, and only 21 percent score at or above the proficient level (National Center for Education Statistics, 2001, p.1).

Additionally, American 8th graders scored below the international average among 41 countries in the *Third International Mathematics and Science Study (TIMSS, 1999)*. With regard to reading, the 1994 *National Assessment of Educational Progress (NAEP) Reading Report Card* found that 41% of 4th graders could not read at the basic level and only 28% performed at or above the proficient level (NCES, 2003)

America's apparent failure to produce quality educational outcomes for all children has led to both state and national initiatives to reform educational practices. In 1994, the United States Congress passed the *Goals 2000: Educate America Act*. This legislation was passed to improve learning and teaching by providing a national framework for educational reform, to promote research, and support systemic changes needed to provide equitable educational opportunities. Within the legislation were several lofty educational goals that were to be met by the year 2000. These included a standard that all children would start school

ready to learn, that the high school graduation rate would increase to at least 90 percent, and that the United States would be the first in the world in mathematics and science achievement.

The National Assessment of Educational Progress (NAEP) released a progress report on those goals in 2000, and the results were less than impressive. One of the indicators used to measure readiness to learn was the percentage of parents that regularly read to their 3 –5 year olds. Results showed only a 3% increase on this variable. Moreover, there have been virtually no increases in high school graduation rates over the last thirteen years, and the United States scored lower than 49% of the nations that participated in the 1999 International Mathematics and Science Study.

The most recent legislation for school reform is the No Child Left Behind Act of 2001 (NCLB). This law expands the federal government's role in K–12 education by making federal aid conditional on those schools meeting academic standards and abiding by policies set by the federal government. The four basic points in NCLB are: 1) Accountability for results through statewide progress goals and annual testing. 2) Emphasis on doing what works based on scientific research. 3) Expanded parental options by allowing parents the opportunity to move their child to a better performing school in the local district. 4) Expanded local control and flexibility in the use of funds to devote more attention to student needs.

In a report published in January of 2004, the Center on Education Policy found that 26% of the nation's public schools had failed to make adequate yearly progress (AYP). Schools are considered to have failed in making AYP if they do not raise achievement scores in every subgroup of students in every grade for two or more consecutive years, or if they fail to improve graduation rates or ensure that 95% of students in each subgroup take the required tests. These data suggest that NCLB has not fulfilled its promise to improve educational outcomes for America's children.

Clearly, the stakes of educational reform are high. The effects of education and schooling on the development of an individual's abilities have implications that reach across the life span. A report from the Carnegie Forum on Education and the Economy (1986) describes some of the potential repercussions of school failure:

If our standard of living is to be maintained, if the growth of a permanent underclass is to be averted, if democracy is to function effectively into the next century, our schools must graduate the vast majority of their students with achievement levels long thought possible for only the privileged few. The American mass education system, designed in the early part of the century for a mass-production economy, will not succeed unless it not only raises, but redefines the essential standards of excellence and strives to make quality and equality compatible with each other. (p.3)

Despite the gravity of the situation, educational reform efforts have stemmed largely from public opinion, theory, and "common sense", as opposed to sound empirical evidence of effective courses of action.

An approach to educational reform that is very popular today and began in the 1980's is whole school reform, which involves high profile education reformers and

organizations developing comprehensive models of curriculum and instruction that encompass the entire school system. Traub (1999) examined ten of these school wide models with regard to such dimensions as student achievement, staff development and support, graduation rates, and attendance. The programs reviewed were chosen because they were either in fairly wide use, or they represented a significant body of thought in education.

Traub noted that each model is based on a theory, and all of these theories cannot be equally true. The differences in the models are broad and deep, although there seems to be at least one shared assumption across most of the models; problems in education lie in classroom practice. Therefore, reform must focus on changing not only *what* is taught, but *how* it is taught (Traub, 1999). Of the programs reviewed, the one that best illustrated this principal was Direct Instruction (DI). Interestingly, DI was also one of only two programs that showed strong empirical evidence of effectiveness (Traub, 1999).

Direct Instruction is an outgrowth of the work Siegfried Englemann and Carl Bereiter's work with disadvantaged children (Bereiter & Englemann, 1966). Their work was based on the assumption that disadvantaged children can "catch up" with their more academically competent peers if they are provided with effective and efficient instruction. According to Bereiter and Englemann, the only way to close the gap between these two groups of children is by teaching at a faster than average rate. To accomplish this, DI curricula focus on the goal of teaching more in less time. This involves using teaching procedures that

maximize the time students spend in instruction and arranging materials to teach a “general case.” A general case strategy is one that uses the smallest possible number of examples to produce the largest possible amount of learning. One example of a general case in DI is through teaching 40 sounds and blending skills it gives the student a generalized decoding skill that is relevant to over one-half of the most common words in English (Gersten & Maggs, 1983).

DI teaching procedures are distinguished from more traditional strategies by their focus on structure and explicit instructions for teachers. The most noticeable departure from traditional instruction is the use of scripted presentations that tell the teacher what to say and do for each task. The examples and sequences used within the scripts have been pre-tested and empirically established as effective. Without explicit directions, teachers may use language the student doesn’t understand or that distracts attention from the example (Binder & Watkins, 1990). Scripts also provide teachers with information about how to handle student errors. Within a DI context, errors are viewed as a means to help the teacher understand the areas that are problematic for students. Different types of errors and the proper way to correct them is specified in the DI Curriculum.

DI lessons are generally taught in small groups of 5 – 10 students, which provides for more adult direction and feedback. The use of frequent unison responding generates higher rates of student responding than most traditional teaching methods, which rely heavily on hand-raising as a means for generating

student participation in the lesson (Heward, 1994). Increased response opportunities also help decrease inattention during a lesson when one student at a time answers (Binder & Watkins, 1990). In a typical DI lesson, the teacher uses signals to cue students when to respond. These signals are used as both a prompt and an evaluation tool. By having the students respond in unison, the teacher can determine whether or not each student is mastering the particular skill they are instructing.

Another key feature of DI is rapid pacing of instruction. In addition to allowing more information to be covered within a lesson, brisk pacing also helps to maintain student attention to the task, which may increase learning and decrease behavior management problems (Binder & Watkins, 1990).

Gradually, DI instruction moves from teacher-guided to more student-guided. This process, called mediated scaffolding (Kameenui & Carnine, 1998), involves teaching students problem-solving strategies, fading assistance, and introducing more complex contexts to help students distinguish essential from nonessential details (Becker & Carnine, 1981). The goal of the process is to foster independence and higher-order thinking (Kozloff & Bessellieu, 2000).

As mentioned previously, DI curricula have been tested rigorously in empirical studies and in field trials (Kozloff & Bessellieu, 2000). This characteristic clearly differentiates DI from most instructional approaches, and also makes it unequivocally consistent with the mandates set forth by NCLB. The largest study conducted to show the superiority of DI to other teaching

methods was entitled Project Follow Through (Adams & Engelmann, 1996). This national study compared the performance of children in over 20 different instructional models that represented the range of current educational practice at the time. The results indicated that the Direct Instruction model was clearly the most effective of all the programs on measures of basic skills achievement, cognitive skills, and self-concept. Despite clear data confirming DI's effectiveness, the release of the study's results generated a great deal of controversy with educational circles, presumably because the principles of DI failed to fit with the predominant views of educational theory and practice. Education's reliance on theory as opposed to data may help explain the lack of implementation of DI programs after the project's results were made available to the public (Cooms, 1998).

The research base for DI is not founded solely on the results of Project Follow Through. Research continues to be conducted to validate the positive learning outcomes associated with DI teaching. Adams and Engelmann (1996) conducted a meta-analysis of DI programs that included *Corrective Mathematics*, *DISTAR Arithmetic I and II*, and *Connecting Math Concepts*. The studies included were required to have means and standard deviation groups, the use of suitable comparison groups, and random selection of participants to groups. In a sample polling of means conducted by the authors, 87% of the studies favored DI programs. A summary of the statistical analysis of math results showed an effect size of 1.11 in favor of DI math programs in 33 of the 37 studies included.

Przychodzin, Marchand-Martella, Martella, and Azim (2004) conducted a review of DI mathematics studies that clearly demonstrate the superiority of DI methods in teaching math skills, especially with children who have history of failure with regard to arithmetic. For example, Parsons, Marchand-Martella, Waldron-Soler, Martella, and Lignugaris/Kraft (2004) studied the use of *Corrective Mathematics* delivered by peer tutors in a secondary general education class for students struggling in math. Ten students were assigned to the learner group based on referrals by a school counselor. All of those students had failed the lowest level math available at the school. Nine other students were recruited by the *Corrective Mathematics* teacher to serve as peer tutors. All students were pre- and post tested using the Calculation and Applied Problems subtest of the Woodcock Johnson-Revised: Test of Achievement (WJ-R). After 60 instructional days, the authors found that both learners and peer tutors experienced posttest gains in one or both areas of the WJ-R.

Another study, conducted by Snider and Crawford (1996) examined 46 fourth graders who were randomly assigned to two general education classrooms. One teacher used *Connecting Math Concepts (CMC), Level D*, a DI program, whereas the other teacher used *Invitation to Mathematics (SF)* by Scott Foresman. *CMC* students scored higher than the *SF* students on the Computation subtest of the National Achievement Test. Additionally, *CMC* students scored significantly higher on both the multiplication facts test and on curriculum-based measures based on *CMC* and *SF*.

Finally, Tarver and Jung (1995) compared *CMC* to a program that combined *Math Their Way (MTW)* and Cognitively Guided Instruction (CGI). One hundred nineteen students entering first grade were assigned to five classrooms. One experimental classroom used *CMC*, while four control classrooms used *MTW / CGI*. Data were collected on student learning gains during both first and second grade. At the end of second grade, *CMC* students scored higher than the control group on all post measures of the Comprehensive Test of Basic Skills – Mathematics as well as on the experimenter-constructed math attitudes survey. Tarver and Jung noted positive effects for both low and high performing students.

Although there has been a great deal of current research conducted to validate the educational benefits of DI, criticisms of the program are still common in the educational community. One such criticism centers on the notion that scripted presentations and predetermined lessons stifle the teacher's creativity. Adams and Engelmann (1996) challenged this criticism by stating that the most important measure of teacher creativity is how well the teacher succeeds at teaching and accelerating student performance and teaching students things they typically have trouble learning. The creative potential of students is limited by their current knowledge. The first job of the teacher, then, is to teach basic skills and knowledge. If the teacher is not achieving attainable instructional goals, the student cannot benefit from any attempt at creativity by the teacher (Adams and Engelmann).

Another common criticism is that direct Instruction ignores individual differences among students, presumably because the program approaches teaching all students in the same manner. However, the measure of whether a program recognizes individual differences is simply to evaluate if the program accommodates students of varying abilities and styles. "If students learn the content on the projected time schedule, their performance is a clear declaration that the program...accommodates the full range of individual differences" (Adams and Engelmann, 1996, p.37).

Still another criticism is that direct Instruction programs are appropriate for low performers only. If this statement were true, low performers would perform in a generically different manner than high performers (Adams and Engelmann, 1996). An example of this might be low performers learning from manipulation, while high performers did not. However, in working with students of different abilities the only differences that occurred were that high performers require less repetition, less review, fewer examples, and often less reinforcement than lower performers (Adams and Engelmann). The greatest challenge to this myth is that research has shown that DI programs have accelerated lower performers beyond higher performers in regular education classrooms (Robinson and Hesse, 1981; Tarver and Jung, 1995; Vitale and Romance, 1992). One of the most firmly held beliefs by many educators is that DI is only appropriate for teaching basic skills and impedes the development of higher order problem-solving skills. Adams & Engelmann (1996) discuss this issue by pointing out that DI programs attempt to

introduce models that permit generalizable learning of core skills. DI teaching units are successively more complicated and less structured, so students are learning how to learn as they master the content. Further, Brody and Good (1992) suggest that the structured learning presented in DI may make independent problem solving an easier pursuit for students because they have a better understanding of how to organize rules, facts, and operations.

The present study is designed to examine the criticism that skills taught within a DI curriculum preclude the development of higher order problem solving in the absence of direct teaching of those skills. Specifically, the study sought to determine whether students taught basic addition and subtraction skills using DI are able to generalize those skills to solve more advanced mathematics problems requiring the same skill set.

Chapter Two Method

Participants and Setting

Two groups of 2nd graders from five regular education classes participated in the study. Group 1 included four girls (Josie, Mona, Marci, and Mary), and one boy (Mark), aged 8 to 9. Group 2 included three boys (Gean, Joe, and Ed) and two girls (Edie and Karlie), aged 8 to 9.

Classrooms selected from which to draw students were those in which the teachers expressed an interest in participation after being given a brief explanation of the study. The students selected were identified by their teachers as low to average performers in the 2nd grade math curriculum as assessed by a research assistant with the Kauffman Test of Educational Achievement (K-TEA). Those students who scored in the low to average range of recommended accuracy levels for addition and subtraction were selected for participation in the study. Because it was necessary for students to read word problems as part of the study's procedures, the participants' reading levels were also assessed using the K-TEA. Only students reading at the end of the 1st grade proficiency levels were selected to participate. K-TEA scores for each participant are shown in Table 1. All experimental sessions were conducted in a resource classroom at White City Elementary School in Ft. Pierce, Florida.

Table 1

Kaufman Test of Achievement Results for Participants

Group	Student	Math Grade Level	Reading Grade
1	Marci	1.7	4.4
	Josie	1.5	3.7
	Mona	1.9	3.9
	DeDe	1.0	3.5
	Mary	1.9	3.1
2	Gean	2.2	3.1
	Joe	2.5	3.1
	Ed	2.8	5.2
	Mark	2.4	5.7
	Karlie	2.2	3.3

Institutional Review Board Procedures

The Institutional Review Board at the University of South Florida and the St. Lucie County School Board approved all procedures prior to data collection. The primary investigator met with the teachers of the students chosen for the study to review the informed consent letter and to answer any questions. Students selected as participants were given assent forms and their parents were given informed consent forms prior to data collection (Appendix A). A letter outlining the study accompanied both the assent and consent forms (Appendix

B). Two phone calls were made to the parents of each participant. The first call was to explain the study and their child's participation in the study. The second call occurred several days later to ask if there were any question or concerns prior to them making a decision about consent. All forms were sent home and collected by each teacher, and subsequently were given to the researcher. Child assent and parent consent were obtained for all the children who participated in the study prior to the start of data collection.

Dependent Variables and Data Collection

The primary dependent variable in this study was the solution of word problems consisting of both addition and subtraction operations involving the concepts of money, temperature, and measurement. Each student's performance was measured throughout the study with multiple probes of the word problems. The probes consisted of short tests containing 10 word problems randomly selected from two web-based banks of word problems (www.EdHelper.com and www.MathStories.com), which were created for teachers from which to draw curriculum. All word problems on these sites were leveled by grade. Only word problems developed for 2nd grade were used in the study. Those problems selected for inclusion in the study assessed the basic arithmetic skills taught as part of the DI (Saxon Math) curriculum, but did not include problems or scenarios directly taught or described to students during the lessons.

Tests were scored by trained research assistants using the answer key provided by the web site. Each test item was scored according to the answer key, and subsequently calculated as a percentage (total number of problems completed correctly divided by total number of problems).

The second dependent measure was taken from the mastery tests included within the Saxon Math curriculum. There were two in-program mastery tests in each unit. The mastery test began with lesson 25 and appeared approximately every 5 lessons. Mastery tests assessed the mastery of the concepts taught in the previous unit. Mastery tests were scored by the primary researcher and another trained research assistant. Each student's final answers to the problems were scored as correct or incorrect and scores were presented as percent of problems completed correctly.

Interobserver Agreement

Both mastery tests, spaced across the course of the study, were scored for interobserver agreement (IOA) with the research assistant. The IOA score for probes was 100%. The mean IOA score for mastery tests was 95% (range, 90% to 100%). The IOA calculation used was for the percentage of agreement for permanent products (i.e., the number of agreements divided by the total of agreements and disagreements multiplied by 100%).

Procedures

Baseline. Prior to beginning the DI lessons, each participant was pretested on a series of probes that consisted of tests containing 10 word

problems randomly selected from the bank of word problems. To obtain stable baseline responding, seven pretests were administered to six of the participants, eight pre-tests to two of the participants, and nine pretests were administered to three of the participants. Additionally, all participants took a standard DI placement test to determine the appropriate starting point within the curriculum for use during the intervention phase. All placement scores for students on Group 1 indicated that they should start in the same unit. Placement test scores for three participants in Group 2 indicated they should start in the same unit. The other two participants placed at the end of the previous unit. Those two students were given the last lesson in the previous unit to complete independently. Both scored 100% so all participants in second group started on the same lesson.

Direct Instruction Lessons. The DI curriculum used for the study was Saxon Math. This series focuses on teaching strategies for learning and retaining facts, understanding place value, solving computational problems, discriminating among various types of story problems, and accurately translating story problems into numerical statements. The lessons used in this study focused on basic math skills, learning and retaining facts, understanding place value, solving computational problems, and defining math vocabulary.

Lessons were delivered by a trained research assistant who was enrolled in the special education teacher preparation program at a local university. A daily lesson with the group of participants occurred Monday through Friday, with each lesson lasting 35 - 55 minutes. This session length was slightly longer than

the time recommended in the Saxon Math Teacher's Manual. The session time decreased to the recommended time of 25 – 45 minutes as the teacher became more fluent with the format of the curriculum. Each lesson in Saxon Math is divided into tasks and includes four components: the Meeting, the Lesson, Class Practice, and Written Practice. A daily lesson is structured as follows:

1. *The Meeting and the Lesson:* These were teacher-directed activities.

Teacher presented exercises through use of the script, listened to student responses, and corrected errors immediately.

2. *Class Practice:* The Student Workbook contained sample skills that had just been taught in the program and that were critical prerequisites for learning the upcoming skills. Student's completed these during the lesson.

3. *Written Practice:* In most lessons, students did a series of exercises on their own. Those exercises reviewed students on previously taught skills.

A total of 14 lessons were completed during the intervention phase of the study. Each participant had to score a minimum of 90% on the written assessment in order to move ahead to the next module. If more than four students scored under the minimum, the instructor conducted extra sessions outside of the daily meeting to bring those participants score to the minimum 90%. When five or more of the participants scored below 90% the instructor conducted extra sessions with the entire group of participants to bring their scores up to the minimum 90%. This occurred only once during the study with Group 2. The teacher re-taught the entire lesson and brought those students

above the 90% required competency. Records were maintained for all participants with regard to test scores for all attempts, as well as the number of tests and sessions required to meet the mastery requirement. A daily meeting occurred with the primary researcher and the research assistant after each lesson to score the daily written practices and determine the lesson to be taught the next day.

Participants met in a student resource room at the school site each day at the same time. The session was conducted without a break. At the end of the session, participants were rewarded with their choice of an edible (Appendix C) if they had participated in the lesson by answering individual questions, choral responding, and completing the written practice.

Procedural Integrity

Each lesson within the Saxon Math curriculum is scripted and sequenced in the same order. To determine if the lessons were being delivered as prescribed, the researcher developed a checklist (Appendix D) with all the tasks in each lesson in the correct sequence. Two additional trained research assistants conducted the observations and completed the procedural integrity checklist for 30% of the lessons. A procedural integrity score for each lesson was derived by dividing the number of steps completed correctly by the total number of steps required to implement the lesson. The mean integrity score was 98.75 % (range, 90% to 100%). One hundred percent of the procedural integrity observations were scored for IOA using the same calculation used for dependent

measures. The mean score for the procedural integrity between the two observers was 98% (range, 90% to 100%).

Chapter Three Results

A multiple probe design across participants was used to analyze the effectiveness of using a DI math curriculum on students' abilities to solve higher-order word problems. Figure 1 shows the number of correct word problems for each student across baseline and treatment conditions. The total possible score for each probe session was 10. Overall, results show the direct instruction curriculum was effective in increasing the mathematical problem solving skills of all children involved in the study. With the exception of one data point for Karlie, all treatment probe scores during treatment were above baseline levels for every participant. Josie obtained a mean baseline score of 1.6 (range, 0 to 4). During treatment, scores were high (mean = 9.3) and more stable (range 8 to 10). Mark obtained a mean baseline score of 2.9 (range, 1 to 5). During treatment, scores improved substantially (mean = 9.8) and variability decreased (range, 9 to 10). For Mona, the baseline mean was 1.9 (range, 0 to 4). Treatment yielded a mean score of 8.4 and reduced variability (range, 7 to 9). Marci obtained a mean baseline score of .71 (range 0 to 3). Substantial increases were observed during treatment (mean = 8), though there was increased variability (range, 5 to 10) and a downward trend across sessions. For Mary, the mean baseline score was .75 (range, 0 to 3). The mean score during treatment was 6.2, though data were variable (range, 4 to 8). Joe obtained a mean baseline score of 4.4 (range, 2 to 8). During treatment, scores improved substantially (mean = 9.6) and remained stable across sessions (range, 9 to 10). For DeDe, the mean baseline score was .63 (range, 0 to 3).

During treatment, the mean score increased to 8.3 (range, 7 to 10), although a downward trend was observed across sessions. Edie obtained a mean baseline score of 3.4, though a great deal of variability was observed across baseline sessions (range, 0 to 7). During treatment, scores increased to a mean of 9.4 and variability decreased (range, 8 to 10). For Karlie, the mean score across baseline was 2. Though initially variable, baseline data stabilized across the later sessions (range, 1 to 5). During treatment, the mean increased to 7.7 across an upward trend (range, 5 to 10). Gean obtained a mean baseline score of 2.1 and demonstrated a good deal of variability across sessions (range, 0 to 6). During treatment, the mean score increased to 9.3 and remained stable across sessions (range, 9 to 10).

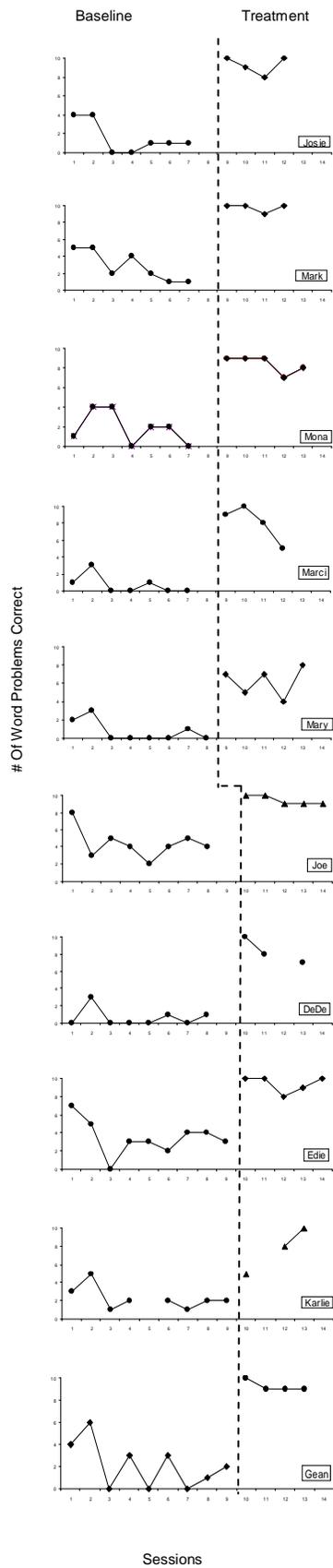


Figure 1. Number of word problems correct across baseline and treatment.

Figure 2 shows the participants' scores on the Saxon Math mastery tests. Performance across the tests was variable within Group One (i.e., test one, M = 73%, range, 67% - 100%; test two, M = 76%, range, 50% - 100%; test three, M = 91.5%, range, 83% - 100%). With regard to specific errors, four of the five participants appeared to have difficulty identifying even numbers in the first test. In the second mastery test, several children had problems writing the number sentences. In the third mastery test, two participants (Marci and Mary) missed several of the addition facts. However, all participants except Marci improved their scores from the first test to the third test (DeDe, who was absent for the third test, showed improvements from the first to second test).

Group Two did not complete the final unit prior to school ending, so the third mastery test was not administered to this group. Within and across the two mastery tests given, a good deal of variability was observed (i.e., test one, M = 75%, range, 67% - 83%; test two, M = 87%, range, 67% - 100%). Two of the students (Melanie and Gean) improved their scores from the first to second test. However, Joe's performance remained stable and Joe did slightly worse on the second test. Only one test was administered to Karlie, on which she scored 100%. With regard to specific errors, several students in Group Two also had problems identifying even numbers, although overall they scored higher than the children in Group One.

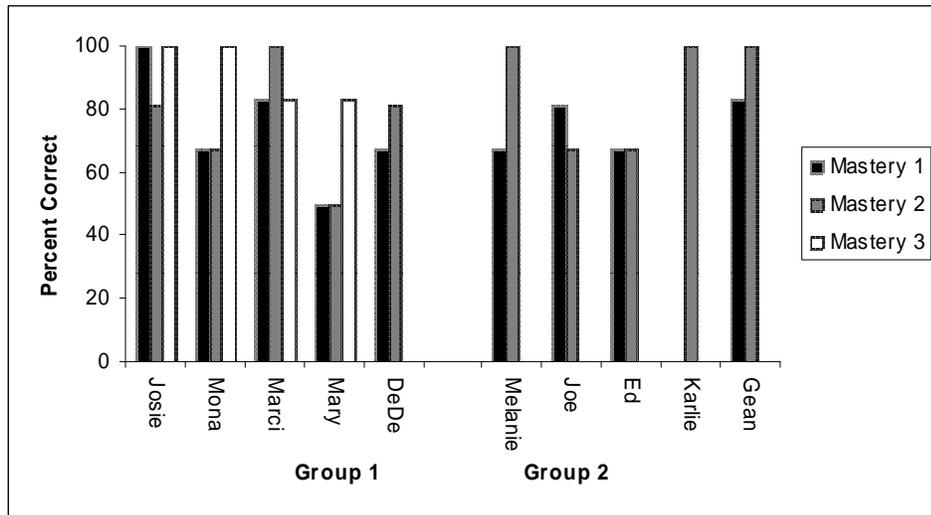


Figure 2. Percentage correct scores on the mastery tests for each participant by group.

Chapter Four Discussion

The present study was designed to examine whether students taught basic math skills using a DI curriculum would be able to generalize learned skills to solve more advanced mathematics problems requiring the same skill set. The results of the present study suggest that the use of the Saxon Math DI curriculum led to generalization of skills to higher-order problem solving, without any specific instruction to the students on the more advanced problems. Word problems were used as the primary measure of the participants' abilities to use the skills in a novel way. The number of word problems correct increased from baseline to treatment for every child who participated in the study, although some children showed more dramatic changes than others.

One of the most common criticisms of DI is that it impedes the development of higher-order problem solving skills through the use of too much teacher-directed drill and practice (Adams & Engelmann, 1996). The results of this study, however, do not support these claims. Instead, they indicate that the mastery of basic skills did lead to increased ability to solve more complicated problems (i.e., word problems) for which the students had no prior training or experience. Six of the participants (Josie, Mark, Joe, Gean, Mona, and Edie) demonstrated immediate improvement in problem solving skills and maintained the gains across time. The other four participants (Mary, Karlie DeDe, and Marci) also showed improvements over baseline, although their data

revealed either slower rates of acquisition or more variable levels of improvement.

Closer examination of the data revealed that some of the differences in performance could be attributed to specific skill deficits. For example, Marci showed initial improvements in her performance that eventually diminished over time. Inspection of Marci's work showed she had difficulty writing number sentences, which is important to the solution of a word problem. The research assistant also reported problems with compliance and attending to instruction, which could have negatively affected her performance, especially as lessons became more complex. Mary showed the least improvement of all the children in the study. Inspection of her work indicated she had difficulty writing numbers and required more repetitions to master a skill. Mary was also absent for 4 lessons, which probably affected her rate of acquisition due to limited exposure to material and fewer opportunities to practice. DeDe showed improvement from baseline to treatment, but had a decreasing trend in her treatment data. DeDe became frustrated easily and would refuse to repeat a task when she made an error. These behaviors probably adversely affected her scores, especially as lessons progressed and tasks became more difficult.

Despite some performance deficits for several of the children, it is important to reiterate that all children's scores improved during the DI lessons and that almost all treatment data points fell above the baseline range. These findings suggest that the DI curriculum was more effective than the children's

regular mathematics curriculum in promoting the application of math skills to novel problems. The students that participated in the study were from five different 2nd grade classrooms, where they received regular math instruction from a variety of teachers. None of the participants improved their performance on the word problem probes prior to the introduction of DI instruction. Therefore, one can not reasonably argue that changes in the classroom environment accounted for improvements in the children's math performance. Further, regular math instruction was suspended once students began DI lessons, which increases the robustness of treatment effects.

Another important finding of the study is more closely related to the independent variable than the dependent variables. Namely, this study showed that the DI teacher could learn how to use the curriculum quickly and obtain good results, despite being inexperienced both with DI and teaching in general. Although the teacher was a student in a university teacher-preparation program, she had relatively little experience as the primary instructor for a group of children. This finding may be particularly relevant for principals and teachers. The large number of instructional requirements, coupled with teacher shortages and a large percentage of teachers teaching "out of field," make an effective, easy-to-master curriculum an incredibly valuable tool. Another benefit to school districts might be that paraprofessionals, tutors, and volunteers could be easily trained to use the curriculum effectively and increase the number of instructional staff available to students. It is also worth noting that the teacher reported liking

the DI curriculum and found it user-friendly. During the daily meetings with the teacher after she had taught the lesson for the day, she stated that the lessons were easy to follow and she enjoyed using the curriculum.

This study also showed that the DI curriculum could be effective even when threats to treatment integrity were present. Although overall treatment integrity scores were high, the teacher did experience some problems with implementing the curriculum. The research assistants who conducted procedural integrity checks noted that the instructor did not consistently use the error correction procedures in the early lessons. The problem was corrected by conducting practice sessions with the primary researcher and the teacher, but it is important to note that students still made impressive gains even when the error correction procedure was used sporadically. Another problem was that the teacher did not consistently require mastery before going to the next lesson. When questioned, the teacher stated that the participants objected many times when she asked them to repeat a lesson or a specific task. Due to her limited experience working with students, she was not sure how to gain compliance in this type of situation. The primary investigator discussed several methods to reinforce compliance during instruction. The teacher initially reported success with the procedures, but later reported the behavior returned and occurred sporadically throughout the instruction.

Despite encouraging results, the current study is not without some limitations. One concern that might be raised is whether the primary dependent

variable (word problem probes) was a valid measure of higher-order processing. One of the most widely accepted definitions of higher-order problem solving is in Bloom's Taxonomy (Bloom, 1984). The second highest order of categorization in the taxonomy is synthesis, which is partially defined as generalizing from given facts. Mathematical facts are given in word problems that must be interpreted and generalized to solve for the answer. Therefore, one could argue convincingly that the dependent measure used in this study was, in fact, an example of a higher-order skill. However, future research is needed to more clearly identify and define what constitutes higher-order processing. In the current study, measures of face validity by math experts and teachers regarding whether the word problems used in the study were a type of higher-order task would have been beneficial. Despite this oversight, the results of the current study show, at a minimum, that the use of DI curriculum resulted in generalization to a novel type of math task. Future researchers should explore the extent of this generalization by testing other types of mathematics tasks concurrent with DI instruction of basic skills.

The current study had participants placed in two groups of 5 students each. It could be argued that the results were due to the amount of attention the teacher was able to give to students in a small group setting. Additional research is needed to determine if DI curriculum would be as effective during whole group instruction with a large class of students.

Another notable variable that may have affected the results involved the timing of the study. Data collection occurred during the last month of school and the final word problem probe was administered the last full day of school. The participants were involved with many end-of-the-year activities and this may have competed with the motivation of some of the students to attend to math instruction (i.e., those that showed downward performance trends or relatively lower scores for the last 1-2 lessons). Although all students showed improvements, one wonders if performance increases could have been greater for some of the students had the DI lessons been conducted earlier in the school year.

It is clear that future research on the effects of DI Math curriculum on higher-order problem solving is needed. Currently, the educational community's belief that scripted curriculum stifles teachers' abilities to teach at the "concept level", and subsequently stifles students' abilities to reach that level, has adversely affected the dissemination and widespread use of one of the most effective curriculums developed to date (Adams & Engelmann, 1996). Research can begin to change the perceptions of educators by continuing to investigate a variety of skills that are commonly thought of as higher-order tasks and evaluating DI's effectiveness on teaching those tasks. Educators are practicing in a time where accountability is high. Many teachers are searching for strategies that deliver faster, better results. Continued research aimed at demonstrating the effectiveness of DI to teach and promote the generalization of a range of

academic skills would benefit both teachers and the students that depend upon them.

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Appendices

Appendix A

Parental Informed Consent

Social and Behavioral Sciences
University of South Florida

Information for Parents

Who are being asked to allow their child to take part in a research study

The following information is being presented to help you decide whether or not you want to allow your child to be a part of a minimal risk research study. Please read this carefully. If you do not understand anything, ask the person in charge of the study.

Title of research study:

The Effect Of Direct Instruction Math Curriculum On Higher-Order Problem Solving

Person conducting the study: Pamela Christofori

Where the study will be done: White City Elementary School

Your child is being asked to participate because there is a need to find effective and efficient classroom curriculum for students. Many of our students are performing below their potential because we are not using the most effective teaching strategies available in education. Your child's teacher has identified your child as one who might benefit from participating in this study.

General Information about the Research Study

The purpose of this research study is to assess the effects of Direct Instruction Curriculum on the skill of higher-order problem solving in math. Direct instruction is a scripted, sequential teaching method used to teach academic content. The procedures involve your child participating in a group with 3-5 other children. The group will be instructed using the Saxon Math Direct Instruction Curriculum.

Plan of Study

Two groups of 3-5 students will come to a resource room at different times during the day, at the school, 5 days a week for 25– 45 minutes. During that time he/she will receive instruction in math using the Saxon Math Direct Instruction Curriculum. This is a research-based program that has been shown to be very effective in the teaching of math skills. Your child will be given a pre- test of word

problems three times before the instruction begins and six times during the study. Your child will also be assessed every 10 lessons completed in the curriculum using a written test that is part of the curriculum. Data will be collected on the performance of your child on each of these assessments.

Your child will be observed by an independent research assistant for every 3 out of 10 lessons conducted. The observations are done to insure that the instructor is conducting the lessons according to the curriculum's directions throughout the study.

Participation in the study will require your child to spend 25–45 minutes out of their classroom engaged in this math instruction.

Your child will be given the choice of a drink, a snack, or a sticker at the end of each lesson. Please tell us of any allergies or restrictions you have for your child regarding food and drink.

Payment for Participation

Your child will not be paid to participate in this study.

Benefits of Taking Part in this Research Study

A potential benefit to having your child in the study might be increased performance in their grade level math and in their problem solving abilities. An overall benefit of this study could be the increased use of effective teaching methods so that students can reach their fullest potential.

Risks of Being a Part of this Research Study: There are no known risks to your child for participation in this study, and you may withdraw at any time.

Confidentiality of Your Child's Records

You and your child's privacy and research records will be kept confidential to the full extent required by law. Authorized research personnel, employees of the Department of Health and Human Services, and the USF Institutional Review Board may inspect the records from this research project.

The results of this study may be published. However, the data obtained from your child will be combined with data from other children in the publication. The published results will not include your child's name or any other information that would personally identify your child in any way.

Child's Assent To Participate in Study

Plan of the study –

You will be using a different book to learn your math. It's called Saxon Math. You will be in a group of 3-5 classmates and go to the resource room with an instructor to have math class. Class will be from Monday to Friday at the same time your current math is scheduled, about 25 – 45 minutes each day. About once or twice a week you will be given 10 word problems to solve. At the end of every 10 lessons there is a mastery test to see what you learned.

Child's Assent Statement

Pamela Christofori has explained to me this research study called *The Effect Of Direct Instruction math Curriculum On Higher-Order Problem Solving*.

I agree to take part in this study.

Signature of Child
taking part in study

Printed Name of Child

Date

Signature of person
obtaining consent

Printed Name of person
obtaining consent

Date

Appendix B

REINFORCER SURVEY

Students Name: _____

Date: _____

Completed By: _____

At the end of each lesson, after you have completed all your work, you will be able to choose one of these items each day. Please answer the following questions so we will have stuff to earn that you really like.

What is your favorite thing to eat for a snack ? _____

What is your favorite thing to drink ? _____

Put a check mark next to the items you would like to earn in math class:

___ Pokemon Stickers ___ Barbie Stickers ___ Sponge Bob Stickers ___ Dora The Explorer Stickers

___ Apple Juice ___ Grape Juice ___ Orange Soda ___ Yahoo Soda

___ Peanuts ___ Potatoes Chips ___ Fritos Chips ___ Cheese Crackers

___ Tootsie Roll ___ Snickers ___ Plain M&M's ___ Reese's Pieces

Appendix C

Procedural Integrity Data Sheet

Observers Name: _____ Date: _____

Start Time: _____ / End Time: _____

Participants: Check the group you are observing: Group 1 ___ Group 2 ___ # of Lesson Observed: _____

Correct Sequence for presentation of the DI Lesson: A checkmark indicates correct implementation of step.

Preparation for Daily Lesson:

_____ 1. Teacher has prepared for the daily lesson by reading it through, identifying any new formats and consulted the

Presentation Book. Observer will ask these six questions of teacher prior to students arriving.

What is this format teaching? _____

How is it structured ? _____

Does the format specify that any steps are to be repeated ? _____

Where are individual turns specified ? _____

What kinds of mistakes are the students likely to make ? _____

What correction procedures should be used ? _____

_____ 2. Instructional area is prepared before students arrive: Student Books on table in front of assigned seat, extra sharpened pencils, scrap paper.

_____ 3. Stand at door of classroom to receive students. Greet with a smile and direct to assigned seat.

Implementation of Daily Lesson:

_____ 1. **Format** – Followed format of lesson closely.

_____ 2. **Signals** - Same signal throughout lesson.

_____ 3. **Signals** – All students responding together when signal is given at right time.

_____ 4. **Watching** – Pays close attention to students responses and responds accordingly.

_____ 5. **Watching** - Talking to students while standing in front of group.

_____ 6. **Watching** – Walking among students when they are writing or teacher is checking work.

_____ 7. **Corrections** - Corrects every error properly according to type of error and procedure required.

_____ 8. **Corrections** - Are delivered to student in a positive tone.

_____ 9. **Feedback** – Students are reinforced as a group for participation and/or correct answers.

_____ 10. **Feedback** - Students are reinforced individually for participation and/or correct answers.

_____ 11. **Pacing** - Moving through lesson as fast as possible without forcing the students to make mistakes.

