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The Homework Debate: How Much Homework is Helpful for Students to Acquire Mathematical Procedural Knowledge?

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Abstract

The effects of using homework guides and homework logs on students' abilities to solve word problems involving basic addition and subtraction facts were studied. Students received one of three versions of addition and subtraction timed tests once per week—every Friday—that focused on measuring automaticity of basic addition and subtraction facts. Thirty-one first-grade students participated in this action-research study. Students' automaticity of basic addition and subtraction facts increased over the course of this study. Results indicated that homework guides positively affected student motivation to put forth more effort on homework. Additionally, word problems that involved basic subtraction facts appeared more difficult to solve; whereas, word problems that involved basic addition facts appeared easier to solve.

How Much Homework is Helpful for Students to Acquire Mathematical Procedural Knowledge?

The purpose of this action-research study was to continue to unearth specifics regarding the effects of homework and students' abilities to learn basic addition and basic subtraction facts. This research study was a replicated study insofar as its research design and implementation was carried out in the previous year.

Literature Review

Homework

Homework has been the topic of countless research studies. The foci of these studies are predominantly on the time spent on homework and/or the debate on homework's appropriateness. This action-research study is grounded in the work of homework expert Dr. Harris M. Cooper. Cooper (2006) reports that "[l]ittle or no research has been conducted that examines the effects of homework on first or second grade [sic] students" (p. 11). This notion seems to merit action research on the topic of homework and its effects on students.

For the purpose of this study, homework is defined as any task assigned by schoolteachers intended for students to carry out during nonschool hours. This definition acknowledges that homework may be completed in school, in afterschool programs, and at home; but for most students, it will be completed in the home setting (Cooper, 2006, p. 1).

Frequency is defined as how often homework is assigned. Based on Cooper's (1989) meta-analysis, the frequency of homework assignments for grades 1-3 should be one to three assignments per week. This means homework may be over-assigned or under-assigned, depending on its frequency.

In addition to frequency, the length of a homework assignment is critical to its effectiveness. The time required to complete a homework assignment should be neither too long nor too short. National Council of Teachers of Mathematics (NCTM) recommends that "[g]rades 1-3 should have up to 20 minutes of homework a night" (Homework, p. 1). NCTM's recommendation holds to the informal rule many teachers use: 10 minutes multiplied by the student's grade level equals the total amount of homework that is appropriate per night (e.g. 10 minutes multiplied by 1 equals 10 minutes of homework that is appropriate for a first-grader per night). Assigning the appropriate amount of homework on a regular basis provides practice, which is important in shaping students' understanding.

Research indicates that "[r]egular practice is a significant factor in the development of fluency. Teachers need to help students at all grade levels understand that skills can be automatic if they practice them" (Krudwig, 2003, p. 5). One of the roles of homework is to offer extra opportunities for practicing a skill. Frequent, repeated practice helps students over-learn skills, which leads to automaticity (hereinafter referred to as "fluency").

Establishing how many rehearsals students need to reach mathematical fluency is important. Teachers who know how many rehearsals are needed can adjust their teaching to make the best use of classroom time. Star (2005) criticizes, "Methods for assessing students' procedural knowledge are somewhat impoverished at present" (p. 410). Hopefully, this action-research study will improve my students' mathematical fluency and my assessment of procedural knowledge.

Methodology

Participants and Setting

This study took place in a large-sized metropolitan (urban) city located in southeastern Wisconsin. The school was a public elementary school which consisted of a semi-diverse student population of approximately 670 students, kindergarten through grade eight.

The teacher, a participant observer in this study, was a 25-year-old, bilingual (Spanish and English), South Korean male. He was in his second year of teaching elementary school. He held a Bachelor of Science in Teaching Degree, a Master of Science in Education, and was licensed to teach K-6 and 5-8 Mathematics in the state of Minnesota.

Data Collection Procedures

Table 1 shows a data triangulation matrix. The following data collection procedures were utilized to answer the three research questions (see Table 1). Two-minute addition and subtraction timed tests that consisted of 50 questions were utilized to assess basic addition and subtraction fact fluency. To be fluent in addition basic facts and subtraction basic facts, it was expected for students to answer 10-15 problems correct out of 50 in one minute. It was decided 10-15 basic facts correct per minute was age and grade appropriate due to the fact that Krudwig (2003, p. 6) determined "having a minimum correct rate for basic facts at 30-40 problems per minute" was fluent for middle school students. Also, given this study took place in a first-grade classroom, it was assumed that the number should be less than—20-29 problems per minute—which was used in the

aforementioned (2007-2008) replicated study that took place within a second-grade classroom.

Table 1

Data Triangulation Matrix

Research Question	**Data Source #1**	**Data Source #2**	**Data Source #3**
1.) How many rehearsals are needed to achieve automaticity (fluency) in solving addition and subtraction word problems?	Timed Tests	Performance Assessment	Homework Logs
2.) How do students feel about solving word problems at home?	Student Survey	Parent Survey	Homework Logs
3.) How do homework guides affect student effort in homework/procedural knowledge?	Student Survey	Homework Logs	

Addition and subtraction timed tests were implemented during early in the first quarter (middle September) of the school year, for Unit 1: Early Number Activities, and recorded throughout the entirety of this study. A total of two different versions of timed tests (both addition and subtraction) were administered in this action research.

Authentic assessment was used in this study. Students carried out performance assessments. Each student performed a think-aloud individually while answering a word problem that involved addition and/or subtraction. The participant observer used a rubric to evaluate students' procedural knowledge.

Homework logs supplemented timed tests and assisted in evaluating how many rehearsals were needed to become fluent. Homework logs (hereinafter referred to as "HL") went home with students weekly (on Monday). The following Monday, the HL was

collected. The subsequent Monday, another HL was sent home. The amount of time spent on homework, as well as the specific days spent on math homework was recorded in HL.

Surveys were used to determine students' feelings about solving word problems at home, as well as how homework guides—which were sent home on Monday, November 3, 2008 (21 of 31 students returned signed)—affected student effort in homework/procedural knowledge. Two surveys were given to students and parent(s)/guardian(s). A pre-survey established a baseline.

Analyses

The path to answer the first research question, "How many rehearsals are needed to achieve automaticity (fluency) in solving addition and subtraction word problems," was not an obvious one. As this realization became more apparent, it was decided instead to look at the patterns that emerged from student performance on addition and subtraction problems throughout the study.

Repeated measures of Analysis of Variance were used to determine if there were significant changes in students' performance on the Timed Tests and Performance Assessments from month to month. Three time points were used to assess change in student scores on the Performance Assessments: October, November, and December. These times correspond to the assessment delivery dates.

In order to utilize as many student scores as possible, the addition and subtraction Timed Test scores for each student were averaged across each of the four months they were administered: September, October, November, and December. This allowed for a Repeated Measures of Variance to be run using four time points and 30 students' scores.

The amount of time spent per day doing homework, as recorded by students on their Homework Logs, was averaged across the class for each week the Homework Logs were distributed. At this point in time, the Homework Logs are being used solely for descriptive purposes.

Results from both the student and parent surveys were used to answer the second research question, "How do students feel about solving word problems at home?" The original intent was to use Chi-square analyses to determine if responses on pre- and post-surveys indicated a change in student and parent/guardian attitudes toward math homework from September to late November/early December.

Results

Firstly, results indicated that there was a significant change in student fluency in Performance Assessment on solving addition word problems but not on solving subtraction word problems. The means and standard deviations for the three months of addition and subtraction word problems assessments (October, November, and December) are shown in Table 2. A repeated-measures ANOVA indicated significant differences in student scores for the assessments on Addition across time ($F_{(2, 60)} = 30.142$, $p < 0.001$), but not for Subtraction ($F_{(2, 60)} = 1.252$, $p = 0.293$). Pairwise comparisons were conducted on the mean addition scores from the performance assessments to determine where exactly the differences occurred. A Bonferroni adjustment was used to maintain an experimentwise alpha of 0.05. These post-hoc comparisons revealed that the scores obtained in October differed from those in both November ($p < .001$) and December ($p < .001$), but there were no significant differences between scores from November and December.

Table 2

Performance Assessment: Addition (N = 31)

	October	November	December
M	4.84	11.19	12.55
SD	2.82	5.30	5.37

Performance Assessment: Subtraction (N = 31)

	October	November	December
M	8.52	9.74	7.87
SD	4.59	5.50	5.43

Secondly, results indicated that there was a significant change in student fluency in the addition and subtraction Timed Tests. The means and standard deviations for the average student scores for the four months of testing (September, October, November, and December) are shown in Table 3. Note that the total possible score on each Timed Test was 50. A repeated-measures ANOVA indicated significant differences in student scores for the Timed Tests on Addition across time ($F_{(3,\ 87)} = 36.397$, $p < 0.001$), and for Subtraction ($F_{(3,\ 87)} = 23.665$, $p < 0.001$). Pairwise comparisons were conducted on the mean addition and subtraction scores from the Timed Tests to determine where exactly the differences occurred. A Bonferroni adjustment was used to maintain an experimentwise alpha of 0.05 for each. These post-hoc comparisons revealed that, for the addition Timed Tests, all months were significantly different from one another. For the subtraction Timed Tests, the post-hoc comparisons indicated that scores obtained in September and October significantly differed from those in November and December. However, September was not significantly different from October, nor was November different from December.

Table 3

Timed Tests: Addition (N = 30)

	September	October	November	December
M	1.82	2.84	3.94	5.80
SD	2.13	2.78	3.04	4.37

Performance Assessment: Subtraction (N = 30)

	September	October	November	December
M	1.56	1.78	3.78	4.20
SD	2.21	1.92	2.72	3.58

Looking at the overall mean amount of time spent per day, the pattern following the progression from Monday to Friday is obvious and quite intuitive. Students spend more time working on their homework at the beginning of each school week than they do at the end. Since the Homework Logs did not afford a place to record time spent on days other than Monday through Friday, this last column could have been used as a general catch-all to include Saturdays and Sundays as well.

Table 4 *Average number of minutes spent on homework per weekday*

Week	***n***	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	***M* (week)**
1	27	12.33	11.44	10.81	10.07	8.92	**10.714**
2	31	14.41	13.48	10.93	No School	No School	**12.94**
3	28	15.214	11.25	13.571	11.892	9.25	**12.235**
4	28	12.214	12.643	12	9.714	9.5	**11.214**
5	28	13.89	13.29	12.11	12.79	5.71	**11.558**
***M* (day)**	**28.4**	**13.637**	**12.450**	**11.872**	**11.126**	**8.340**	

Week 1: October 20, 2008 – October 26, 2008
Week 2: October 27, 2008 – November 2, 2008
Week 3: November 3, 2008 – November 9, 2008
Week 4: November 10, 2008 – November 16, 2008
Week 5: November 17, 2008 – November 23, 2008

Responses on the student post-survey showed notable changes for seven of the 12 questions from both surveys. These questions and responses can be found on Table 5. As the semester progressed from September to December, the percentage of students claiming that homework was always easy for them rose from 50% to 74.2%.

Table 5

Select questions from Student Pre- and Post-Survey, n(%)

Pre-Survey (N = 32); Post-Survey (N = 31)

		Always	Sometimes	Rarely	Never
I enjoy solving math word problems	Pre	16 (50)	8 (25)	1 (3.1)	7 (21.9)
	Post	22 (71)	4 (12.9)		5 (16.1)
Homework instructions are difficult to understand	Pre	5 (15.6)	9 (28.1)	5 (15.6)	13 (40.6)
	Post	7 (22.6)	13 (41.9)		11 (35.5)
When I solve word problems I like to use strategies to help me	Pre	11 (34.4)	8 (25.0)	1 (3.1)	12 (37.5)
	Post	18 (58.1)	10 (32.3)	1 (3.2)	2 (6.5)
Adults help me with my homework	Pre	8 (25.0)	9 (28.1)	3 (9.4)	12 (37.5)
	Post	14 (45.2)	10 (32.3)	1 (3.2)	6 (19.4)
Word problems are difficult for me	Pre	8 (25.0)	8 (25.0)	3 (9.4)	13 (40.6)
	Post	4 (12.9)	6 (19.4)	3 (9.7)	18 (58.1)
If I do not understand my homework, I ask for help	Pre	10 (31.3)	17 (53.1)		5 (15.6)
	Post	23 (74.2)	4 (12.9)	1 (3.2)	3 (9.7)
Homework is easy for me	Pre	16 (50.0)	6 (18.8)	6 (18.8)	4 (12.5)
	Post	23 (74.2)	5 (16.1)		3 (9.7)
I try harder if I can use a homework guide	Post	28 (90.3)	3 (9.7)		

The parent/guardian pre-survey was administered on September 15, 2008 and the parent/guardian post-survey was administered on November 24, 2008. Each survey

consisted of the same 16 statements to be rated by the parent/guardian on a four point Likert scale. Twelve of these statements were rated using the same scale as the student pre- and post-survey: *Always, Sometimes, Rarely,* and *Never*. The remaining four statements were concerned with parent/guardian perception of homework quantity and were rated using the following Likert scale: *Yes, No, Maybe,* and *Do Not Know*. The parent/guardian post-survey contained two additional statements to be rated on the latter scale. Thirty-one parent/guardian pre-surveys were returned as well as 31 parent/guardian post-surveys.

Pre-survey responses indicated that parents and guardians (henceforth referred to as parents only) believed their child could try to do better on his/her homework all of the time (51.6%) or some of the time (25.8%). It appears, at the early age of these first-graders, that students of this class are harder on themselves than their parents or that they have already fallen prey to the pressure of response bias.

Table 6

Select questions from Parent/Guardian Pre- and Post-Survey, n(%)

Pre-Survey (N = 31); Post-Survey (N = 31)

		Always	**Sometimes**	**Rarely**	**Never**
My child enjoys solving math word problems.	Pre	13 (41.9)	10 (32.3)	2 (6.5)	6 (19.4)
	Post	11 (35.5)	17 (54.8)	2 (6.5)	1 (3.2)
When my child solves word problems, he/she likes to use strategies to help.	Pre	13 (41.9)	9 (29.0)	2 (6.5)	7 (22.6)
	Post	15 (48.4)	14 (45.2)	0	2 (6.5)
I help my child with his/her homework.	Pre	20 (64.5)	8 (25.8)	2 (6.5)	1 (3.2)
	Post	16 (51.6)	12 (38.7)	3 (9.7)	0
Word problems are difficult for my child.	Pre	4 (12.9)	13 (41.9)	10 (32.3)	4 (12.9)
	Post	2 (6.5)	16 (51.6)	8 (25.8)	5 (16.1)

If my child does not understand his/her homework, he/she will ask for help.	Pre	25 (80.6)	4 (12.9)	2 (6.5)	0
	Post	25 (80.6)	4 (12.9)	1 (3.2)	1 (3.2)
My child could try to do better on his/her homework.	Pre	16 (51.6)	8 (25.8)	4 (12.9)	3 (9.7)
	Post	7 (22.6)	16 (51.6)	5 (16.1)	3 (9.7)
Homework is easy for my child.	Pre	8 (25.8)	18 (58.1)	4 (12.9)	1 (3.2)
	Post	7 (22.6)	19 (61.3)	3 (9.7)	2 (6.5)

Discussion

This observational study did not have a starting point to determine what mathematical fluency should be for first-grade students. The current corpus of research is virtually empty when it comes to studies conducted on first graders, and there appears to be no leading authority in mathematics research for early-elementary grades. The research findings presented in this study may eventually be a harbinger for future research studies in the realm of mathematical fluency for first graders.

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