Hands-On Equations® Research, Interim Results: Study #102b, August 15, 2007
The Effects of Hands-On Equations on the Learning of Algebra
by Regular 6th Grade Rural School Students:
A Comparison of Achievement With and Without the Game Pieces

Hands-On Equations (HOE), developed by Dr. Henry Borenson, uses numbered-cubes to represent the constants, and blue pawns to represent the variable ***x***. It also uses a scale representation on which the students "set up" the equation. The students then proceed to use "legal moves," which are the mathematical counterpart of the abstract algebraic methods which are used to solve these linear equations. The system thus makes abstract linear equations visual and understandable, and further provides students with the means of solution through a kinesthetic approach which makes sense to them.

The program is unique in that the abstract knowledge base needed by students to solve these equations is transformed into an easily understood and manageable set of verbal, visual and kinesthetic responses using manipulatives. The program teaches algebraic principles which students in grade 3 to 8 can apply in any sequence desired to solve the given equation. Hence, the students using Hands on Equations need not memorize a series of steps to solve an equation, as is the case in more traditional instruction. Rather they feel empowered to use their thinking and understanding of basic principles to solve the problem at hand.

The research study uses a Multi-Site Replications Design and a Meta Analysis procedure to study the effect of the HOE program on many groups of students with different characteristics (regular education, special ed., gifted, elementary, middle-school, high school, etc). All of these groups of students will be studied separately. Presently we have data on more than 75 classrooms,

This particular study (102b) was designed to measure the effects of the first 7 lessons of the HOE program on the learning of algebra by 6th grade students in a rural school district located in the pacific northwest of the United States. In addition, the study was designed to determine if there was any significant difference in student achievement by taking the post-test with the game pieces vs. taking the post-test without the game pieces.

A pre-test was given to the students before they were exposed to the program. At the conclusion of Lesson #6, the students were provided with a post-test in which they were at liberty to use their game pieces (the pawns, cubes, and laminated scale). The students were then instructed in Lesson #7, and given a second post-test. This time the students were to take the post-test <u>without</u> using the game pieces. The students, however, were free to use the pictorial notation they had learned in Lesson #7.

In this study, all the teachers were experienced teachers with the large majority having 10 or more years of teaching experience, although this was their first year with HOE. The teachers participating in the study had been taught the methods of instruction to use with HOE by a Borenson and Associates, Inc. instructor in a one-day workshop in early May of 2007. The teachers began to implement the program with their students very soon after the training, after first giving all their students the pre-test. They then taught the first six lessons and administered the post-test for Lesson #6 between May 14th and June 4th. Following this post-test, each teacher taught Lesson #7 and then administered the post-test for Lesson #7 between May 15th and June 11th. The students were provided with 15 minutes for each of the tests.

This study is a meta-analysis of 11 separate studies, each involving a separate classroom of 6th grade students. (NOTE: Although there were 13 sixth grade classes which participated in this study, we had to exclude two of them from the group analysis: one class was excluded because the teacher did not administer one of the post-tests to the class; the other class was excluded because each of the students in that class obtained a perfect score on both of the post-tests. Although this result is theoretically possible, it was excluded from the combined study since we wanted to measure typical classrooms.)

RESULTS:

Eleven classrooms were included in this meta-analysis (Combined **N** = 190). Each classroom's data was analyzed independently to provide feedback to each teacher about the performance of their students. t tests were conducted between the means of the pre-test and the post-test after Lesson # 6, between the means of the pre-test and the post-test after Lesson #7, and between the means of the Lesson #6 and Lesson #7 post-tests. The effect sizes between the pre-test and the post-test after Lesson #6 and between the pre-test and post-test after Lesson Seven were large and highly significant. The gain between the pre-test mean (2.89) and the post-test after Lesson #6 mean (5.54) produced a t value of 25.15; the gain between the pre-test mean (2.89) and the post-test after Lesson #7 mean (5.64) produced a t value of 22.48; the difference between the post-test after Lesson #6 mean and the post-test after Lesson #7 mean was not large enough for significance (t = 1.34).

CONCLUSIONS:

This study demonstrated that 1) the combined group of 190 6th grade rural school students achieved a large and highly significant gain* from the pre-test to the post-test following Lesson #6, and 2) that this significant gain was maintained on the post-test following Lesson #7, where the students did <u>not</u> use the game pieces (rather, they used the pictorial notation learned in Lesson #7). This result demonstrates that students who learn the HOE methods of solving equations are able to be equally successful with or without the use of the game pieces. In other words, the students are able to transfer their hands-on learning to the pictorial method presented in Lesson #7, which uses only paper and pencil, and be equally successful in solving the equations.

* In percentage terms, the average pre-test score for the entire group of 190 students was 48.2%. The average score for the entire group on the Lesson #6 post-test <u>using</u> the game pieces was 92.3%. The average score for the entire group on the Lesson #7 post-test <u>without</u> using the game pieces was 94%. Copies of the tests are shown below.

Report Submitted by Larry W. Barber, Ph.D., August 15, 2007

TEST QUESTIONS FOR STUDY #102B

Pre-Test Questions	**Post-Test After Lesson #7**
1. $2x = 8$	**1. $2x = 6$**
2. $x + 3 = 8$	**2. $x + 3 = 10$**
3. $2x + 1 = 13$	**3. $2x + 1 = 7$**
4. $3x = x + 12$	**4. $3x = x + 2$**
5. $4x + 3 = 3x + 6$	**5. $4x + 3 = 3x + 7$**
6. $2(2x + 1) = 2x + 6$	**6. $2(2x + 1) = 2x + 10$**
Post -Test after Lesson #6	
1. $2x = 10$	
2. $x + 3 = 8$	
3. $2x + 2 = 10$	
4. $3x = x + 4$	
5. $4x + 3 = 3x + 9$	
6. $2(2x + 1) = 2x + 8$	

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