Hands-On Equations Research, Interim results Nov. 3, 2007 (Study #105a)
The Effects of Hands-On Equations on the Learning of Algebra by Regular 8th Grade 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.

This research study, as well as the series of studies of which this is a part, 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 students, special education students, elementary, middle, and high school students, inner city, rural, suburban, gifted and handicapped). All of these groups of students will be studied separately. Presently we have data on more than 85 classrooms.

This particular study (105a) was designed to measure the effects of the first 7 lesson of the HOE program on the learning of algebra by 8th grade students in the regular education classroom (90% regular students; 10% LD students). 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 without using the game pieces. The students however were free to use the pictorial notation they had learned in Lesson #7.

The teachers in this study were experienced teachers with a minimum of 3 to 5 years of teaching experience, although this was their first year teaching with HOE procedures. These teachers had been taught the methods of instruction to use with HOE by various Borenson and Associates, Inc. Instructors in a one-day workshop sometime in early 2007. The teachers administered the pre-test to their students sometime begin March 19th and May 8th. They then taught the first six lessons and administered the post test after Lesson #6 between March 27th and May 24th. They then taught Lesson #7 shortly thereafter and administered the post-test after Lesson #7 between March 28th and May 6th. All the students were allowed 15 minutes to take each test.

RESULTS

Five 8th grade classrooms were included in this meta-analysis (Combined N = 105). One classroom was located in each of the following states: IL, MD and MO. Two classrooms were located in KY. Each classroom's data was analyzed independently to provide feedback to each teacher about the performance of their students. Statistical t tests were conducted between the means of the pretest and the post-test

after lesson #6, between the means of the pretest 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 #7 were large and highly significant. The gain between the pre-test mean (3.89) and the post-test after Lesson #6 mean (5.26) produced a t value of 8.895; the gain between the pre-test mean (3.89) and the post-test after Lesson #7 mean (5.34) produced a t value of 9.99; the difference between the post-test mean after Lesson #6 and the post-test meant after Lesson # 7 mean was not large enough for significance (1.20).

CONCLUSIONS

This study demonstrated that 1) The combined group of 105 8^{th} grade students achieved a large and significant gain from the pre-test to the post-test following Lesson #6, and 2) This significant gain was maintained on the post-test following Lesson #7, where the students did not use the game pieces (rather, they used the pictorial notation learned in Lesson #7). This result, as well as that of Study 59a, involving 123 4^{th} graders, and Study 102b involving 190 6^{th} graders, demonstrates that students who learn the HOE methods of solving equations can be equally successful with or without 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.

The chart below shows the consistency in the scores on both post-tests for each of the three groups.

N= number of students	**Pre-test**	**Post-test after Lesson #6**	**Post-test after Lesson #7**
Grade 4, n=123	**30%**	**84%**	**88%**
Grade 6, n=190	**48.2%**	**92%**	**93%**
Grade 8, n=105	**64.8%**	**87.7%**	**88.8%**

This report was submitted by Larry W. Barber PhD, November 3, 2007.

QUESTIONS FOR STUDY #105a, 59a and 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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