A STUDY OF THE INSTRUCTIONAL EFFECTIVENESS OF
Holt McDougal Chemistry **2012**©
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ABSTRACT

To help secondary school students develop better knowledge and analysis skills and strategies about Chemistry, *Houghton Mifflin Harcourt* has published, **Holt McDougal** *Modern Chemistry ©2012*. Chemistry is a hands-on, problem solving subject. For that reason, the *Modern Chemistry* program includes multiple sample problems in each chapter to help reinforce a consistent 4-step problem-solving process which helps students clearly see each step of a similar problem that they will practice on their own. Students learn to *Analyze*, *Plan*, and *Solve* problems and *Check Their Work*.

In order to evaluate **Holt McDougal** *Modern Chemistry ©2012*, Houghton Mifflin Harcourt contracted with the Educational Research Institute of America (ERIA) to conduct a full academic year study to test the effectiveness of the program. The study was conducted during the 2011/2012 academic year.

A test was developed to assess students' understanding, knowledge, analysis skills and strategies in chemistry. The **Holt McDougal** *Modern Chemistry ©2012*program had not been previously used in the schools by any classes.

The results showed that the **Holt McDougal** *Modern Chemistry ©2012*classes made statistically significant gains over the course of the academic year. These strong gains were made equally strong regardless of gender, ethnicity, or school attended. The results also showed the **Holt McDougal** *Modern Chemistry ©2012* program proved equally effective with both higher and lower pretest scoring students.

Overview of the Study

This report describes an academic year study conducted to determine the impact of the **Holt McDougal** *Modern Chemistry ©2012* program for high school students. For the full academic year the entire program was the primary instructional program in all classes.

Research Questions

The following research questions guided the design of the study and the data analyses:

1. Is **Holt McDougal** *Modern Chemistry ©2012* effective in improving the skills and knowledge of high school students regardless of gender, ethnic background, or school attended?
2. Is **Holt McDougal** *Modern Chemistry ©2012* effective in improving skills and knowledge of lower performing as well as higher performing high school students?

Design of the Study

The program's efficacy was evaluated using a pretest/posttest design. The study took place during the 2011/2012 academic year. All of the students in the study were enrolled in grades 11 and 12. A total of eight different teachers in three different schools across two states were included in the study. The study took place over the entire academic year.

During the first two weeks of instruction, students were administered a comprehensive test designed to cover the content of the *Holt McDougal Modern Chemistry ©2012* program. A similar posttest was used at the end of the study. Pretest and post-test administration was under the direction of the classroom teacher. All tests were returned to ERIA for scoring and analyses.

Project Background

The following focus for the program, as put forth by the publisher, highlights the importance of a research/best practices based program:

> *Holt McDougal Modern Chemistry ©2012 presents a balanced approach to conceptual and problem-solving instruction. Many improvements have been made through a newly designed student book to make chemistry more accessible to more students than ever. The content has been chunked and organized around main ideas. Strategic vocabulary has been highlighted, critical thinking questions have been added, and reading Check for Understanding questions are included to test student comprehension. Additionally, key formulas have been highlighted to help students focus on the key parts of the formula and the unknown variable in the sample problems has been highlighted and color coded throughout the book helping students' further focus on the problem solving process as they solve the practice problems.*

Timeline and Program Use

The teachers used *Holt McDougal Modern Chemistry ©2012k* text as their primary instructional program. The teachers reported using the program for an average of 3 days per week for an average of 35 minutes per day over the entire school year. Pretests were administered at the end of September, 2011 and posttests were administered the middle of June, 2012.

Description of the Research Sample

The study included a total of 671 grade 11 and 12 students for whom matched pretests and post-tests were available. There were three different schools in two different states and a total of 8 chemistry teachers included in the study. One school was located in the Midwest and two were located in the West.

Table 1 provides the demographic characteristics of the schools included in the study. It is important to note that the school data does not provide a description of the make-up of the classes that participated in the study. However, the data does provide a general description of the schools and, thereby, an estimate of the make-up of the classes included in the study.

Table 1
Demographic Characteristics
of the Schools Included in the Study

	Location	Grades	Enrollment	% Minority	% Free/Reduced Lunch	% Special Education
1	Suburban	09-12	1820	31%	24%	N/A
2	Suburban	09-12	1970	31%	30%	N/A
3	Urban	09-12	3432	58%	7%	5%
AVERAGES			**2407**	**40%**	**20%**	**5%**

Description of the Assessment

The pretest and posttest used in the study were developed to assess standards-based Chemistry topics across all of the program chapters. Based on these standards a 45 item multiple-choice assessment test was developed focusing on the skills, strategies, and knowledge necessary for effective understanding of Chemistry.

Table 2 provides the statistical results for the administration of the pretest and the post-test. The KR 20 reliabilities for the post-tests indicate the test was reliable for arriving at decisions regarding the achievement of the students to whom the tests were administered.

The pretest reliability is a bit low. However, since the content of the test covered material which the students had not yet been taught, the reliability would be expected to be lower due to the amount of guessing expected.

Table 2
Pretest and Post-Test Test Statistics

Test	Reliability*	SEM**
Pretest	.55	3.0
Post-test	.75	2.9

Reliability computed using the Kuder-Richardson 20 formula.
*** SEM is the Standard Error of Measurement.*

Data Analyses

Standard scores were developed in order to provide a more normal distribution of scores. The standard scores were a linear transformation of the raw scores. A mean raw score was translated to a mean standard score of 300 and the standard deviation of the raw scores was translated to 50. Standard scores were then used for the statistical analyses.

Data analyses and descriptive statistics were computed for the standard scores from the standards based Chemistry assessments. The $\leq.05$ level of significance was used as the level at which increases would be considered statistically significant for all of the statistical tests.

The following statistical analyses were conducted to compare students' pretest scores to posttest scores:

- A paired comparison *t*-test was used to compare the pretest mean standard scores with the posttest mean standard scores for all students.
- A repeated measures analysis of variance was used to determine if gender, racial background or particular school site influenced pretest/post-test differences.
- The students were split into two groups based on pretest scores. Paired comparison *t*-tests were used with the group that scored higher and the group that scored lower on the pretest to determine if the program was equally effective with lower performers and higher performers.

An effect-size analysis was computed for each of the paired *t*-tests. Cohen's *d* statistic was used to determine the effect size. This statistic provides an indication of the strength of the effect of the treatment regardless of the statistical significance. Cohen's *d* statistic is interpreted as follows:

.2 = small effect
.5 = medium effect
.8 = large effect

Data Results and Analyses

Total Group Analysis

A paired comparison *t*-test was conducted to determine if the difference from pretest standard scores to posttest standard scores was statistically significant. For this analysis, researchers were able to match the pretest and posttest scores for 667 students. Table 3 shows that the average standard score on the pretest was 277, and the average standard score on the posttest was 323. The increase was statistically significant ($\leq.0001$). The effect size was large.

Table 3
Paired Comparison *t*-test Results
Pretest/Posttest Comparison of Standards Scores
for Three Schools

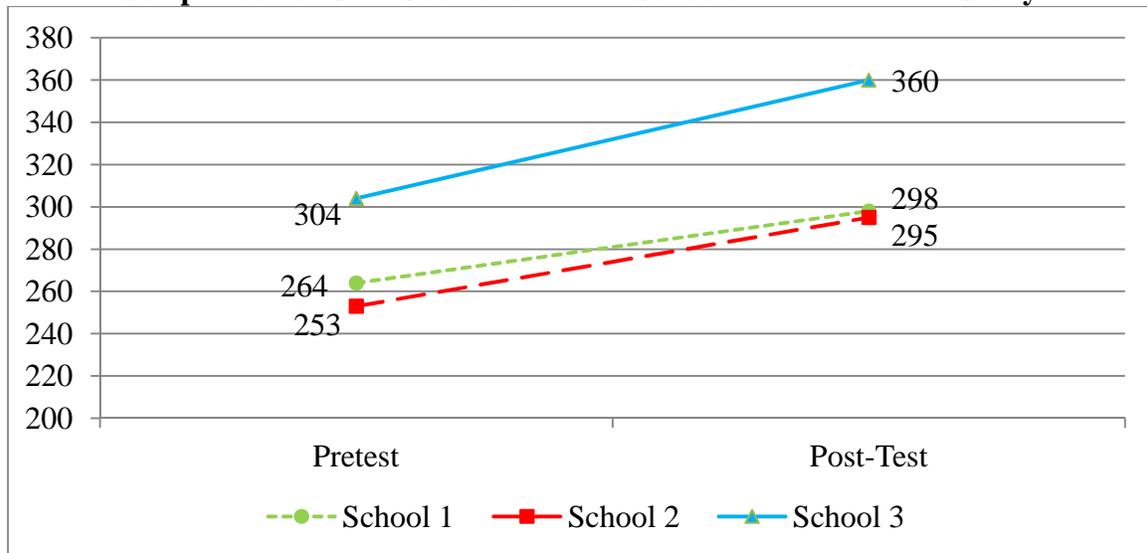| Test	Number Students	Mean Standard Score	SD	t-test	Significance	Effect Size
Pretest	667	277.3	38.1	26.855	≤.0001	1.02
Posttest	667	322.8	50.2			

A Repeated Measures Analysis of Variance (ANOVA) was conducted to assesses if ethnicity, gender, or school had a significant effect on the gains from pretesting to post-testing. The results showed that students' ethnicity had no significant effect ($F (3, 658) = .849$, $p = .467$) and neither did students' gender ($F(3,658) =.654$, $p = .581$). However, there was a significant effect for school ($F(2,658) = 13.507$, $p = .0001$).

Table 4
Paired Comparison *t*-test Results
Pretest/Posttest Comparison of Standards Scores
for Three Schools

Test	Number Students	Mean Standard Score	SD	t-test	Significance	Effect Size
School 1						
Pretest	168	264.3	30.2	10.979	≤.0001	1.00
Posttest	168	297.7	35.6			
School 2						
Pretest	220	253.2	28.4	14.136	≤.0001	1.15
Posttest	220	294.7	42.0			
School 3						
Pretest	279	304.0	31.8	21.173	≤.0001	1.59
Posttest	279	360.0	38.5			

To examine the school effect a paired comparison t-test was computed and the results are shown in Table 4. Analyses indicated that students from all three schools made significant gains (≤.0001) and the effect size was large at each site. The difference is that School 3 had pretests that were significantly higher than the other two schools. This growth from pretest to posttest for students from all 3 schools is depicted in Figure 1.

Figure 1
Comparison of Gain Scores for Three Schools Included in the Study

Higher and Lower Scoring Students

An additional analysis was conducted to determine if students who scored lower on the pretest made gains as great as those students who scored higher on the pretest. For this analysis students were ranked in order on the basis of their pretest standard scores. The group of 667 students was divided into two groups of 332 and 333 students. The first group included those students who scored lower on the pretest with a mean of 246 with scores ranging from 177 to 272. The higher scoring group scored an average standard score on the pretest of 308 with scores ranging from 272 to 385.

Pretest-to-posttest comparisons are shown in Table 5 for the lower and higher pretest scoring students. Scores were analyzed using a paired comparison *t*-test to determine if both groups made significant gains.
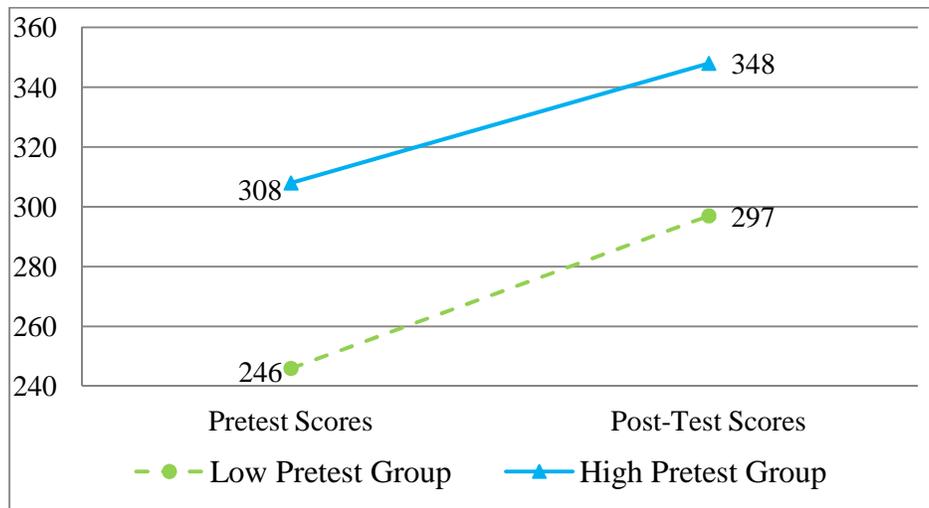
For both the higher and the lower scoring group, the average scores increased. The increase for both groups was statistically significant (≤.0001). The effect size for both groups was large.

Table 5
Paired Comparison *t*-test Results for Pretest/Posttest Standard Scores
for the High- and Low-Scoring Pretest Groups

Test	Test Form	Number of Students	Mean Standard Score	SD	t-test	Significance	Effect Size
Lower Scoring Group							
Total	Pretest	333	246.1	19.6	21.309	≤.0001	1.54
Total	Posttest	333	297.2	42.6			
Higher Scoring Group							
Total	Pretest	334	308.3	24.0	16.926	≤.0001	1.13
Total	Posttest	334	348.2	43.8			

Figure 2 provides a pretest-to-posttest comparison of the standard scores of lower and higher scoring pretest students. Both groups increased their scores about the same.

Figure 2
Standard Score Increases for Lower and Higher Pretest Score Students

Conclusions

This study sought to determine the effectiveness of ***Holt McDougal Modern Chemistry*** **©2012,** a high school chemistry program published by *Houghton Mifflin Harcourt*. The study was carried out with Grade 11 and 12 chemistry classes across three schools and two states. The teachers were using the program for the first time and received no special instruction in using the program.

Two research questions guided the study:

Question 1: Is ***Holt McDougal Modern Chemistry*** **©2012** effective in improving the skills and knowledge of high school students in chemistry regardless of gender, ethnic background, or school attended?

A test designed to assess the knowledge, skills, and analytic skills in Chemistry was developed to assess students at the beginning and end of academic year tryout of the program. Statistical analyses of students' scores showed that the students increased their scores statistically significantly on the assessment. The effect size was large.

No differences were seen in the pretest/post-test score differences for male and female students. Both groups made statistically significant gains and the effect size for both the male and female groups was large.

No differences were seen in the pretest/post-test score differences for the three ethnic groups identified. All three groups made statistically significant gains and the effect size for each group was large.

Question 2: Is ***Holt McDougal Modern Chemistry*** **©2012** effective in improving students' skills and knowledge in chemistry of lower performing as well as higher performing high school students?

Statistical analyses showed that for both the lower and higher pretest scoring students the increases were statistically significant. For both groups the effect size was large.

On the basis of this study, both research questions can be answered positively.

- ***The Holt McDougal Modern Chemistry* ©2012 *textbook program is very effective in improving the chemistry skills and knowledge of high school students. Gains were very strong and positive regardless of gender, ethnicity, and school attended.***
- ***The Holt McDougal Modern Chemistry* ©2012 *textbook program is very effective in improving skills and knowledge in Chemistry of lower performing as well as higher performing high school students.***