**MEMORANDUM** August 21, 2015

TO: Board Members

FROM: Terry B. Grier, Ed.D.
Superintendent of Schools

SUBJECT: **NEW DIGITAL ENERGY GAME PROGRAM EVALUATION, 2014–2015**

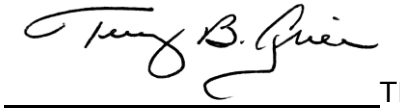
CONTACT: Carla Stevens, (713) 556-6700

The New Digital Energy Game (NDE), sponsored by Chevron, in collaboration with Tietronix Software, Inc. and the Houston Independent School District (HISD), was implemented for the fifth consecutive year in HISD's middle and high schools. NDE combines aspects of strategy, construction, and game management, requiring players to build energy companies, gain dominant market share, and meet the needs of cities throughout the United States. Cooperative teams of students play against artificial intelligence, competing across three levels of difficulty. Variations in difficulty are incorporated into lessons that students must master in order to open options within the game.

Paired t-test analysis of a student sample yielded a statistically significant increase in students' overall interest rating in science from pre- to post survey, and a decrease in their overall attitude rating over the same time period. Propensity score, nearest neighbor matching yielded a higher percent of items correct on the mid-year District Level Assessment (DLA) in science for NDE students compared to students who did not participate in the program. The difference between the groups was statistically significant, suggesting that the NDE program had a positive effect on students' DLA science performance.

**Administrative Response**: The HISD Strategic Partnership Department will continue to coordinate with Chevron to support implementation of prekindergarten through 12 engineering education activities. These efforts will also serve as a resource to help teachers generate future engineers, scientist, geologist, doctors, and other STEM career opportunities for HISD students.

Should you have any questions or require any further information, please contact me or Carla Stevens in the Department of Research and Accountability, at 713-556-6700.


TBG

TBG/CS:vh

cc: Superintendent's Direct Reports
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Hortense Campbell
Teresa Phillips

HOUSTON INDEPENDENT SCHOOL DISTRICT

# RESEARCH

Educational Program Report

## THE EFFECT OF THE NEW DIGITAL ENERGY GAME ON STUDENTS' INTEREST, ATTITUDE, AND SCIENCE ACHIEVEMENT USING PROPENSITY SCORE MATCHING, 2014–2015

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EVALUATION REPORT
BUREAU OF PROGRAM EVALUATION
Volume 9, Issue 1, August 2015

# *The effect of the New Digital Energy game on students' interest, attitude, and science achievement using propensity score matching, 2014–2015*

**By Venita Holmes, Dr.P.H.**

*During the 2014–2015 academic year, 1,148 students registered and 820 elementary, middle, and high-school students played the New Digital Energy Game (NDE) game in the Houston Independent School District (HISD). The NDE game was designed to enrich students' science experiences in order to stimulate their interests and attitudes to pursue science careers. The game was funded by Chevron Corporation and developed by Tietronix, Inc. Paired t-test analysis of a student sample yielded a statistically significant increase in students' overall interest rating in science from pre- to post survey, and a decrease in their overall attitude rating over the same time period. Propensity score, nearest neighbor matching yielded a higher percent of items correct on the mid-year District Level Assessment (DLA) in science for NDE students compared to students who did not participate in the program. The difference between the groups was statistically significant, suggesting that the NDE program had a positive effect on students' DLA science performance. Notable highly statistically significant intercorrelations were as students' post-interest and post-attitude ratings increased, their science DLA results increased.*

## Background

U.S. educators have persistently sought to improve academic achievement for low-performing students through reform laws such as *No Child Left Behind* (U.S. Department of Education, 2001; Education Week, 2011). However, the lack of substantial academic progress for students over the years (Phillips, 2014) has led to the emergence of new technologies to support student's academic success. A shift in education from a didactic model of instruction to a constructivist model that emphasizes students as active learners has played a pivotal role in the development of these technologies (Jong, Shang, Lee, F., & Lee, J., 2008).

Much attention has been devoted toward understanding the cognitive, social, and cultural features in computer games and their educational benefits to students (Gee, 2005; Squire, 2005). Research has shown that computer games that provide instruction have the potential to stimulate the academic environment and increase student's awareness and knowledge of phenomenon to solve problems (Honey & Hilton, 2010; Jones, 1996; Mundie, 2011; Owston, 2009; Yang, Kun, & Chein, 2010). "Fun and enjoyment are important in the process of learning as learners can be more relaxed, motivated and willing to learn" (Jong, et al., p., 54, 2008). Electronic gaming has been considered instrumental toward engaging students in critical thinking necessary to apply subject matter to "real-life" experiences (Curriculum Review, 2009). Digital games may encourage students to ask unanswered questions and teach them to use problem-solving techniques.

Brendzel (2004) pointed out that "games provide a natural motivation" (p. 32) to apply good teaching strategies to help build science concepts. Contest can further stimulate students' drive to compete by improving their comprehension skills through a format that may be more interesting to students. Interested students may be more engaged in activities that they value (Bulunuz & Jarret, 2009). Ogunkola (2011) found that increased attitudes and interest in an activity is correlated with good study habits and engagement in school. Disengaged students are more likely to have poor attendance and more likely to drop out of school (Balfanz, Herzog, & MacIver, 2006).

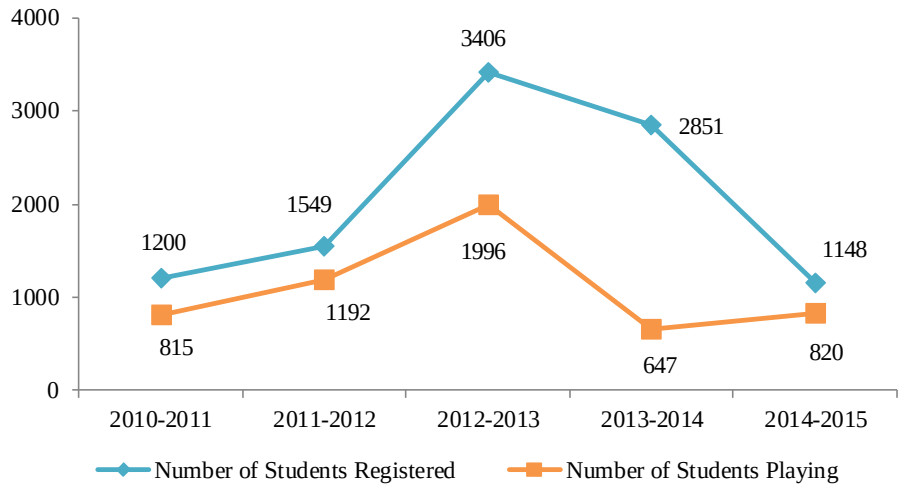


Figure 1. Number of students who registered and played the NDE game, 2010–2011 through 2014–2015

NDE game tasks accommodated all academic levels by combining strategy, construction, and game management, while requiring players to build energy companies and gain dominant market share to meet the needs of U.S. cities. Students played as teams against artificial intelligence, competing across three levels of difficulty. Variations in difficulty were incorporated into lessons that students had to master to open options within the game. Lessons and questions prompted students to game-play decisions that required understanding of physics, chemistry, earth science, and math concepts.

To that end, this study measured the effects of the NDE game on students' science achievement. In addition, the study measured student's perceptions toward increasing their interests and attitudes about science.

## Methods

### *All Student Participants*

All HISD science teachers were invited to recruit students to participate in the NDE game during the fall of 2015. Teachers were required to register. Teachers of winning teams had the opportunity to attend innovative professional development in science.

**Figure 1** presents the number of students who registered along with the number of students who played the game over the past five academic years. Twenty-two schools and 29 teachers were represented in the 2012–2013 data; whereas, 16 schools were represented in the 2013–2014 data. By the 2014–2015 academic year, a total of 22 teachers were reflected in the data at 17 schools. (See **Appendix A** for the 2014–2015 NDE schools.) Student registration steadily increased from 2010–2011 to 2012–2013 and steadily decreased from that point to 2014–2015. At the same time, students playing the game dropped by 20.6 percent from the 2012–2013 to the 2013–2014 academic year, and increased by 26.7% from the 2013–2014 to the 2014–2015 academic year.

### *Selected Student Sample*

The study sample was selected based on having completed the pre- and post-science energy interest and attitude surveys. Among the 820 students who played the game, the student identification numbers of 369 students were captured in the survey data. The number of students who registered and participated in the game by school can be found in **Appendix B**.

**Table 1** presents a profile of the 369 NDE students whose data were analyzed in this program evaluation. The majority of the NDE student sample was female (50.4%) and economically disadvantaged (57.5%). Comparatively, the District had a higher percentage of economically disadvantaged (75.5%), at-risk (66.4%), limited English proficient (LEP) (29.9%), and special education students (7.5%) than the NDE student sample.

Table 1: NDE Student Sample vs. HISD, 2014–2015

| | NDE Student Sample† | HISD* |
|---|---|---|
| **Gender** | **%** | **%** |
| Male | 49.6 | 51.0 |
| Female | 50.4 | 49.0 |
| **Eco. Disadv.** | 57.5 | 75.5 |
| **At Risk** | 36.9 | 66.4 |
| **G/T** | 28.5 | 15.4 |
| **LEP** | 10.8 | 29.9 |
| **Spec. Ed.** | 5.4 | 7.5 |

*2014–2015 HISD Facts and Figures
†NDE student sample = 369

*Measures*

Students' interest and attitude were assessed using a web-based survey format that was accessed at the game site. The instruments included a 10-item science interest survey and a 10-item science attitude survey. The survey items measuring interest and attitude had good internal consistency, with a Cronbach alpha coefficient of .81 and .86, respectively. While students were encouraged to complete the instruments, no incentives were offered for completion. Interest was rated using a Likert-type scale: very often - 4; regularly - 3; sometimes - 2; and never or hardly ever - 1. Attitude was rated strongly agree - 4; agree - 3, disagree - 2, and strongly disagree - 1.

Academic performance was measured using District Level Assessment (DLA) data in science. The DLA was administered in February 2015. The timeframe of the science DLA administration was consistent with when the NDE program ended in February 2015. Propensity score, nearest neighbor matching was used to estimate the probability of being exposed to treatment given a set of observed variables and taking into consideration science DLA scores. Students selected for the comparison group attended the same schools as NDE students. Propensity score matching is a common practice in social science to make causal inferences based on observational data (Cohen, 1988). NDE students who participated in the survey study sample were used in the propensity score matching. Gender, economic status, LEP, G/T, special education program status, and at risk were matching criteria. Bias analysis (**Appendix C**) was conducted and yielded a comparison sample in that the treated and untreated shared the same characteristics; thus, the selection bias had been mitigated in the "new" sample (Austin, Grootendorst, and Anderson, 2007). Based on matching criteria, *Stata* selected 193 NDE students and the 46,362 students in the comparison group for the model (**Appendix D**).

Descriptive statistics were presented on the measures. Comments about students' experiences were summarized. Correlation analysis was conducted to determine whether there was a relationship between students' interest, attitude, and DLA science performance.

## What was the impact of the NDE game on students' science interest and attitude?

Data were gathered on NDE student's science interest and attitude before and after participation in the game during the 2014–2015 academic year. The overall mean along with the mean ratings by survey item are presented. Additional paired t-test analyses include standard deviations, t-statistics, and p-values.

### Science Interest Survey Results

**Figure 2** show a statistically significant increase in the students' overall science interest mean rating from pre- ($M = 2.24$, $SD = .666$) to post-survey ($M = 2.31$, $SD = .699$), $t(368) = 2.55$, $p = .01$. Item-by-item interest ratings can be found in **Figure 3**. Among the 10 items measuring interest, there were significant increases in mean ratings on three of the items: "the extent that students read books or magazines about science outside of school" ($p < .05$), "participated in after-school science activities" ($p < .001$), and "attended science study groups" ($p < .05$). Other increases in interest were noted on the items reflecting that students "talked to their teacher about science," "participated in science competitions," "talked to their friends about science," "visited websites about science," and "watched news on TV that involved science concepts." There was a slight decrease in ratings on items measuring that "students had fun when learning science" and "talked about science to parents or family members."


Figure 2: Overall mean interest and attitude ratings from pretest to posttest

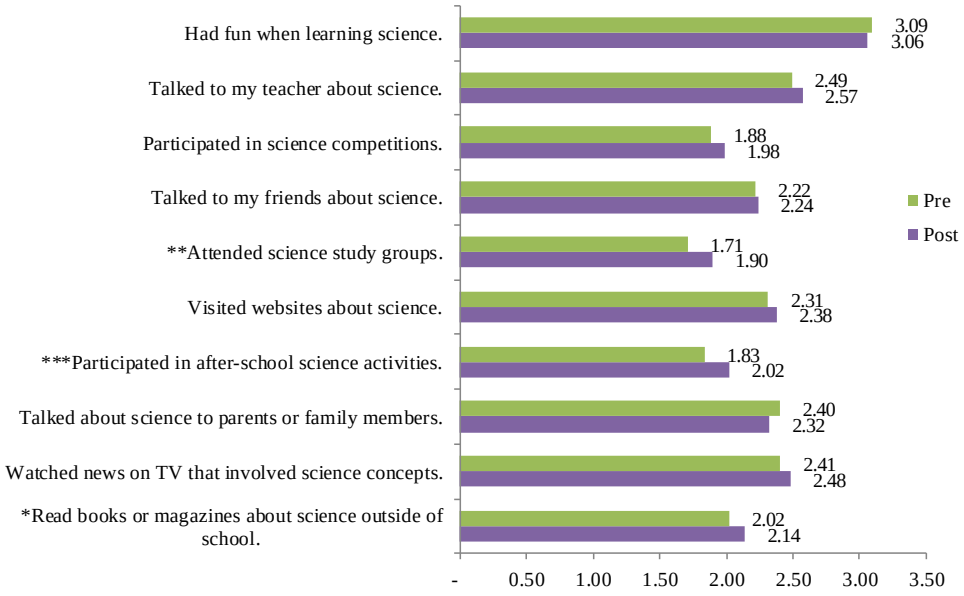


Figure 3: Pre- and post-survey ratings of NDE students on items measuring interest in science (4-point Likert-type scale)
Note: *Statistical significance at $p < .05$; **$p < .01$; ***$p < .001$

**Science Attitude Survey Results**

Relative to attitude about science, a decrease in students' overall mean rating was noted from pre- (M = 3.05, SD = .717) to post-survey (M = 2.98, SD = .826), t (326) = -1.77, p = .08.

Item-by-item pre-and post-attitude ratings can be found in **Figure 4**. Ratings increased on the item "I would like to have a career involving science" from pre- (M = 2.72) to post-survey (M = 2.74). However, the positive change was not statistically significant at $p < .05$.

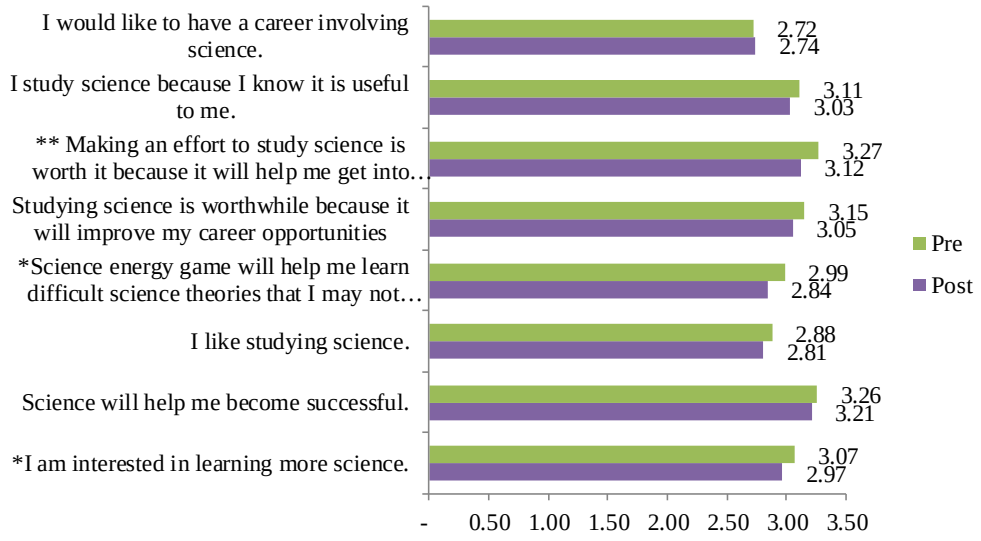


Figure 4: Pre- and post-survey ratings of NDE students on items measuring attitude about science (4-point Likert-type scale)
Note: *Statistical significance at $p < .05$; **$p < .01$

Table 2: T-test Analysis based on the Percentage of Items Correct on Science District Level Assessments, spring 2015

| | n | Mean | Mean Diff. | S.E. | t |
|---|---|---|---|---|---|
| NDE Sample | 193 | 66.8 | 7.8 | 2.08 | 3.77* |
| Matched Student Sample | 46,362 | 58.9 | | | |

*p < .05

Statistically significant decreases in mean ratings from pre- to post-survey were noted on the following items: "making an effort to study science is worth it because it will help me get into college" ($p < .01$), the "science energy game will help me learn difficult science theories that I may not understand without seeing in the game" ($p < .05$), and "I am interested in learning more science" ($p < .05$).

## What was the effect of the NDE game on students' science achievement?

Propensity score, nearest neighbor matching was used to determine the impact of the NDE program on NDE student's 2015 District Level Assessments (DLAs) science scores. The statistical model used in the analysis controlled for economic status, grade level, gender, special education program status, and gifted/talented identification, at risk, and limited English proficient. Matched students were enrolled in the same schools as NDE students, and yielded a sample of 193 NDE students and 46,362 comparison-group students in the model.

**Table 2** presents the academic performance of the NDE sample and the matched sample on the science DLA (February 2015 administration). The NDE student sample had a higher percentage of items correct (66.8%) due to participation in the program compared to students who did not participate in the program (58.9%). The difference between the groups was statistically significant ($t = 3.77$, $p < .001$). The results from the model suggested that the NDE program had a positive effect on students' DLA science performance.

## What were the associations between science interest, attitude, and DLA science results?

**Table 3** depicts means and standard deviations along with intercorrelations of the measures for the NDE student sample. There were strong positive associations between students' ratings on the interest, attitude, and science DLA. A notable finding was that as students' post-interest and post-attitude ratings increased, their science DLA results increased. These intercorrelations were highly statistically significant at $p < .01$.

## Discussion

The New Digital Energy game was designed to increase student's understanding of science concepts by introducing game construction and management strategies. Students worked as teams to build energy companies, gain dominant market share, and meet the needs of cities throughout the United States. Students played against artificial intelligence to answer challenging questions about science energy. An objective of the game was to increase student's interest and attitude about science as they increased their knowledge of

Table 3: Summary of Intercorrelations, Means, and Standard Deviations for Scores on the Pre- and Post-Science Interest, Attitude, and Science DLA Measures for NDE Sample, 2015 (n = 194)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Pre-Interest | - | | | | |
| 2. Post-Interest | .784** | - | | | |
| 3. Pre-Attitude | .652** | .592** | - | | |
| 4. Post-Attitude | .585** | .698** | .701** | - | |
| 5. Science DLA | .177* | .235** | .167* | .328** | - |
| Mean | 2.09 | 2.21 | 2.94 | 2.81 | 66.85 |
| Std. Deviation | .63 | .76 | .75 | .87 | 18.67 |

* Correlation is significant at the p < .05 level (2-tailed test)
**Correlation is significant p <.01 level (2-tailed)

science concepts.

There were several limitations to the study. First, given the team format, the study lacked data on actual time spent by individual students playing the game. Thus, differential effects of student's exposure to the game on their DLA performance, interest, and attitude could not be assessed. Another limitation was the lack of a comparison group to assess the impact of the game on students' interests and attitudes. While a pre- post-test design provided an alternative method for comparing students, threats to validity could still exist relative to knowing whether other external factors influenced the changes in student outcomes over time (Boyd, 2002). In consideration of these threats, propensity score matching was used to reduce bias and assess whether participation in the game had an effect on students' science achievement while controlling for key demographic characteristics. The findings included a statistically significant difference between the NDE student sample's DLA science performance and the performance of the control group on the assessment. Finally, the lack of data at the four survey data collection points on all students who played the game resulted in substantial attrition. (The number of students who played the game was substantially lower than the number of students who initially registered (820 out of 1,148 students). Even less students were included in the final analysis of the survey data (369). The recruitment process relied on teacher commitment, which may have contributed to attrition of the initial group of student participants.

For the current year program evaluation, positive correlations were found between student's interest, attitude, and DLA science scores. In addition, as student's science DLAs scores increased, there was a highly statistically significant increase in their post-interest and post-attitude perceptions about science. This finding was consistent with the expectation that a positive relationship exists between interests and achievement (Brendzel, 2004).

This study offers promising results regarding influencing student's perceptions about science and science achievement. Moreover, what may be more important is that students were exposed to science material needed to enhance their understanding of science concepts (Wainwright & Linebarger, 2006). These experiences may be, particularly, valuable to students who, otherwise, could not afford them. Teachers were provided the opportunity to attend workshops to stay abreast of innovative trends and best practices in science.

Future research may explore other innovative strategies for improving student behavior and academic achievement in science. This may be, particularly, important given the achievement gaps that exist for low-performing students in the targeted content area (U.S. Department of Education, 2001; Education Week, 2011, Phillips, 2014.

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For additional information contact the HISD Department of Research and Accountability at 713-556-6700 or e-mail Research@Houstonisd.org.

## Appendix A

### All Registered NDE Student Participants by School, 2014–2015

| | Frequency | Percent |
|---|---|---|
| Hilliard Elementary | 42 | 3.7 |
| Briargrove Elementary | 13 | 1.1 |
| Clifton Middle School | 34 | 3.0 |
| Crockett Elementary School | 62 | 5.4 |
| Eastwood Academy | 27 | 2.4 |
| Holland Middle School | 97 | 8.4 |
| Long Middle School | 19 | 1.7 |
| Mickey Leland College Preparatory | 280 | 24.4 |
| Montgomery Elementary | 107 | 9.3 |
| Pershing Middle School | 57 | 5.0 |
| Piney Point | 17 | 1.5 |
| Project Chrysalis MS | 8 | .7 |
| Ryan Middle School | 2 | .2 |
| Travis Elementary | 58 | 5.1 |
| Washington High School | 76 | 6.6 |
| Welch Middle School | 16 | 1.4 |
| Westside High School | 32 | 2.8 |
| White Elementary | 81 | 7.1 |
| Young Women’s College Preparatory | 120 | 10.5 |
| Total | 1148 | 100.0 |

## Appendix B

### NDE Student Survey Sample by School

| School | Frequency | Percent |
|---|---|---|
| Washington High School | 28 | 7.6 |
| Gregory Lincoln Education Middle School | 1 | .3 |
| Pershing Middle School | 97 | 26.3 |
| Travis Elementary | 51 | 13.8 |
| Eastwood Academy for Academic Achievement | 6 | 1.6 |
| Gregory-Lincoln | 3 | .8 |
| Mickey Leland College Preparatory Academy | 58 | 15.7 |
| Young Women's College Preparatory Academy | 96 | 26.0 |
| Hilliard Elementary | 29 | 7.9 |
| **Total** | 369 | 100.0 |

## Appendix C

### Propensity Score Matching Bias Analysis

| | Mean | | | t-test | | V(T)/ |
|---|---|---|---|---|---|---|
| **Variable** | **Treated** | **Control** | **% bias** | **t** | **p> t** | **V(C)** |
| Gender | .31606 | .31606 | 0.0 | -0.00 | 1.000 | . |
| Eco. Status | .55959 | .55959 | 0.0 | -0.00 | 1.000 | . |
| LEP | .09845 | .09845 | 0.0 | 0.00 | 1.000 | . |
| G/T | .36788 | .36788 | 0.0 | -0.00 | 1.000 | . |
| Special Ed. | .01554 | .01554 | 0.0 | -0.00 | 1.000 | . |
| At Risk | .33161 | .33161 | 0.0 | -0.00 | 1.000 | . |

* if variance ratio outside [0.75; 1.33]

| Ps R2 | LR chi2 | p>chi2 | Mean Bias | Med Bias | B | R | % Var |
|---|---|---|---|---|---|---|---|
| -0.000 | -0.00 | 1.000 | 0.0 | 0.0 | 0.0 | 1.00 | . |

* if B>25%, R outside [0.5; 2]

## Appendix D

### Treated and Control Group Statistics
### Science DLA

| | Treated (NDE) (n = 193) | Controls (46,362) | | | |
|---|---|---|---|---|---|
| | **% Correct** | **% Correct** | **Difference** | **S.E.** | **T-stat** |
| **Unmatched** | 66.8 | 54.3 | 12.5 | 1.502 | 8.30 |
| **Matched** | 66.8 | 58.9 | 7.9 | 2.078 | 3.77 |

| **Prior to Matching** | **Treated (n = 193)** | **Controls (46,362)** |
|---|---|---|
| | **% Correct** | **% Correct** |
| **Gender** | | |
| Male | 31.6 | 49.2 |
| Female | 68.4 | 50.8 |
| **Economically disadvantaged** | 56.0 | 76.4 |
| **At risk** | 33.2 | 66.9 |
| **LEP** | 9.8 | 30.8 |
| **Special Ed** | 1.6 | 7.8 |
| **G/T** | 36.8 | 17.3 |

## Appendix E

### NDE Student Survey Sample Science Interest

| | n | Pre | Std. | Post | Std. | t | p |
|---|---|---|---|---|---|---|---|
| Read books or magazines about science outside of school. | 369 | 2.0 | .8905 | 2.1 | .9411 | 2.496 | .013* |
| Watched news on TV that involved science concepts. | 369 | 2.4 | .9541 | 2.5 | .9297 | 1.447 | .149 |
| Talked about science to parents or family members. | 369 | 2.4 | 1.009 | 2.3 | .9761 | -1.500 | .134 |
| Participated in after-school science activities. | 369 | 1.8 | .9821 | 2.0 | 1.020 | 3.533 | .000*** |
| Visited websites about science. | 369 | 2.3 | .9718 | 2.4 | .9817 | 1.188 | .235 |
| Attended science study groups. | 369 | 1.7 | .9835 | 1.9 | .9974 | 3.471 | .001** |
| Talked to my friends about science. | 369 | 2.2 | 1.004 | 2.2 | 1.004 | .349 | .727 |
| Participated in science competitions. | 369 | 1.9 | .9945 | 2.0 | 1.016 | 1.724 | .086 |
| Talked to my teacher about science. | 369 | 2.5 | 1.035 | 2.6 | 1.006 | 1.4921 | .137 |
| Had fun when learning science. | 369 | 3.1 | .9492 | 3.1 | .8892 | -.627 | .531 |

Statistical significance: *p < .05; **p < .01; ***p < .001

## Appendix F

### NDE Student Survey Sample Science Attitude

| | n | Pre | Std. Dev. | Post | Std. Dev. | t | p |
|---|---|---|---|---|---|---|---|
| I am interested in learning more science. | 368 | 3.1 | .8892 | 3.0 | .9435 | -2.277 | .023* |
| Science will help me become successful. | 364 | 3.3 | .8723 | 3.2 | .9574 | -.985 | .325 |
| I like studying science. | 360 | 2.9 | .9701 | 2.8 | 1.007 | -1.408 | .160 |
| Science energy game will help me learn difficult science theories that I may not understand without seeing in the game. | 364 | 3.0 | .9344 | 2.8 | 1.015 | -2.550 | .011* |
| Studying science is worthwhile because it will improve my career opportunities | 368 | 3.2 | .9252 | 3.1 | .9862 | -1.831 | .068 |
| Making an effort to study science is worth it because it will help me get into college. | 363 | 3.3 | .8889 | 3.1 | .9412 | -2.967 | .003** |
| I study science because I know it is useful to me. | 357 | 3.1 | .9444 | 3.0 | .9910 | -1.416 | .158 |
| I would like to have a career involving science. | 363 | 2.7 | 1.106 | 2.7 | 1.114 | .321 | .748 |

Statistical significance: *p < .05; **p < .01