Research and Accountability Department

EVALUATION REPORT

BUREAU OF PROGRAM EVALUATION

Volume 7, Issue 2, May 2013

The Effect of the New Digital Energy (NDE) Game on Students' Science Energy Knowledge Acquisition, Interests, and Teacher Instructional Practices, 2012–2013

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Using a pre-post design, this study evaluates the association between participating in a science game (NDE) and science energy knowledge and science interest. A survey was used to explore teacher perceptions of the game on their instructional practices. Outcome measures were collected at the individual level and the game was played at the team level. The results of the study indicate that for secondary students, post-science knowledge and interest increased very slightly, and for elementary students, post-interest increased slightly while post-science knowledge decreased slightly. These results suggest that NDE does not appear to be strongly associated with improved science knowledge and interest, at least for the subset of students who participated in this study, although increases were statistically significant. Further analysis is needed to demonstrate the game's effect on students' knowledge and interest. The majority of teachers whose students participated in the game indicated changing their instructional practices based on students' inquiry and feedback. Generally, students indicated the game was fun and expanded their understanding of science. Longitudinal tracking of elementary students' science course selection and grades as they progress through school could provide alternative measures of NDE program impact.

Background

In its third year, Chevron expanded funding of the NDE game from middle- and high-school to include elementary-school students in the Houston Independent School District (HISD). Tasks were modified to accommodate all student academic levels. Students played as teams against artificial intelligence, competing across three levels of difficulty. Variations in difficulty were incorporated into lessons that students must master to open options within the game. Lessons and questions led students to game-play decisions that required understanding of physics, chemistry, earth science, and math concepts. A meta-site supplemented their learning and success for subsequent game play. The game combined 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. The program included field trips to the Ocean Star Offshore Drilling Rig & Museum in Galveston and the Houston Museum of Natural Sciences' WEISS Energy Hall and Hall of Paleontology. Prizes were awarded by level (elementary and secondary) for high scores and participation in the game.

As technological competencies increase, U.S. students continue to struggle in science achievement (Sparks, 2013; U.S. Department of Education, 2011). Research based on international science assessments found a decline in fourth to tenth-grade science performance as students progress through school (Leinward & Pollock, 2007). Psychology learning theorists explored the role of social and cultural experiences in gaining knowledge and the development of learning through socially-mediated activities (Cole, 1978). Vygotsky proposes "humans are active, vigorous participants in their own existence" throughout the developmental process (Cole, p. 123). Practical experiences in science education through active participation in social milieu may provide a favorable environment for learning (Driver, Newton, & Osborne, 2000).

The National Science Foundation (n.d.) emphasizes the importance of designing and testing innovative approaches to learning by applying technology to meet the needs of all learners. Research postulated that computer games enhance the educational experience of students, partly due to the multifaceted process required to learn science (National Research Council, 2011). Jones (1996) noted that the interaction between the use of technology and student learning may be influenced by various factors, including students' interest in science. Bulunuz and Jarret (2009) identified the relationship between interest and effort, concluding that the more effort, the more interest, and interested individuals are more engaged and engrossed by activities because of their value. Ogunkola (2011) supported relationships between attitudes, interests, study habits, and the use of technology among a sample of 300 high-school students in Barbados. The importance of stimulating students' interest has also been documented among middle-school students, noting that students who are disengaged from school are more likely to have poor attendance and more likely to drop out (Balfanz, R., Herzog, L. & Mac Iver, D, 2006).

Mundie (2008) maintains that "technology has the potential to help reinvent the education process, and excite and inspire young learners to embrace science, math and technology" (p.1). In efforts to add to the body of knowledge, Plass (2011) cites Resnik in noting, "the best educational activities connect not only to important concepts but also to students' interests and passions" (p.1).

Computer games are inherently interactive and have, increasingly, become a new and innovative approach to teaching and learning science as they capture the attention of youth. In addition, computer games allow students to be transported into another reality and engage in activities that simulate the real world while exploring natural phenomena that cannot be directly observed (Games Research, 2011; Mundie, 2011).

Previous research conducted on an NDE secondary-level student sample found higher overall mean ratings on a survey that measured students' interest and attitudes in science following participation (Holmes, 2012). Nevertheless, there continues to be a gap in the research concerning the use of games, which features contribute to student learning, and whether social factors influence student outcomes. This study will build on the body of knowledge by considering background characteristics of students who participated in the game and assessing whether outcomes and perceptions persist in both elementary and secondary student populations.

Methodology

All HISD elementary and secondary science teachers were invited to recruit students to participate in the NDE game during fall 2012. Teachers were required to register and sign a letter of commitment. As shown in **Figure 1**, the number of students who registered and the number of students who played the game in 2012–2013 more than doubled from the first year of implementation in 2010–2011 possibly due to the program's expansion from secondary to include elementary schools. Sixteen secondary schools and 26 teachers were represented in the 2011–2012 data considering 85 secondary schools were invited to participate. Comparatively, 22 schools and 29 teachers were represented in the 2012–2013 data. This included 10 elementary and 12 secondary schools.

Measures and Variables

Students were administered a web-based, 17-item multiple-choice science energy assessment using a pre- and post-test design. HISD science curriculum staff and the Tietronix's Inc. game developers compiled the science assessment questions to align to the Texas Essential Knowledge and Skills (TEKS) standards and content covered in the game. The instrument had been used in previous research conducted in 2011–2012 with a comparable secondary student sample (Holmes, 2012). Based on the 2012–2013 data, the Cronbach alpha coefficient was .71, indicating

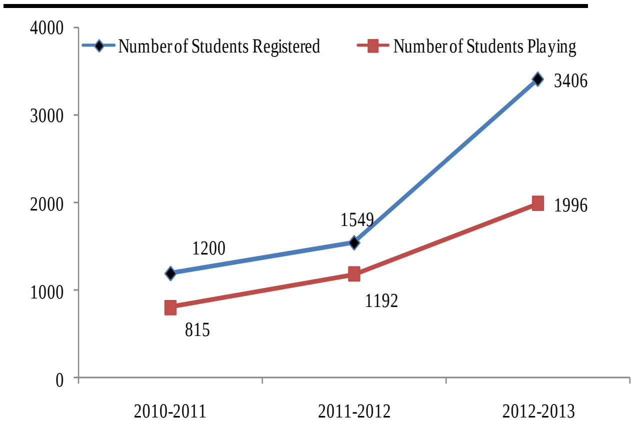

Figure 1. Number of all students who registered and participated in the NDE game, 2010-2011 through 2012–2013.

good internal consistency (Pavot, Diener, Colvin, and Sandvik, 1991).

Another variable analyzed in the study was students' science interests. Data were captured during pre- and post-game participation. Survey items were adapted from the Program for International Student Assessment 2009 (PISA). The science interest survey was used in previous research with secondary students (Holmes, 2012). The instrument had good internal consistency in 2012–2013, with a Cronbach alpha coefficient of .91. Links to both instruments were accessed at the game's website. Completion of the assessment and survey were voluntary. However, students were offered incentives (e.g., tablets, trips to museum, trophies) to participate.

Elementary student data were analyzed independently from secondary student data. This was the first year elementary students participated in the game, thus, they had less exposure to the survey and assessment content and data collection methods. Assessment questions were not modified due to an expectation that content would be covered in the game.

Students were organized in teams. It is estimated that teams spent approximately 100 hours playing the game (F. Hughes, Tietronix Software, Inc., personal communication, April 10, 2013). Given the team format of the game, the actual number of hours each team member spent playing the game is unknown. This is important because individual student outcomes could be related to exposure to science content and experiences during the game.

Data Analysis

Descriptive statistics, including means and standard deviations, were calculated based on student responses to the science energy assessment and the science interest survey items using IBM SPSS software**.** Paired sample data measuring the percent correct on the pre- and post-science energy knowledge assessments and the mean ratings on the science interest survey were described in this evaluation. Pearson correlation coefficients measured the association between pre- and post-science energy knowledge as well as pre- and post-interest in science ($p<.05$). Linear mixed-effects modeling examined the effect of social factors on students' science interest and science energy knowledge after participating in the game. This model took into account students nested in schools. The analysis was conducted at the school level because most schools had only one teacher. Teacher-level rather than school-level analysis would have reduced sample sizes, further compromising the reliability of the results.

Student Sample

Data for 462 secondary students and 78 elementary students who completed the four measures (pre- and post-science energy assessments as well as pre- and post-science interest surveys) were included in this analysis. Students in the matched samples were enrolled at six elementary and seven secondary schools (five middle and two high schools). **Table 1** presents demographic characteristics of the matched student samples.

The majority of elementary and secondary students were female (56.4 and 53.0 percent, respectively) and gifted and talented (G/T) (75.6 and 58.4 percent, respectively). A higher proportion of secondary students received free or reduced lunch compared to elementary students (72.9 vs. 46.2 percent). Compared to students district wide, both the elementary and secondary student samples were more likely to be female and G/T, and less likely to be at risk, or LEP. The demographic characteristics of district-level students were 51.1 percent male, 15.6 percent G/T, 62 percent at risk, 29.8 percent LEP, and 79.7 percent economically disadvantage (PEIMS, 2012–2013) analysis.

Table 1: Demographic Characteristics of Matched-Paired Elementary and Secondary NDE Student Samples, 2013

	Elem. (4^{th}-5^{th}) (*n* = 78)	**Secon. (6^{th}-12^{th}) (*n* = 462)**	**District**
Gender	**%**	**%**	
Male	43.6	47.0	51.1
Female	56.4	53.0	48.9
Free/Reduced Lunch	46.2	72.9	79.7
At Risk	21.8	12.3	62.0
Gifted & Talented (G/T)	75.6	58.4	15.6
LEP	15.4	17.1	29.8
Elementary Grade			
Fourth	38.5	-	-
Fifth	61.5	-	-
Secondary Grade			
Middle (6^{th}-8^{th})	-	89.4	-
High (9^{th}-12^{th})	-	10.6	-

What was the effect of the NDE game on students' acquisition of science energy knowledge and interest?

Descriptive statistics, Pearson's correlations, paired t-test analysis, and linear mixed-effects modeling were conducted to evaluate the effect of

Table 2: Elementary NDE Student Means, Standard Deviations, and Inter-correlations on Science Assessment and Interest Predictor Variables (n=78)

Variable	***M***	***SD***	**1**	**2**	**3**
Post Science Energy Knowledge	55.81	19.52	.663**	.036	.087
Predictor Variables					
Pre Science Energy Knowledge (1)	56.64	19.18	--	-.031	.042
Pre Interest Rating (2)	2.43	.504		--	.743**
Post Interest Rating (3)	2.59*	.647			

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the .05 level (2-tailed)

the NDE game on students' science energy knowledge and interests. The findings are presented at elementary and secondary student levels.

Elementary Student Sample Findings

Table 2 presents results for 78 elementary students who completed the science energy assessments and surveys before and after participation in the game. There was a slight decrease in science knowledge scores from pretest (M = 56.64, SD = 19.18) to post-test (M = 55.81 and SD = 19.52), t (77) = -.46, p = .646 (two-tailed) for elementary students. The mean decrease was .84, and the 95% confidence interval of the difference in pre- and posttest scores ranged from -2.75 to 4.41. The results were not statistically significant at p < .05. There was an increase in the mean interest rating from pretest (M = 2.43, SD = .504) to posttest (M = 2.59, SD =.657), t (77) = 3.11, p=.003 (two-tailed). The increase was statistically significant at p <.05. The 95% confidence interval of the difference ranged from .056 to .254. The eta squared statistic denotes the magnitude of the game's effect. The eta square was .11, indicating a moderate effect of the program on elementary students' interest in science (Cohen, 1988, pp. 284-7). Cause and effect relationships cannot be determined because a comparison group is necessary to infer causality. (See **Appendix A** for mean ratings by survey item.).

The relationships between pre- and post-science energy knowledge and pre- and post-science interest were investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. Table 2 shows strong, positive correlations between the variables. Specifically, based on the instrument used in this report, Pearson r coefficients indicate as pre-science energy knowledge increased, post-science energy knowledge increased (r =.663, n = 78, p <.01). Also, pre-interest ratings increased as post-interest ratings increased (r =.743, n = 78, p <.01). While these relationships were statistically significant, only a small proportion of the variance in post-performance could be explained by pre-performance on the instruments.

Secondary Student Sample Findings

Table 3 depicts results for the sample of 462 secondary students who completed the science energy assessments and surveys before and after participation in the NDE game. A paired t-test analysis revealed a statistically significant increase

Table 3: Secondary NDE Student Means, Standard Deviations, and Inter-correlations on Science Assessment and Interest Predictor Variables (n=462)

Variable	***M***	***SD***	**1**	**2**	**3**
Post-Science Energy Knowledge	65.72	19.91	.455**	-.023	-.038
Predictor Variables					
Pre-Science Energy Knowledge (1)	63.28	18.04	--	.045	.093*
Pre-Interest Rating (2)	2.22	.651	-	--	.669**
Post-Interest Rating (3)	2.28	.692			

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the .05 level (2-tailed)

in the percent of science energy knowledge items students answered correct from pretest (M = 63.28, SD =18.04) to posttest (M = 65.72, SD = 19.91), $t(461)$ = 2.64, p = .008 (two-tailed). The 95% confidence interval ranged from .626 to 4.26. The eta squared statistic (.01), indicated the NDE program had a small impact on students' science energy knowledge. This effect is not practically significant.

Table 3 also shows that there was a statistically significant increase in science interest of secondary students from pretest (M = 2.22, SD = .651) to posttest (M = 2.28 and SD = .692), t (461) = 2.12 p = .035 (two-tailed). The 95% confidence interval of the difference ranged from .004 to .104. The eta squared statistics (.01) revealed a small effect of the game on secondary students' interest in science. The effect is not practically significant. (See **Appendix B** for mean ratings by survey item.) The relationships between pre- and post-science energy knowledge and pre- and post-science interest were investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. Table 3 shows strong, positive correlations between the variables. As pre-science energy knowledge increased, post-science energy knowledge increased (r =.455, n = 462, p <.01). Also, as pre-interest ratings increased, post-science interest ratings increased (r = .669, n = 462, p < .01). The data also revealed a statistically significant positive correlation between pre-science energy knowledge and post-science interest ratings (r = .093, n = 462, p < .05). While these relationships were statistically significant, only a small percentage of the variance in post-performance can be explained by pre-performance.

Linear Mixed-Effects Modeling

A linear mixed-effects model was used to analyze how much the variation from school to school contributed to the variation in science energy knowledge and science interest. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, multicoll inearity, and homoscedasiticity. Pre-science energy knowledge, economic status, gender, at-risk status, and G/T status were used as covariates in the model. Pre-science energy knowledge was centered on the group means. The variables were used as fixed effects and random effects to adjust for the variation within and between groups. These variables were selected because they were considered social factors that

Table 4: Elementary Student Sample Linear Mixed-Effects Modeling, 2013

	Post-Science Energy Knowledge		**Post-Science Interest**	
	β	***p***	***β***	***p***
Schools	43.16	.000**	2.30	.000**
Eco	.658	.934	.393	.016*
Gender	7.31	.354	.108	.477
At Risk	-3.11	.575	.009	.966
G/T	.427	.933	.024	.897
Pre-Science Energy Knowledge	.429	.890	-	-
Pre-Science Interest	-	-	.826	.000**

could have an effect on student performance (Beckar and Luthar, 2002).

The elementary school dataset was relatively small and excluded schools with less than six students, thus, the minimum number of students in each school was six and the maximum number was 75 students. **Table 4** shows the *Beta* coefficients and p-values for elementary students. Economic status and pre-science interest were strong predictors of post-science interest among elementary students (p < .016 and p<.001, respectively). There was a statistically significant difference in post-science energy knowledge and post-science interest between the schools (p < .001).

Regarding secondary students, pre-science interest was a strong predictor of post-science interest (p <.001). There was also a statistically significant difference in post-science energy knowledge and post-science interest between the schools (p <. 001) (**Table 5**).

Table 5: Secondary Student Sample Linear Mixed-Effects Modeling, 2013

	Post-Science Energy Knowledge		**Post-Science Interest**	
	β	***p***	***β***	***p***
Schools	66.22	.000**	2.30	.000**
Eco	-2.135	.345	.059	.536
Gender	-2.585	.332	-.013	.902
G/T	7.587	.033	.042	.577
Pre-Science Energy Knowledge	.151	.919	-	-
Pre-Science Interest	-	-	.661	.000**

What were students' overall impressions of the NDE game?

Elementary and secondary students were asked to provide additional comments about the NDE game following participation. Student responses were analyzed using IBM SPSS Text Analytics to identify themes. Data analysis was based on comments of 46 elementary students and 143 secondary students.

The most prevalent responses centered around students' positive impressions of the game. Students replied that the game was "fun" (n = 6), they liked the game (n = 4), or the game was "excellent" or "good" (n = 2). One student wrote, *"The game helped me concentrate harder and learn a lot."* While another student commented, *"The game is the best game about science, because you learn but in a fun way*." Three elementary students mentioned that the game was "*complicated*" or *"confusing*". Among the seven students who mentioned "*glitches*" in the game, six still had positive comments about the game.

Several elementary students perceived long-term benefits of participating in the game. Some comments were:

> "*It is a great experience that will help me have a back up in my career. It will help me understand and become successful.*"

Another student wrote:

> "*I loved working on the Energy Game with my teammates and I think that I learned a lot about natural resources. The game was really fun for me and my whole team. I hope that you keep it up for a long time for other people to enjoy. It benefited me a lot.*"

Secondary students had similar experiences as elementary students playing the game. A total of 143 secondary students out of 462 (31.0 percent) provided additional comments. Comments included the game was "*fun*" (n = 37) or "*helpful*" (n = 20); and "*awesome,*" "*great,*" or "*amazing*" (n = 13). A student wrote:

> "*It [was] very fun and educational and whoever created it thank you, it's very useful. I appreciate having the opportunity to play this game, thank you.*"

Another student wrote:

> "*It's an amazing game! It's entertaining and gives us a small perspective into that career. It prepares us for our future*."

Yet another student replied:

> "*I like the game and I think it is fun and I am learning new stuff at the same time. I like this game a lot involving science and other things that I have improved in science because of the science energy game. It is very helpful and fun!"*

At the same time, 14 students discussed *"glitches"* in the game; some mentioned how these glitches affected their outcome playing the game.

What were NDE teachers' perceptions regarding the game's impact on student performance?

Over the past two academic years, teachers whose students participated in the game were asked their perceptions regarding how the game influenced their instructional practices and student learning. Eight out of 26 secondary teachers (30.8 percent) provided feedback in 2011–2012 and 16 out of 29 elementary and secondary teachers (55.2 percent) provided feedback in 2012–2013. It should be noted that several teachers responded in both years.

Background information on training and professional development was captured in the survey. A higher proportion of teachers in 2011–2012 compared to 2012–2013 agreed they received adequate training from game administrators (100% vs. 80%), had adequate technology skills to assist students (100% vs. 93.8%), and had sufficient resources to meet technical requirements (88.9% vs. 62.6%). Teachers' agreement regarding accessing technical support was consistent in both years (75%). More teachers indicated having campus administrator support during the current academic year (2012–2013) compared to the previous year (2011–2012).

Teachers were asked whether the game changed their instructional practices in specific areas. Results for the past two years are presented in **Table 6.** The majority of teachers indicated in both years their instructional practices changed in all areas measured. However, a higher percentage of teachers indicated assigning more team projects, cooperative group tasks, and adjusting their instructional practices based on student inquiry and feedback in 2012–2013 compared to 2011–2012. The most disagreement among teachers in the current year concerned assigning more web-based instruction activities compared to assigning more team projects and assigning more cooperative group tasks the previous year (26.7% and 28.6%, respectively).

Table 6: Teacher Perceptions Regarding the NDE Game's Impact on Instruction, 2011–2012 and 2012–2013

Since participating in the game, indicate the level of agreement that you changed your instructional practices in the following areas:	**Strongly Agree/Agree %**		**Disagree/Strongly Disagree %**	
	2011-12 (n = 8)	**2012-13 (n = 16)**	**2011-12 (n = 8)**	**2012-13 (n = 16)**
Assign more web-based instructional activities	75.0	73.2	25.0	26.7
Assign more team projects and cooperative group tasks	71.4	75.0	28.6	25.0
Access more websites about science concepts	87.5	87.5	12.5	12.5
The science game exposed my students to information that required the use of critical thinking skills.	100.0	100.0	0.0	0.0
Students seemed more interested in science after participating in the game.	100.0	93.7	0.0	6.3
I adjusted my instructional practices based on students' inquiry and feedback.	75.0	87.5	25.0	12.5
I used additional resources to support the concepts covered in the game.	87.9	81.2	12.5	18.8
Students seemed more motivated to do well in science after participating in the game.	100.0	93.7	0.0	6.3

Discussion

Chevron's partnership and financial support of the NDE game has resulted in the game's expansion from 16 secondary schools in 2011–2012 to 22 elementary and secondary schools in 2012–2013. The game created learning environments, which allowed students to work together to solve problems aligned to their academic levels and to science instructional content. Students had the opportunity to actively engage in learning with other students across all academic abilities and grade levels.

Major objectives of the game were to increase students' interest in science and their knowledge of science energy concepts. Exploration of the game's influence on social factors, such as economic status, provides a perspective that may be used to enhance the game and equally benefit all students.

Following the first year of the game, survey results of secondary students reflected perceptions of increased interest in being more involved in science-related activities during and outside of school (Holmes, 2012). There was also evidence that students increased their aspirations to pursue science careers and energy-related careers as adults based on changes in students' attitudes from pre to post-survey. In 2012–2013, both elementary and secondary students showed overall increase interest in science. The results were statistically significant for both student groups, and practically relevant for elementary students. The results of the study also indicate that for secondary students, post-science knowledge and interest increased very slightly, and for elementary students, post-interest increased slightly while post-science knowledge decreased slightly. These results suggest that NDE does not appear to be strongly associated with improved science knowledge and interest, at least for the subset of students who participated in this study, although increases were statistically significant.

Social factors, including school, economic status, gender, G/T status, and LEP status were examined to determine their effect on student outcomes. Overall, interest in science and attainment of science energy knowledge varied by school. Students who were economically disadvantaged had lower interest compared to non-economically-disadvantaged students. Student interest before playing the game was a significant contributor to their interest after the game. These findings highlight the need for science administrators to collaborate closely with teachers to identify issues and additional supports needed at their school to further enhance students' interest and knowledge, particularly among students who are economically disadvantaged. Findings related to social factors also point to the possibility that students, regardless of background, could benefit from the game, as there were no practical differences among males and females or G/T, LEP, and at-risk students.

The game's effect on students and teachers was also noted in additional comments provided by participants at post-survey. In general, the perceptions of both groups were positive relative to the game's impact on learning and instruction. Students noted the game was fun and helped expand their understanding of science. In spite of the fact that some teachers were involved in the game during previous years, the majority continued to indicate they modified instructional practices after the game based on student inquiry and feedback. The use of the game continued to motivate many teachers to seek additional professional development to increase their understanding of science energy concepts. At the same time, students noted technical problems and teachers pointed out issues meeting technical requirements of the game, which could have negatively impacted their perceptions and learning processes. Considering all of these factors, the research provides preliminary support for using computer games to improve student learning in science, given adequate resources and technical support.

There were several limitations to this study. First, given the team format, the study lacked data on the actual time spent by individual students playing the game. This could have affected students' experiences in gaining knowledge and influenced their interest in science at posttest. Continued collaboration is needed with game developers to develop a system for tracking individual student performance in order to provide a direct link to student interest and knowledge outcomes.

Another limitation was the lack of a comparison group. While a pre- posttest design provided an alternative method for comparing students, threats to validity could still exist relative to knowing whether other external influence affected the change in student outcomes (e.g. history), that students would have changed their perceptions without participating in the program (maturation), and students' familiarity with the surveys and assessments could have influenced improvements, (testing) (Boyd, 2002). To overcome some of the threats, regression analysis was used to control for demographic differences and pre-performance that may have influenced post-science interest and science energy knowledge. Finally, the lack of data at the four 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, which was 1996 out of 3406 students.) The recruitment process relied on teacher commitment, which may have contributed to attrition of the initial group of participants.

With Chevron's support, recommendations are to continue game development to foster student interest and build on science learning through the use of technology among students and teachers. Strategies to successfully recruit teachers and students in all targeted schools should be developed to expose more students to the experience, particularly those who are struggling in the content area and students who are economically disadvantaged.

Future analysis could include longitudinal tracking of science interest and knowledge, particularly for elementary student groups who are more representative of district wide students relative to G/T and economic status. Variables, such as science course-taking and science course grades could be considered as possible indicators of the game's effect as students' progress through school. Identifying a comparison group of students who were not exposed to the game could help demonstrate the effect of the game over time. Offering incentives may help to reduce attrition and increase sample sizes.

Research has not definitively linked the use of media to learning. What may be more important is the educational content of the material that students are exposed to that matters most (Wainwright & Linebarger, 2006). To that end, using media could be a viable way to introduce challenging concepts to students, stimulate personal interest in any given content area, and enhance teacher instructional practices.

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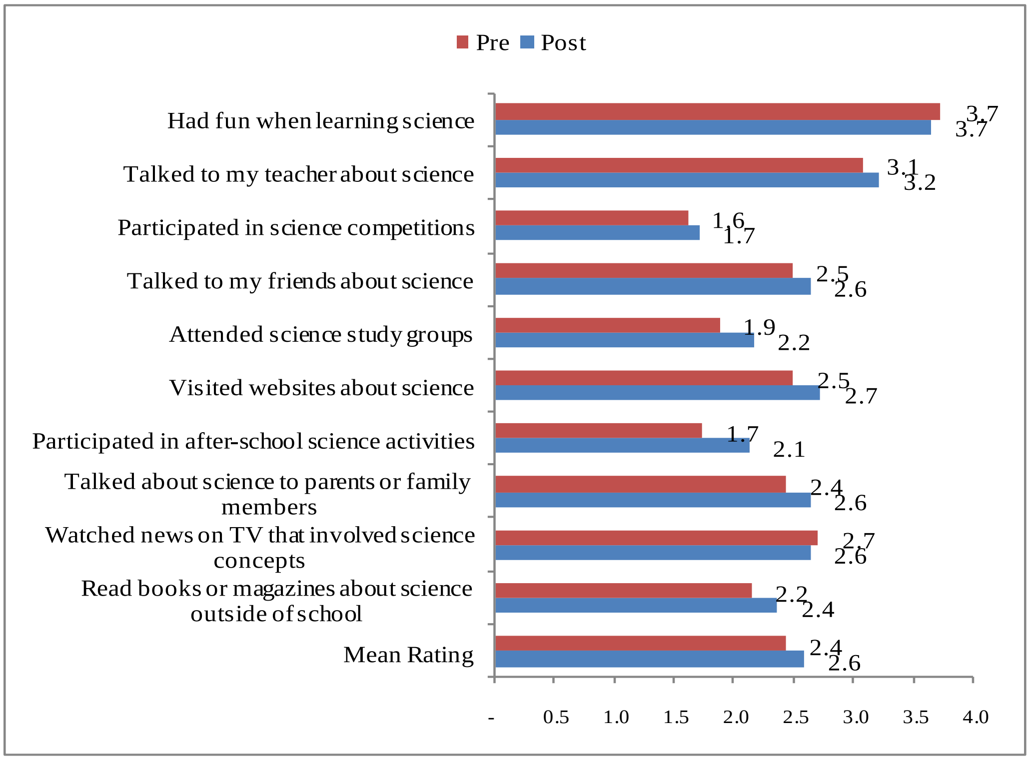
Appendix A
Pre- and Posttest Interest Ratings of Elementary Student Sample
Rating Scale: (4) Very Often; (3) Regularly; (2) Sometimes; (1) Never or hardly ever



Appendix B
Pre- and Posttest Interest Ratings of Secondary Student Sample
Rating scale: (4) Very Often; (3) Regularly; (2) Sometimes; (1) Never or hardly ever