Improving Student Learning with Graphically-Enhanced Textbooks:

# A Study of the Effectiveness of the Wiley Visualizing Series

## 2009

*This study was conducted by SEG Research, an independent educational research firm located in New Hope, Pennsylvania. SEG Research provides research, evaluation, and assessment services to educational publishers, educational technology providers, assessment service providers and government agencies. SEG has been meeting the research and assessment needs of organizations since 1979. This research was supported by a grant from Wiley Publishing.*

## Improving Student Learning with Graphically-Enhanced Textbooks:

# A Study of the Effectiveness of the Wiley Visualizing

### Effectiveness Study Overview

During the fall semester of 2009, SEG Research conducted a national, multi-site study of students enrolled in entry-level college Psychology, Geology and Environmental Science courses, to evaluate the effectiveness of Wiley Visualizing.[1] The study examined the effectiveness of Wiley Visualizing by comparing the growth in content knowledge and skills among students using Wiley Visualizing and a comparable group of students who did not use Wiley Visualizing. Using a quasi-experimental, pre-post design, this study compared the growth in student content knowledge and skills of students in classes using Wiley Visualizing (Treatment Group) and a comparable group of students who did not use Wiley Visualizing (Control Group).

The findings indicate that students using Wiley Visualizing made significantly greater gains in content area knowledge and skills over the course of a semester than students in classes that did not use Wiley Visualizing.

### Wiley Visualizing Description

Wiley Visualizing is an instructional program that includes both graphically-enhanced textbooks and digital media. Wiley Visualizing makes extensive use of graphical content to enhance the student learning experience and is designed to better engage students and improve student learning.

[1] Environmental Science was eliminated from the study due to small sample size and attrition.

The Wiley Visualizing is based on what is often referred to as the *fundamental multimedia principle*: Information is more effective when presented in words and pictures than words alone (Mayer, 2005).

Research has shown that the brain processes information using two channels: visual and auditory. The brain can accommodate more information when it is presented both visually and aurally. By taking advantage of this multimodal processing capability, we can dramatically enhance student learning through multimedia instruction. Wiley Visualizing is a graphically rich Textbook designed to take advantage of these multiple modes of information processing.

## Information Processing

Our ability to process information is a multi-step process that involves the perception, attention, selection, organization and integration of information (Sweller, 2003). At the center of this process is **long term memory**. Our long term memory stores our accumulated knowledge. Our accumulated knowledge is organized into "chunks" of information in what are known as **schema**. Schemas allow us to organize information in meaningful ways and help us integrate and organize new information (Chi, Glaser, and Rees, 1982). In short, our long term memory is where what we know is stored and where we integrate new information. If information does not find its way into long term memory, it is lost. Learning can be thought of as change in our long term memory.

**The limitations of working memory.** Before information can be integrated into long term memory it must be received and processed by our working memory. Working memory is very limited; it can only handle small amounts of information before it has to be integrated into our long term memory or lost. George Miller (1956) suggested that we can only process about seven pieces of information at one time. And, we must do so quickly, as working memory can only keep information for about 20 seconds.

**Multiple channels for information processing.** It is widely believed that there are multiple channels in working memory. Baddeley (1992) proposes an auditory and a visual channel. The auditory channel handles information that is heard, while the visual channel processes information that is seen. Text seems to have unique processing requirements, with words initially captured by the visual channel and then converted to sounds in the auditory channel (Mayer, 2005).

Research suggests that the visual channel handles less information than the auditory channel (Miler, 2005). However, when information is presented using both the visual and auditory channels, working memory can handle more information overall.

Using multiple channels can increase the amount of information that the brain can process (Sweller, 2005). But, there is still the risk of cognitive overload. Too much information delivered in an ineffective manner can interfere with the brain's ability to successfully integrate information into long term memory.

**Organizing information using schema.** The information in working memory is integrated into long term memory using existing schema (Sweller, 2003). If there are no existing schema in which to "fit" the information, new schema need to be created and working memory may need to do some extra work to help organize the information (Baddeley 1999). If information is poorly organized, or if it is difficult to relate newly presented information to existing schema, working memory can handle even less information. This can be prevented somewhat by presenting information that will assist the learner in organizing information, along with the information to be learned.

**Brain Processing and Multimedia Learning.** So what do we know about brain processing that is relevant to multimedia learning? We know that:

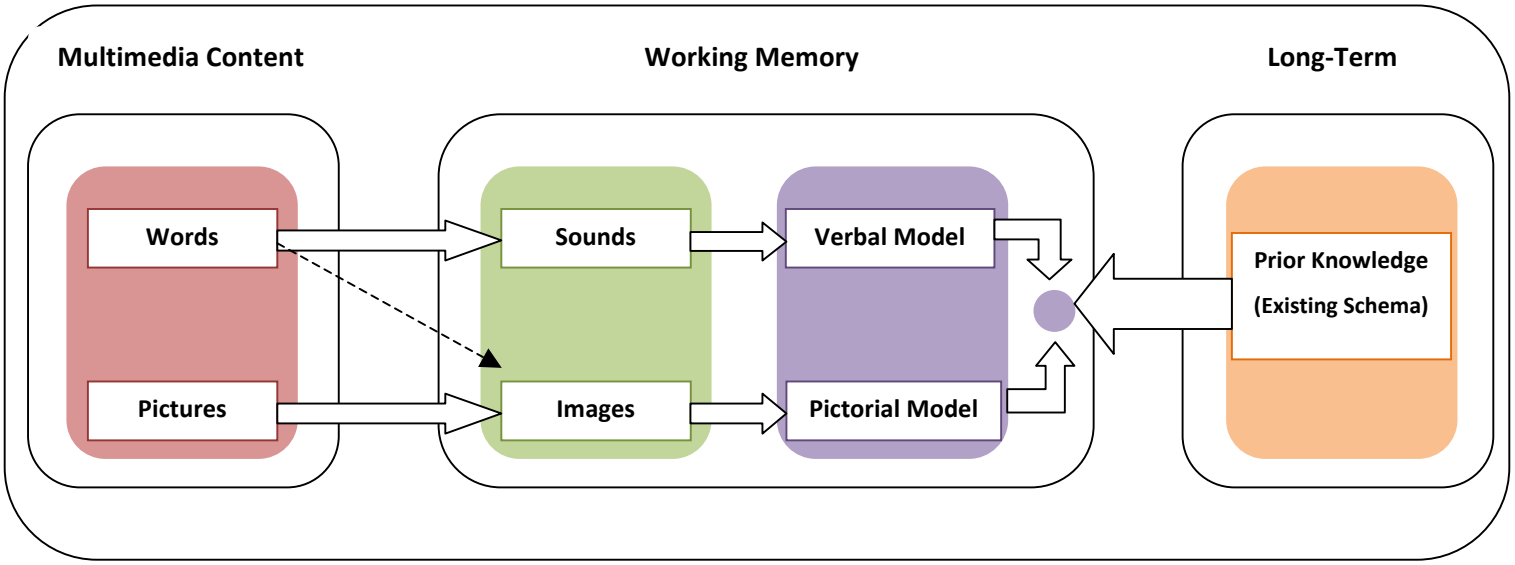
1. Effective multimedia recognizes that working memory has a limited capacity to process information.

2. Effective multimedia presentations take advantage of both the auditory and visual channels in working memory to deliver content. Using multiple channels increases the overall amount of information the brain can process.

3. Effective multimedia understands that text may be particularly challenging to process, with involvement from both the visual and auditory channels required.

4. Effective multimedia presentations recognize that long-term memory organizes information into meaningful chunks called schema. Presenting information in a way that makes use of existing organizing structures (schema) or that helps students organize the information can greatly assist the learner in incorporating information into long term memory.

**Figure 3: Information Processing Model Based on Mayer (2005)**



## Research Question

This study investigated the following question: Do students using Wiley Visualizing Textbooks show larger gains in content knowledge and skills than a comparable group of students who do not use Wiley Visualizing?

## Student Sample

During the fall semester of 2009, 1,203 students enrolled in courses taught by 17 instructors at 12 different institutions from across the United States participated in a controlled study of the effectiveness of Wiley Visualizing. Classes either used Wiley Visualizing (Treatment Group) or used another textbook (Control Group) during the course of the study. There were 779 students in the Treatment Group and 287 students in the Control Group. Table 1 shows the number of students in each subject area studied and in each Gender and Ethnicity group. The total number of students listed for each background variable differs since some students did not provide this information.

In some cases, students did not provide complete background information. Where data was missing, the student's results were eliminated from those analyses.

**Table 1. Demographic Profile of Student Participants**

| Variable | Number (N) of Students | Percentage of Students |
|---|---|---|
| **SUBJECT** | | |
| **Environmental Science** | 182 | 17% |
| **Geology** | 238 | 22% |
| **Psychology** | 646 | 61% |
| **TOTAL (All Subjects)** | **1066** | **100%** |
| **GENDER** | | |
| **Male** | 410 | 40% |
| **Female** | 626 | 60% |
| **Total (All Gender)** | **1036** | **100%** |
| **ETHNICITY** | | |
| **Caucasian** | 34 | 3% |
| **African American** | 154 | 16% |
| **Hispanic** | 649 | 65% |
| **Asian/Pacific Islander** | 97 | 10% |
| **Mixed Race and Other** | 58 | 6% |
| **Total (All Ethnicity)** | **992** | **100%** |

## Comparability of Study Groups

### Psychology

It is very important in a study comparing student growth to establish that the Treatment Group and Control Group are similar in background and ability. Demonstrating baseline equivalence of the sample (treatment and comparison groups) minimizes potential bias from selection in quasi-experimental designs that can alter effect size estimates. If the Treatment Group and the Control Group are not similar, we cannot be sure if the growth we see is due to the treatment (in this case, use of Wiley Visualizing) or the result of some differences in the individuals that existed before we conducted the study.

Ideally, this matching is accomplished by sampling study participants of similar ability and with similar background characteristics. However, any observed differences can be adjusted for statistically using Analysis of Covariance (ANCOVA), as was used in this study. The Treatment Group and Control Group were compared with respect to their initial knowledge and skills, as well as their Gender and Ethnicity. The results indicate that the groups were similar in ability (see Table 2 and 3) and background (see Tables 4, and 5).

**Ability Comparison.** The content knowledge and skills pretest scores were used to compare the initial Psychology knowledge and skill levels for students in both the Treatment and Control Groups. The mean test scores for students in both Groups are presented in Table 2 and the Analysis of Variance table comparing the two Groups is presented in Table 3.

**Table 2. Comparison of Initial Content Knowledge and Skill levels (Pretest scores) for the Treatment Group and Control Group (Psychology)**

| STUDY GROUP | Pretest Mean | Pretest Standard Deviation | Vocabulary Standard Deviation | |
|---|---|---|---|---|
| **Treatment Group** | **16.29** | 3.92 | 58.30 | |
| | (N=473) | | | |
| **Control Group** | **17.50** | 4.33 | 60.71 | |
| | (N=173) | | | |
| **Total Group** | **16.62** | 4.07 | 59.42 | |
| | (N=646) | | | |

**Table 3. Analysis of Variance Comparison of Wiley Group and Control Group Pretest Scores (Psychology)**

| Source | Type III Sum of Squares | df | Mean Square | F | Significance | Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 185.158[a] | 1 | 185.158 | 11.387 | .001 | .017 |
| Intercept | 144685.443 | 1 | 144685.443 | 8898.277 | .000 | .933 |
| GROUP | 185.158 | 1 | 185.158 | 11.387 | .001 | .017 |
| Error | 10471.401 | 644 | 16.260 | | | |
| Total | 189047.000 | 646 | | | | |
| Corrected Total | 10656.559 | 645 | | | | |

The Psychology Treatment and Control Groups were comparable in ability. While there was a statistically significant difference between the Treatment and Control Groups ($F=11.39$; $df=1,644$, $p<.001$), the difference was not meaningful. The pretest scores were only about one point apart on the 50-item scale and group membership accounted for less than 2% of the variance in pretest scores.

**Gender and Ethnicity.** The number of female and male students and the number of students in each ethnic group in both the Wiley Users and Control Groups were counted. These counts are presented in Tables 4 and 5.

**Table 4. Comparison of Gender Composition of the Treatement Group and Control Group (Psychology)**

| STUDY GROUP | Gender | | | |
|---|---|---|---|---|
| | Missing | Female | Male | Total |
| **Treatment Group** | 13 | 291 | 169 | 473 |
| **Control Group** | 4 | 110 | 59 | 173 |
| **Total** | 17 | 401 | 228 | 646 |

**Table 5. Comparison of the Ethnic Composition of the Treatment Group and Control Group**

| STUDY GROUP | Ethnicity | | | | | | |
|---|---|---|---|---|---|---|---|
| | Missing | Asian | Black/ African American | Caucasian | Hispanic | Mixed Race or Other | Total |
| **Treatment Group** | 34 | 9 | 65 | 304 | 37 | 24 | 473 |
| **Control Group** | 8 | 8 | 52 | 76 | 15 | 14 | 173 |
| **Total** | 42 | 17 | 117 | 380 | 52 | 38 | 646 |

A statistical comparison of the two study groups shows that the Treatment/Wiley Group and Control Group were very similar with respect to Gender and Ethnicity. There were no statistical differences in the expected and observed frequencies for Gender (chi square =.27, df=2, p<.87). There was a statistically significant difference in Ethnicity (chi square =34.64, df=6, p<.001); however the correlation (contingency coefficient) was only .22, accounting for about 4% of the variance in pretest scores, suggesting that differences between the two groups were not substantial.

## Geology

The Geology Treatment Group and Control Group were compared with respect to their initial knowledge and skills, as well as their Gender and Ethnicity. The results indicate that the groups were similar in ability (see Table 6 and 7) and background (see Tables 8 and 9).

**Ability Comparison.** The content knowledge and skills pretest scores were used to compare the initial Geology knowledge and skill levels for students in both the Treatment and Control Groups. The mean test scores for students in both Groups are presented in Table 6 and the Analysis of

Variance table comparing the two Groups is presented in Table 7. The Geology Treatment and Control Groups were comparable in ability. There was no significant difference between the Treatment and Control Groups (F=1.759; df=1,238, p<.186).

**Table 6. Comparison of Initial Content Knowledge and Skill Levels (Pretest scores) for the Treatment Group and Control Group (Geology)**

| STUDY GROUP | Pretest Mean | Pretest Standard Deviation | Vocabulary Standard Deviation | |
|---|---|---|---|---|
| **Treatment Group** | **16.88** | 4.71 | 58.30 | |
| | (N=165) | | | |
| **Control Group** | **17.73** | 4.03 | 60.71 | |
| | (N=73) | | | |
| **Total Group** | **17.14** | 4.52 | 59.42 | |
| | (N=238) | | | |

**Table 7. Analysis of Variance Comparison of Treatment Group and Control Group Pretest Scores (Geology)**

| Source | Type III Sum of Squares | df | Mean Square | F | Significance | Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 35.810[a] | 1 | 35.810 | 1.759 | .186 | .007 |
| Intercept | 60625.457 | 1 | 60625.457 | 2977.444 | .000 | .927 |
| GROUP | 35.810 | 1 | 35.810 | 1.759 | .186 | .007 |
| Error | 4805.333 | 236 | 20.362 | | | |
| Total | 74784.000 | 238 | | | | |
| Corrected Total | 4841.143 | 237 | | | | |

**Gender and Ethnicity.** The number of female and male students and the number of students in each ethnic group in both the Wiley Users and Control Groups were counted. These counts are presented in Tables 8 and 9.

**Table 8. Comparison of Gender Composition of the Treatment Group and Control Group (Geology)**

| STUDY GROUP | Gender | | | |
|---|---|---|---|---|
| | Missing | Female | Male | Total |
| **Treatment Group** | 9 | 82 | 74 | 165 |
| **Control Group** | 2 | 34 | 37 | 73 |
| **Total** | 11 | 116 | 111 | 238 |

**Table 9. Comparison of the Ethnic Composition of the Wiley Group and Control Group**

| STUDY GROUP | Ethnicity | | | | | | |
|---|---|---|---|---|---|---|---|
| | Missing | Asian | Black/ African American | Caucasian | Hispanic | Mixed Race or Other | Total |
| **Wiley Group** | 17 | 10 | 12 | 99 | 16 | 11 | 165 |
| **Control Group** | 3 | 2 | 7 | 39 | 19 | 3 | 73 |
| **Total** | 20 | 12 | 19 | 138 | 35 | 14 | 238 |

A statistical comparison of the two study groups shows that the Treatment Group and Control Group were very similar with respect to Gender and Ethnicity. There were no statistical differences in the expected and observed frequencies for Gender (chi square =.1.278, df=2, p<.53), or Ethnicity (chi square =13.88, df=5, p<.02).

## Description of the Pretest and Posttest

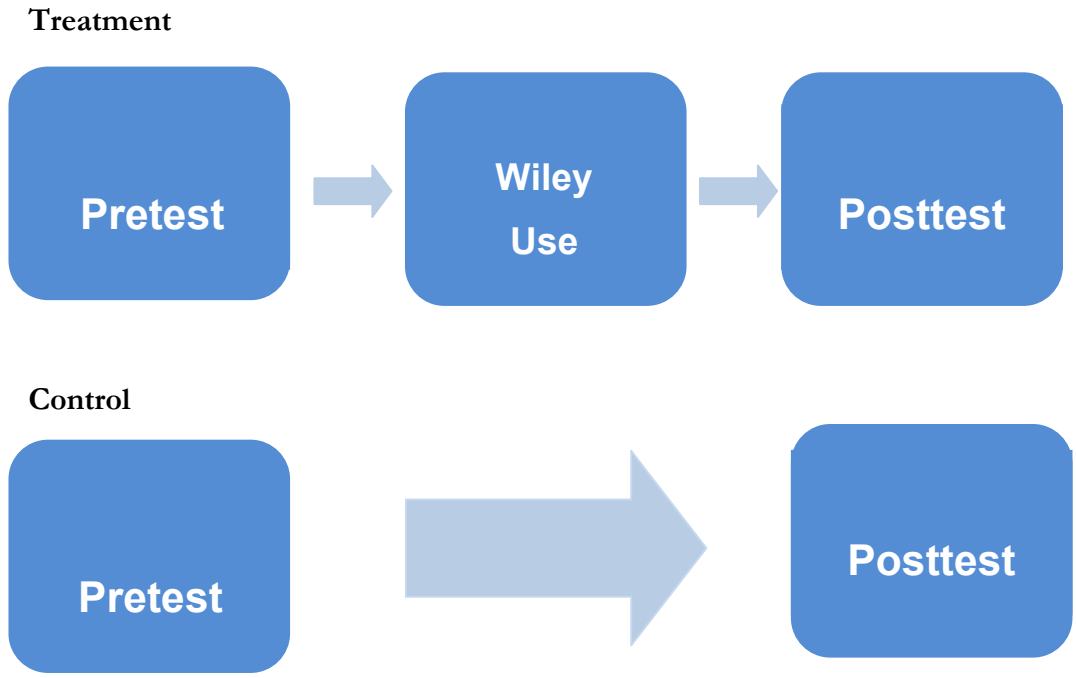
The content knowledge and skills of students participating in the study were measured using 50-item, multiple-choice measures developed based on a survey of commonly covered topics in the introductory Psychology and Geology courses. The Tables of Contents for four commonly used introductory Textbooks were used as a basis for determining commonly taught topics. The assessment was used as both the pretest and posttest measure; students took the test in August/September at the beginning of the semester and then again in November/December at the end of the semester. The reliability of the Psychology test was .87, and the reliability of the Geology test was .86 (Cronbachs Alpha).

## Study Design

The goal of this effectiveness study was to compare the growth in content knowledge and skills for students in classes using Wiley Visualizing to a group of students in classes that did not use Wiley Visualizing Textbook. Students' growth in content knowledge and skills was measured by comparing their proficiency at the beginning of the fall 2009 semester and again at the end of the semester after receiving instruction. Students in the Treatment Group and the Control Group were administered the 50-item pretest at the beginning of the fall semester in August and September of 2009 and at the conclusion of the semester in November and December of 2009. Students received approximately 12-15 weeks of instruction between the pretest and posttest. Students in the Treatment Group used Wiley Visualizing, while those in the Control Group used a textbook other than Wiley Visualizing. The results were then compared statistically.

The study employed a pre-post, Treatment-Control Group design. Since the students were not randomly assigned to the groups, this is considered a quasi-experimental design. This design is illustrated in Figure 1 below.

**Figure 1 Study Design**



### Data Collection

When completing the pretest, students were asked to provide additional background information regarding Gender and Ethnicity for use in characterizing the sample of students participating in the study and for use in comparing the background characteristics of the Treatment and Control Groups. Due to privacy concerns or other personal preferences, some students did not provide this additional information. Therefore, there was insufficient information to provide additional analyses examining these specific variables.

Instructors participating in the study were provided with pretest booklets, answer sheets and administration manuals in August 2009. The instructors then administered the content knowledge and skills pretests according to the administration instructions provided. The completed test booklets and answer sheets were returned to SEG, where they were scanned and entered into a database. Any questions that the students did not answer were scored as incorrect. Students answering fewer than five questions were removed from the analysis. All data was reviewed and checked for accuracy before scoring and analysis.

Near the conclusion of the fall semester of 2009, following approximately 12-15 weeks of instruction, instructors administered the posttest.

## Findings

### Measuring Growth

The growth in content knowledge and skills in each subject area for the Treatment Group and the Control Group was compared using a statistical procedure known as Analysis of Covariance (ANCOVA). This approach provides an accurate way to compare growth over time controlling for any potential differences in student skills between the two study groups that may have been present at the beginning of the study. Any differences in skill levels between the Treatment Group and Control Group that may have existed at the beginning of the study were controlled to ensure that any differences in subsequent growth were the result of whether or not Wiley Visualizing was used

and not merely the result of differences that existed at the start of the study. Using this method, we were able to compare differences as if the two groups were matched in initial proficiency. While no procedure can completely eliminate differences that may exist at the outset of a study, ANCOVA is widely recognized as an effective way to control for differences.

Only students who had taken both the pretest and posttest were included in the study. Students who left the class after the pretest was administered or who joined the class after the pretest period were not included in the growth comparisons.

## *Psychology Results*

### *Pre-Post Growth for Students Using Wiley Visualizing Textbook*

Students who were in classes that used Wiley Visualizing showed substantial growth from pre- to posttest in Psychology content knowledge and skills. During the course of the study, students in classes using Wiley increased their scores by nearly 6 points (5.97) or about 12%. (Mean pretest=16.40; Mean posttest score=22.37). The posttest scores were significantly higher ($t=16.55$; $df=1,277$; $p<.001$).

To better understand the magnitude of growth for students using Wiley Visualizing we looked at the "effect size", a common metric that can be used to evaluate the amount of growth across studies, when different measures are used. The effect size was .98. This indicates that students using Wiley Visualizing showed substantial growth in content knowledge and skills during the course of the semester.

While the growth achieved by students using Wiley Visualizing is an important indicator of the effectiveness of this Textbook, a more complete way to assess growth is to compare the growth achieved by students in classes using Wiley Visualizing to students in classes that did not use Wiley Visualizing Textbook. This allows us to see the unique contribution using Wiley Visualizing made to students' growth.

### *Comparison of Treatment and Control Group Growth*

The overall growth in Psychology knowledge and skills as measured by the 50-item assessment for those students in classes using Wiley Visualizing (Treatment Group) were compared to the content knowledge and skills of those students in classes not using Wiley Visualizing (Control Group). Analysis of Covariance (ANCOVA) was used to evaluate the difference in the posttest results (dependent variable) between Wiley Visualizing Users and those not using Wiley Visualizing (independent variable) controlling for the initial pretest results (covariate). The pretest scores were used as the covariate to place students in the Wiley Group and Control Group on the same baseline. The comparisons were based on 277 Treatment Group students and 134 Control Group students for whom both the pretest and posttest results were available.

The results show a significant difference in the Psychology content knowledge and skills posttest scores between the Treatment Group and the Control Group ($df=2,411$; $F=39.00$; $p<.001$) when initial content knowledge and skills (pretest) are controlled, with an effect size of .58. The results are summarized in Table 10 below. Effect size was calculated as the difference in the study group means divided by the pooled standard deviation.

**Table 10. Analysis of Covariance Comparison of Treatment Group and Control Group Posttest Scores (Psychology)**

| Source | Type III Sum of Squares | df | Mean Square | F | Significance | Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 3813.046[a] | 2 | 1906.523 | 66.024 | .001 | .245 |
| Intercept | 2320.438 | 1 | 2320.438 | 80.358 | .001 | .165 |
| Pretest (Covariate) | 3139.939 | 1 | 3139.939 | 108.737 | .001 | .210 |
| Study Group | 1126.170 | 1 | 1126.170 | 39.000 | .001 | .087 |
| Error | 11781.567 | 408 | 28.876 | | | |
| Total | 205257.000 | 411 | | | | |
| Corrected Total | 15594.613 | 410 | | | | |

**Table 11. Descriptive Statistics Comparison of Treatment Group and Control Group (Psychology)**
**(Adjusted for Pretest Covariate)**

| Group | N | Mean Posttest | Standard Deviation |
|---|---|---|---|
| Wiley | 277 | 22.65 | 6.245 |
| Control | 134 | 19.08 | 5.592 |
| Total | 646 | 21.48 | 6.167 |

## *Geology Results*

### *Pre-Post Growth for Students Using Wiley Visualizing Textbook*

Students who were in classes that used Wiley Visualizing showed substantial growth from pretest to posttest in Geology content knowledge and skills. During the course of the study, students in classes using Wiley increased their scores by about 5 points (5.27) or about 11%. (Mean pretest=17.13; Mean posttest score=22.40). The posttest scores were significantly higher (t=8.479; df=1,97;p<.001). The effect size was .86, indicating that students using Wiley Visualizing showed substantial growth in content knowledge and skills during the course of the semester.

### *Comparison of Treatment and Control Group Growth*

The overall growth in Geology knowledge and skills as measured by 50-item assessment for those students in classes using Wiley Visualizing (Treatment Group) were compared to the content knowledge and skills of those students in classes not using Wiley Visualizing Textbook. (Control Group). Analysis of Covariance (ANCOVA) was used to evaluate the difference in the posttest results (dependent variable) between Wiley Visualizing Users and those not using Wiley Visualizing (independent variable) controlling for the initial pretest results (covariate). The pretest scores were used as the covariate to place students in the Wiley Group and Control Group on the same baseline. The comparisons were based on 97 Treatment Group students and 61 Control Group students for whom both the pretest and posttest results were available.

The results show a significant difference in the Geology content knowledge and skills posttest scores between the Treatment Group and the Control Group (df=2,157; F=28.17; p<.001) when initial

content knowledge and skills (pretest) are controlled, with an effect size of .73. The results are summarized in Table 12 below.

**Table 12. Analysis of Covariance Comparison of Wiley Group and Control Group Posttest Scores (Geology)**

| Source | Type III Sum of Squares | df | Mean Square | F | Significance | Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1779.990[a] | 2 | 889.995 | 33.718 | .001 | .303 |
| Intercept | 925.092 | 1 | 925.092 | 35.048 | .001 | .184 |
| Pretest (Covariate) | 1117.702 | 1 | 1117.702 | 42.345 | .001 | .215 |
| Study Group | 743.534 | 1 | 743.534 | 28.169 | .001 | .154 |
| Error | 4091.257 | 155 | 26.395 | | | |
| Total | 74087.000 | 158 | | | | |
| Corrected Total | 5871.247 | 157 | | | | |

**Table 13. Descriptive Statistics Comparison of Wiley Group and Control Group (Geology) (Adjusted for Pretest Covariate)**

| Group | N | Mean Posttest | Standard Deviation |
|---|---|---|---|
| Wiley | 97 | 22.501 | 6.498 |
| Control | 61 | 18.040 | 4.389 |
| Total | 158 | 20.270 | 6.115 |

## SUMMARY AND DISCUSSION

This study examined the effectiveness of Wiley Visualizing.. The study examined the effectiveness of this graphically enhanced Textbook Series designed to engage students and increase student achievement, by comparing the growth in content knowledge and skills among students using Wiley Visualizing to a comparable group of students who did not use Wiley Visualizing. The study employed a quasi-experimental, pre-post design

### Pre-Post Growth for students using Wiley Visualizing Textbook

Students who were in classes that used Wiley Visualizing Textbooks showed substantial growth from pretest to posttest. During the course of the study, students in classes using Wiley Visualizing increased their scores by about 5- 6 points, or about 11% to 12%. The posttest scores were significantly higher, with effect sizes ranging from .86 to .98. This indicates that students using Wiley Visualizing Textbooks showed substantial growth in content knowledge and skills during the course of the semester.

While the growth achieved by students using Wiley Visualizing Textbooks is an important indicator of the effectiveness, a more complete way to assess growth is to compare the growth achieved by students in classes using Wiley Visualizing to students in classes that did not use Wiley Visualizing Textbook. This allows us to see the unique contribution Wiley made to students' growth.

### Comparison of Treatment and Control Group Growth

The overall growth in Psychology knowledge and skills for those students in classes using Wiley Visualizing (Treatment Group) were compared to the content knowledge and skills of those students in classes not using Wiley Visualizing(Control Group). Students using Wiley Visualizing showed much greater increases in knowledge and skills than their counterparts using other Textbooks. This was true for both Psychology and Geology. The effect size for Psychology was .58, while the effect size for Geology was .73.

## Conclusion

Wiley Visualizing Users showed significant gains in content knowledge and skills from pretest to posttest. More importantly, students using Wiley Visualizing did significantly better than their peers who did not use Wiley Visualizing.

The effect sizes for Psychology and Geology (.58, .73) are substantial, indicating that the students who used Wiley Visualizing performed better than those students who did not use Wiley Visualizing.

One way to interpret the magnitude of the effect size is to consider the potential percentile gains that could be achieved by using Wiley Visualizing. For a student at the 50th percentile, use of Wiley Visualizing could increase the student's score in Psychology to the 72nd percentile or in Geology to the 77th percentile.

These findings are particularly significant for two reasons: First, the study was conducted for only a single semester, representing fewer than 15 weeks of instruction. Second, there are many influences on student achievement; that textbook choice accounted for such a large effect on student growth in content knowledge and skill in this context, is particularly noteworthy.

## References

Baddeley, A. (1992) "Working memory." *Science*, 255, pp.556-559.

Baddeley, A. (1999) *Human memory*. Boston: Allyn and Bacon.

Betrancourt, M. (2005) "The animation and interactivity principles in multimedia learning." In R. E. Mayer (Ed.). *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Chandler, Panda Sweller, J. (1991). "Cognitive load theory and the format of instruction." *Cognition and Instruction*, 8, pp.293-332.

Chi, M., Glaser R., and Rees, E. (1982) "Expertise in problem solving." In R. Sternberg (Ed.) *Advances in the Psychology of human intelligence* (pp.7-75) Hillsdale, NJ. Erlbaum

Clark, R.E. and Feldon, D.F. (2005) "Five common but questionable principles of multimedia learning." In R. E. Mayer (Ed.). *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Craig, S.D., Gholson B., and Driscoll, D.M. (2002). "Animated pedagogical agent in multimedia education environments: Effects of agent properties, picture features, and redundancy." *Journal of Educational Psychology*, 94, pp.428-434.

Gardner, H. (1993) *Frames of Mind: the theory of multiple intelligences*. New York: Basic Books.

Gardner, H. (1999) *Intelligence reframed: Multiple intelligences for the 21st Century*. New York: Basic Books.

Gee, J.P. (2005): "Learning by design: Good video games as learning machines." *E-Learning*. Vol.2 pp. 5-16.

Harcourt Assessment (2002) Stanford *Achievement Test Series™, Tenth Edition, Technical manual*: San Antonio, Texas: Harcourt Assessment.

Institute for Learning Styles (2008) "Overview of the seven perceptual styles." Retrieved August 28, 2008 from http://www.learning styles .org

Kalyuga, S. (2005) "Prior knowledge principle in multimedia learning." In R. E. Mayer (Ed.). *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Kalyuga, S.,Chandler, P. and Sweller, J. (1999). "Managing spilt attention and redundancy in multimedia instruction." *Applied Cognitive Psychology*, 13, pp.351-371.

Kolb, D. A., Boyatzis, R., & Mainemelis, C. (2001). "Experiential learning theory: Previous research and new directions." In R. Sternberg and L. Zhang (Eds.) *Perspectives on cognitive learning, and thinking styles*. Mahwah, NJ: Erlbaum

Lee, J., Grigg, W., and Dion, G. (2007). *The Nation's Report Card: Mathematics 2007(NCES 2007–494)*.National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

Lowe, K. (2002) *What's the story: making meaning in primary classrooms*. ERIC Document No. ED468691

Miller, (1956) "The magic number of seven plus or minus two. Some limits on our capacity for processing information." *Psychological Review*; Vole, 63, 31-97.

Mayer, R.E. (2003*) Learning and Instruction*. Upper Saddle River, NJ: Prentice Hall.

Mayer, R.E. (2005) "Introduction to multimedia learning." in R. E. Mayer (Ed.). *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Mayer, R.E. (2005a). "Principles of multimedia learning based on social cues: personalization, voice, and image principles." In R. E. Mayer, (Ed.) *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Mayer, R.E. and Chandler, P. (2001) "When learning is just a click away: Does simple interaction foster deeper understanding of multimedia messages?" *Journal of Educational Psychology*, Vol. 93, pp. 390-397.

Mayer, R.E. and Sims, V.K. (1994) "For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning." *Journal of Educational Psychology*, 86, pp.389-401

Mayer, R.E., Sobko, K., and Mautone, P.D. (2003) "Social cues in multimedia learning: role of speaker's voice." *Journal of Educational Psychology*, 95, pp. 419-425.

Park, O. (1994). "Dynamic visual displays in media-based instruction." *Educational Technology*, pp. 21–25.

Perkins, D. (1992) *Smart Schools: Better thinking and learning for every child*. New York: The Free Press.

Pollock, E., Chandler, P., and Sweller J. (2002) "Assimilating complex information." *Learning and Instruction*, 12, pp. 61-86.

Sweller, J. (2003) "Evolution of human cognitive architecture." In B. Ross (Ed.), *The Psychology of learning and Motivation* (Vol. 43, pp.215-266). San Diego, CA: Academic Press.

Sweller, J. (2005) "Implications of cognitive load theory for multimedia learning." in R. E. Mayer (Ed.). *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Tversky, B., Bauer-Morrison, J., & Betrancourt, M. (2002). "Animation: can it facilitate?" *International Journal of Human-Computer Studies*, Vole 57, 247-262.