

CHAPTER 4 RESULTS

Out of the 289 students that participated in the study, 145 science and engineering majors completed all of the required five forms after completing either a constructivist or objectivist instruction module or the absence of a module, which was used as a control. The five forms were analyzed and each of the null hypotheses was tested. The corresponding results are described below. These hypotheses were designed to measure the impact of an on-line instructional module on learning through the Internet. The five forms included:

1. An on-line computer attitude survey (with demographic questions)
2. A Motivated Strategies for Learning Questionnaire (which evaluates self-regulated learners and self-efficacy)
3. A verbal comprehension test (a general indicator of aptitude)
4. An instructional pre-assessment; and
5. An instructional post-assessment (exactly the same as the pre-assessment).

Descriptive Statistics

The criterion-referenced assessment(s) used in the study consisted of 20 questions each (Appendix D). Two subsections of 10 items each covered general chemistry and water chemistry knowledge, which contained material specific to the learning modules. The second subsection of items were used for data analysis. An item difficulty analysis of the pre- and post-assessment, as measured by percent correct on each item, was conducted (Table 4 -1). Three items on the pre-assessment and all ten items on the post-assessment resulted in a percent correct rate of 0.50 or higher. In addition, reliability data is presented in table 4 -1.

Table 4 -1. Pre/Post-Assessment Item Difficulty and Reliability Data.

Item Difficulty	Pre	Post
0.91-1.0	0	0
0.81-0.90	0	0
0.71-0.80	1	2
0.61-0.70	2	2
0.51-0.60	0	6
0.41-0.50	2	0
0.31-0.40	2	0
0.21-0.30	2	0
0.11-0.20	1	0
0.00-0.10	0	0
Total Number of Items	10	10
Cronbach's Alpha	.8341	.8435
Split half reliability	.8615	.8408
Split half w/Spearman	.9256	.9135

The 145 data points were used in this study because they contain results for the pre- and the post-assessment, which is required to determine the score differential before and after the instructional module(s) were reviewed. Drop out rate should be considered whenever activities are performed remotely via electronic media, such as the Internet.

The number of forms completed by the participants varied from one page to the completion of all five forms. The following table 4 -2 details this data.

Table 4 -2. Participant Completion Form Distribution.

Age	Complete (a)	Complete except for Posttest (b)	Incomplete (c)	First Page Complete (d)	Total Number (e)	% Complete (f)
Total Number	185	37	33	34	289	64
Engineers and Scientists 18-30	145	0	0	0	145	100

(a) – Number of participants who completed all forms of the study.

(b) – Number of participants who completed all forms except the post-assessment.

(c) – Number of participants who completed some of the forms.

(d) – Number of the participants who only completed the first page of the forms.

(e) – Total number of participants who accessed the web page,

(f) – Percentage of participants who completed the study.

As one of the demographic items, the participant was asked to provide their major area of study in school. Although a test relating major to formats was not performed, this response enabled the separation from non-technical participants. Table 4 -3 presents the distribution of major areas of study categories of participants.

Table 4 -3. Distribution of Participant Major Study's.

Major	Males	Females	Total
Chemical Engineer	13	7	20
Civil Engineer	5	1	6
Computer Engineer	4	3	7
Electrical Engineer	2	3	5
Environmental Engineer	21	14	35
Mechanical Engineer	22	13	35
Other Engineer	7	10	17
Chemist	6	5	11
Other Sciences	4	5	9
Total Number of Participants	84	61	145

Hypothesis 1

Hypothesis one states that there is no significant difference in post-assessment scores between the constructivist and the objectivist presentation formats in an on-line learning environment. Out of the 289 participants to access the web page, 145 participants were selected for data analysis. The difference in these numbers are itemized in table 4 -3 and represent incomplete data and a narrowing of the study population to examine only engineers and scientists. Incomplete data could not be used because it did not contain the post-assessment scores, which indicate performance differential before and after completing the instructional

module. Participants were to complete several forms, review an instructional module and then complete an on-line post-assessment. Statistics and results for each group for each assessment are presented in table 4-4.

Table 4 –4. Descriptive Statistics for Instructional Module Groups.

Group	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
Constructivist Mean	3.37	4.66	23.1	3.1	5.9	68
SD	1.17	1.65	9.4	2.4	3.2	68
Variance	1.42	2.84	88.2	5.7	10.4	68
Objectivist Mean	3.43	4.79	23.2	3.8	7.0	65
SD	1.15	1.60	8.4	2.5	2.8	65
Variance	1.38	2.73	70.7	6.3	8.0	65
Control Mean	3.50	4.63	24.6	3.9	4.0	12
SD	1.18	1.81	5.1	3.0	3.0	12
Variance	1.48	3.31	26.3	9.0	8.7	12

To determine the significance of this hypothesis, a simple analysis of covariance (ANCOVA) with general linear model procedures was performed comparing the format with participant post-assessment scores. Table 4 -5 presents the results of the ANCOVA which indicate there was a significant difference at $\alpha = .05$ between groups on post-assessment scores. However, the major difference occurred between the groups with instruction and the control. A follow-up linear model procedure demonstrated that there was not a significant difference between the two instructional module groups on the post-assessment scores, thus hypothesis one is accepted.

Table 4 -5. ANCOVA Source Table for Post-Assessment vs. Group.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	97.077220	48.538610	8.57	0.0003
Pre	1	511.365459	511.365459	90.33	0.0001

Parameter	Estimate	T for Ho: Parameter=0	Pr > T	Std Err of Estimate
Group 1	2.532893107	3.39	0.0009	0.74773423
Group 2	3.092253463	4.14	0.001	0.74762496
Group 3	0.000000000			
Pre-Assessment	0.758958244	9.50	0.0001	0.07985691

Hypothesis 2

Hypothesis two states that there is no significant difference in post-assessment scores due to the participant's gender, age or racial identity. The ANCOVA with general linear models includes internal regression equations and examines the relationships among the dependent variable, the post-assessments, and the independent variables, the participants age, gender and racial identity. It provides estimates of the magnitude and statistical significance of the relationships among the variables and therefore can identify those independent variables that are best predictors for learning on-line. For age distribution descriptive statistics

refer to table 4 -6; for gender distribution, refer to table 4 -8; and for the distribution of racial identities, who participated in the study, refer to table 4 -10.

Table 4 -6. Distribution of Participant Age and Descriptive Statistics.

Age	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
18-21 - Mean	3.41	4.74	23.2	3.1	6.0	85
SD	0.39	0.52	8.0	2.1	2.9	85
Variance	0.16	0.27	63.8	4.3	8.5	85
22-26 - Mean	3.43	4.74	21.7	4.3	7.0	41
SD	0.45	0.67	8.8	3.0	3.1	41
Variance	0.20	0.45	77.5	9.1	9.8	41
27-30 - Mean	3.36	4.52	26.9	3.5	5.8	19
SD	0.32	0.68	10.3	2.9	4.0	19
Variance	0.10	0.47	106.7	8.4	15.7	19

Part 1 of Hypothesis 2: Age

The age of the participants was restricted between 18 and 30 years. Although table 4-6 presents statistical data for three groups of ages, age was considered a continuous variable. The data in table 4-6 was created to examine the potential differences between a younger age group (18-21 years) and an older age group (27-30 years). The descriptive statistics for all three age groups were similar.

The ANCOVA was used to determine whether there was a significant difference between age groups on post-assessment scores. Table 4 -7 presents the results of the ANCOVA, which indicate that there was not a significant main effect at $\alpha = .05$ with age. However, there is a significant interaction between age and treatment leading to the rejection of this portion of hypothesis two.

Table 4 -7. ANCOVA Source Table for Post-Assessment vs. Age.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	39.317585	19.658793	3.51	0.0330
Age	1	0.005898	0.005898	0.79	0.5337
Age*Group	2	48.613319	24.306659	4.33	0.0151
Pre	1	400.258428	400.258428	71.38	0.0001

Parameter	Estimate	T for Ho: Parameter=0	Pr > T	Std Err of Estimate
Intercept	0.735848889	0.13	0.8969	5.66475041
Group 1 – Constructivist	7.192546058	1.17	0.2435	6.13843249
Group 2 – Objectivist	0.401197909	0.06	0.9486	6.20726260
Group 3 – Control	0.000000000			
Age	0.068092426	0.30	0.7678	0.23007969
Age*Group 1	-0.302231921	-1.21	0.2281	0.24956700
Age*Group 2	0.106736978	0.43	0.6701	0.24998681
Age*Group 3	0.000000000	0	0	0

These values are at an age of zero.

Part 2 of Hypothesis 2: Gender

The ratio of males to females in this study is relatively equal as indicated in table 4-8. The percentage of participating males (58%) approximately equaled the participating females (42%). In addition, all other values in this table are very similar, providing an indication that there may not be significant differences between technically oriented males and females with regards to learning science specific information on the Internet. This trend was confirmed with an ANCOVA.

Table 4 -8. Distribution of Participant Gender and Descriptive Statistics.

Gender	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
Male - Mean	3.36	4.64	23.4	3.6	6.4	84
SD	0.41	0.60	8.9	2.5	3.0	84
Variance	0.17	0.36	79.4	6.5	9.0	84
Female - Mean	3.48	4.82	23.1	3.3	6.0	61
SD	0.37	0.57	8.3	2.5	3.3	61
Variance	0.14	0.32	69.2	6.1	11.1	61

Table 4 -9 presents the results of the ANCOVA which confirm the earlier indication from the descriptive statistics that there was not a significant difference at $\alpha = .05$ between gender groups on post-assessment scores, thus this portion 2 of hypothesis two would be accepted.

Table 4 -9. ANCOVA Source Table for Post-Assessment vs. Gender.
Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	39.317585	19.658793	3.51	0.0330
Gender	1	1.084855	1.084855	0.19	0.6608
Gender*Group	2	11.470010	5.735005	1.02	0.3625
Pre-Assessment	1	400.258428	400.258428	71.38	0.0001

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Intercept	0.735848889	0.13	0.8969	5.66475041
Group 1	7.192546058	1.17	0.2435	6.13843249
Group 2	0.401197909	0.06	0.9486	6.20726260

Table 4-9 Continued

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Group 3 - Control	0.000000000			
Gender 1 – Male	0.381604386	0.27	0.7912	1.43806591
Gender 2 – Female	0.000000000			

Part 3 of Hypothesis 2: Racial Identity

As indicated in table 4-10, it is not possible to determine significance between racial identities due to the overwhelming numbers of white participants (77%), unless a weighting of the statistics were performed on the total number of minorities (23%). This was not performed because of the low number of minority participants. Therefore, when the ANCOVA was performed, it did not indicate a significant difference between post-assessment scores and racial identity and thus, this portion 3 of hypothesis 2 resulted in an inconclusive result for significance.

Table 4 -10. Distribution of Participant Racial Identity and Descriptive Statistics.

Racial Identity	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
White - Mean	3.39	4.74	24.4	3.5	6.4	111
SD	0.39	0.48	8.3	2.6	3.1	111
Variance	0.15	0.23	68.1	6.8	9.5	111
African American	3.44	4.88	24.4	3.9	6.6	7
SD	0.40	0.73	7.8	1.8	2.8	7
Variance	0.16	0.53	61.6	3.1	7.6	7
Native American	3.64	4.78	15.3	3.0	4.7	3
SD	0.21	0.38	8.1	1.0	2.9	3
Variance	0.04	0.14	65.3	1.0	8.3	3
Hispanic - Mean	3.56	4.55	18.4	2.5	5.0	11
SD	0.53	1.06	8.2	1.4	3.4	11

Table 4-10 Continued

Racial Identity	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
Variance	0.29	1.12	67.9	2.1	11.8	11
Asian Pacific	3.38	4.57	19.6	4.1	6.6	13
SD	0.39	0.86	10	2.9	3.6	13
Variance	0.15	0.74	100	8.6	13.0	13

Hypothesis 3

Hypothesis three states that there is no relationship between the aptitudes of verbal comprehension and the post-assessment score. An aptitude measure of verbal comprehension ability was administered which provides a good indicator of general aptitude. The descriptive statistics for verbal aptitude are presented in table 4-11 and reliability statistics for this measure are presented in table 4 -12.

Table 4 -11. Verbal Aptitude Descriptive Statistics.

	Number	Mean	SD	Variance	Range	Possible
Verbal	145	23.3	8.6	74.6	5-44	48
Post-scores	145	6.3	3.1	9.8	0-10	10

Table 4 -12. Verbal Aptitude Test Reliability Data.

Parameter	Result
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Cronbachs Alpha	.9002
Split Half	.8710
Spit Half (w/Spearman)	.9311

A significant difference was not determined by a simple ANCOVA between the verbal and post-assessment scores in this study. Table 4 -13 presents the results of the ANCOVA, which indicate that there was not a significant difference at $\alpha = .05$ between post-assessment scores and the verbal aptitude scores, thus hypothesis three would be accepted.

Table 4 -13. ANCOVA Source Table for Post-Assessment vs. Verbal Aptitude, Attitude and Self-Regulated Learners/Self-Efficacy.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Pre	1	334.515023	334.515023	59.57	0.0001
Group	2	18.083963	9.041981	1.61	0.2038
Verbal	1	1.777648	1.777648	0.32	0.5746
Attitude	1	0.838987	0.838987	0.15	0.6997
Self-Regulated /Self-Efficacy	1	0.487494	0.487494	0.09	0.7687
Verbal*Group	2	3.847060	3.847060	0.34	0.7106
Attitude*Group	2	15.718519	7.859259	1.40	0.2504
Self-Regulated /Self-Efficacy *Group	2	1.207739	0.603870	0.11	0.8981

Parameter	Estimate	T for Ho: Parameter=0	Pr > T	Std Err of Estimate
Intercept	- 1.438535010	-0.16	0.8766	9.24716711
Pre-Assessment	0.687603518	7.72	0.0001	0.08909053

Hypothesis 4

Hypothesis four states that there is no significant difference between attitudes towards computers and post-assessment scores. Computer attitudes were measured through a survey questioning participants about on-line learning materials, usefulness, and methods. A high rating on the 1-5 Likert scale represented a positive (good) attitude toward computers. This survey was developed in a survey design graduate course and was pilot tested in the same course. Descriptive statistics for the computer attitude survey are presented in table 4-14, reliability statistics are presented in table 4 -15 and refer to table 4-13 above for the computer attitude ANCOVA data.

Table 4 –14. Computer Attitude Descriptive Statistics.

	Number	Mean	SD	Variance	Range	Possible
Computer Attitudes	145	3.41	1.16	1.40	1-5	5

Post-scores	145	6.3	3.1	9.8	0-10	10
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Table 4 -15. Computer Attitude Survey Test Reliability Data.

Parameter	Result
Cronbachs Alpha	.7295
Split Half	.7046
Spit Half (w/Spearman)	.8267

There was no significant difference between computer attitude and post-assessment scores in this study. The results of the ANCOVA (table 4-13) indicate that there was not a significant difference at $\alpha = .05$ between post-assessment scores and the computer attitude scores, thus hypothesis four would be accepted.

Hypothesis 5

Hypothesis five states that there is no significant relationship between self-regulated learners or self-efficacy and post-assessment scores. An 81 item Motivated Strategies for Learning Questionnaire (MSLQ) with a seven-point Likert scale, developed by Pintrich (1995) was used to determine participant self-regulated learning potential and self-efficacy (belief in one's own capabilities). A one on the scale represented when the statement was not true at all of the participant and a seven would indicate when it was true of them. There are essentially two sections to the MSLQ, a motivated section and a learning section. The motivated section consists of 31 items that assess students' goals and value beliefs and their anxiety. The learning strategy section includes 31 items regarding students' use of different cognitive and metacognitive strategies. In addition, this section includes 19 items concerning the student's management of different resources. Descriptive statistics for the MSLQ are presented in table 4-16, reliability statistics are presented in table 4 -17 and refer to table 4-13 above for the ANCOVA data.

Table 4 -16. Motivated Strategies and Learning Questionnaire Descriptive Statistics.

	Number	Mean	SD	Variance	Range	Possible
Self-Regulated/ Self-Efficacy	145	4.71	1.64	2.83	1-7	7
Post-scores	145	6.3	3.1	9.8	0-10	10

Table 4 -17. Motivated Strategies and Learning Questionnaire Reliability Data.

Parameter	Result
Cronbachs Alpha	.9177
Split Half	.9410
Spit Half (w/Spearman)	.9696

There was no significant difference between MSLQ parameters and post-assessment scores in this study. The ANCOVA (table 4 –13) results indicate that there was not a significant difference at $\alpha = .05$ between post-assessment scores and the self-regulated learning/self-efficacy scores, thus hypothesis five would be accepted.

Summary

The five forms completed by the participants were analyzed to test five null hypotheses. The following hypothesis were tested at the $\alpha = .05$ level using an analysis of covariance. None of the five hypotheses could be rejected.

Hypothesis 1: There is no significant difference in post-assessment scores between the constructivist and the objectivist presentation formats in an on-line learning environment. Based on the ANCOVA, this hypothesis is accepted. The mean pre- and post-assessment scores for the constructivist module were 3.1 and 5.9 compared to the mean scores of the objectivist module of 3.8 and 7.0 out of a total possible of 10.

Hypothesis 2: There is no significant difference in post-assessment scores due to the participants gender or age. Based on the ANCOVA, part one (gender) and part two (age) of this hypothesis is accepted. There was a 30% difference between the number of males and females participating in this study. Mean values of the post-assessment scores were similar at 6.4 for males and 6.0 for females, thus significant differences between genders were not found and it appears that gender does not play a role in learning science specific information through the Internet. There are insignificant differences between individuals in the restricted age grouping between 18 and 30 years.

The final aspect of this hypothesis, racial identity, could not be established due to the heavy bias of white participants and thus the results were inconclusive.

Hypothesis 3: There is no relationship between the aptitudes of verbal comprehension and the post-assessment score. Based on the ANCOVA, this hypothesis is accepted and non-significant results were obtained between post-assessment scores and verbal aptitude.

Hypothesis 4: There is no significant difference between attitudes towards computers and post-assessment scores. Based on the analysis, this hypothesis is accepted.

Hypothesis 5: There is no significant relationship between self-regulated learners, self-efficacy and post-assessment scores. Based on the analysis, this hypothesis is accepted.