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Grade level expectations: do they prepare students for introductory college chemistry?

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GRADE LEVEL EXPECTATIONS: DO THEY PREPARE STUDENTS FOR INTRODUCTORY COLLEGE CHEMISTRY?

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and Agricultural and
Mechanical College
in partial fulfillment of the
requirements for the degree of
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in

The Interdepartmental Program in Natural Sciences

By
Micah Moriah Davies
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To my mom and dad, thank you for your love and support. Through your example, I have learned the greatest lesson of all, what it means to be a Christian. To my brother and sister, thanks for always being a source of laughter and love. To Lauren Baggett, thank you for being my personal cheerleader, you always had the right words to say to encourage me.

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ABSTRACT

This study investigates whether the Grade Level Expectations (GLEs) as outlined by the Louisiana Department of Education prepare students for introductory college level chemistry. A sample of 135 students in Dr. Watkins fall 2009 CHEM 1201 classes were tested for correlations between knowledge of the GLEs (chemical concept inventory pre-test and post-test score and normalized gain) and performance in CHEM 1201 (average exam score and final exam score). No significant correlations were found between any of these variables.

For further analysis, students were grouped into two groups, in-state public school students and out-of-state/private school students. It was assumed that in-state public school students were educated using the GLEs as the framework for their education while out-of-state/private school students were not. It was determined that both groups of students were statistically similar in every category with the exception of their final exam score, with the out-of-state/private school students performing better. There was also no significant relationship between any of the variables (pre-test score, post-test score, normalized gain, average exam score, final exam score) when the students were grouped.

INTRODUCTION

What factors have the largest effect on student success in introductory college chemistry? Many researchers have asked this question over the past decade. Tai *et al.* (2006) studied factors such as race, ethnicity, highest parent education level, standardized test scores, high school course enrollment, and time spent covering particular chemical concepts, in order to create a logistic regression model to predict college chemistry grades. While there is no denying that mathematical ability is a major factor in student success (Fletcher, 1978; Denny, 1974; Pickering, 1975; Ozsogomonyan *et al.*, 1979; Spencer, 1996); it is also plainly evident that secondary schools are not doing their part in adequately preparing the student for an introductory college chemistry course (Potgieter *et al.*, 2005; Potgieter *et al.*, 2008).

Recently Tai investigated the effect of the teacher's instructional practices on the success of his/her students once they entered a college level chemistry class. Tai found that a higher frequency of peer teaching and everyday examples resulted in higher college chemistry grades, while demonstrations, individual work, exam preparation and community projects all had a negative impact on college chemistry grades (Tai, 2007). Using a multi-variable linear regression, Tai estimated the value of the slope for each indicator. These estimates are shown in the table below.

Table 1. Parameter estimates from Tai's study on teacher instructional practices.

	Parameter Estimate
Everyday Examples	0.27
Peer Instruction	0.34
Demonstrations	-0.36
Standardized Exam Prep	-0.63
Community Service Projects	-0.76
Individual Work	-0.38

It is important to note that these results were attained by varying the confidence level between 90% and 99%. At the standard confidence level of 95%, the use of everyday examples is not a significant predictor of success in introductory college chemistry.

Tai has also examined the relationship between chemistry content background and its association with college chemistry grades. In 2006, he surveyed a group of over 3500 students regarding the amount of time spent on each of the following areas of chemistry: atoms and the periodic table, chemical reactions and equations, solutions, gases and gas laws, stoichiometry, nuclear reactions, biochemistry, and history/people of chemistry. Each student was asked to rate the amount of time spent on each of these topics ranging from "none at all" to "it was a recurring topic". After considering other factors such as race/ethnicity, parent educational level, and mathematical ability, Tai was able to conclude that stoichiometry was the single most important topic in predicting success in college chemistry. "The predicted grade of students who reported a heavy emphasis on stoichiometry was 2.6 points higher than their peers who reported studying stoichiometry for "A Few Weeks" or "A Month". However, compared to students who reported no stoichiometry, the heavy emphasis students were predicted to earn grades 5.1 points higher" (Tai, 2006). Some of the students themselves also seemed to grasp the effect of their understanding of stoichiometry on their college chemistry grades. One student is quoted as saying "…most helpful was the depth [with which] we covered stoichiometry" (Tai, 2006). Based on Tai's research it is evident that teachers who chose to spend more time facilitating a deeper understanding of stoichiometry did a better job of preparing their students for success in college level chemistry.

Grade Level Expectations (GLEs)

Grade Level Expectations (GLEs) are a group of standards created in 2003, as outlined by the Louisiana State Department of Education, which specify the knowledge expected to be gained by the end of a particular course. The GLEs are designed to further clarify national content standards and benchmarks (Louisiana State Department of Education, 2010). Each core subject at every grade level has a set of these standards. The GLEs serve as a general outline of a course and are the key components of the units in the state's comprehensive curriculum. According the Louisiana Department of Education's GLE Handbook, GLEs do not represent the entire coursework but rather the content that is expected to be mastered by year end, implying that these skills may have been introduced in previous years and will need to be retained. The objectives of the GLEs are described as follows:

> "The GLEs were developed with the following goals in mind:
>
> - to articulate learning from PreK–12
> - to be appropriate for the developmental or grade level of students
> - to move from the concrete to the abstract
> - to attend to prerequisite skills and understandings
> - to be specific, but not so specific as to be too small in "grain size" compared with other GLEs for a particular content area
>
> The GLEs were developed with an effort to avoid including:
>
> - statements of curricular activities or instructional strategies
> - value-laden concepts and understandings"
>
> (Louisiana Department of Education, 2004).

The chemistry GLEs cover a wide variety of topics ranging from atoms and molecules to nuclear reactions, and vary in detail from the broad "predict the conductivity of a solution" to the specific "apply knowledge of stoichiometry to solve mass/mass, mass/volume, volume/volume, and mole/mole problems" (Louisiana Department of Education, 2010). The purpose of the GLEs is to create a general understanding of a large number of chemistry topics. And, while at many schools chemistry is viewed as a college preparatory course, it seems that students are not gaining the necessary knowledge in high school in order to be successful in the introductory chemistry class at the college level.

For this study, the assumption was made that all public school students in the state of Louisiana were taught using the GLEs as a guide. This assumption was based on the fact that teachers are encouraged to use the Louisiana Grade Level Expectations in conjunction with the comprehensive curriculum as a guide for what material is to be taught throughout the year.

The purpose of this study is to investigate how well the Louisiana State Department of Education's Grade Level Expectations (GLEs) for chemistry prepare a student for an introductory college level chemistry class.

MATERIALS AND METHODS

Students enrolled in Dr. Steven Watkins Chemistry 1201 classes at Louisiana State University for the fall semester of 2009 served as the pool of participants for this study. Students were selected to participate in the study based on their completion of three bonus assignments: fill out a survey about high school instructional practices (Appendix A); take a pre-test assessment exam at the beginning of the semester; take a post-test exam at the end of the semester. Of the 350 students enrolled in the two sections of Chemistry 1201 taught by Dr. Watkins, 135 students fulfilled all requirements for participation in the study. The majority of these students (80.7%) were true college freshman, having been out of high school less than six months; 1.6% had been out of school for 7-12 months, 13.3% exited high school within the last 1-3 years and 4.4% completed high school more than three years ago. When asked about their high school experiences, 86.0% responded that the highest high school chemistry coursework taken was basic high school chemistry, with only 8.8% completing Chemistry AP, and 5.2% completing Chemistry II. It is also important to note that 63.7% of the participating students attended public high schools, while the remaining 36.3% graduated from private schools. The participants in the study received extra credit for each of the three assignments they completed, skewing the sample's grades toward the higher end of the grading scale (Table 1).

Table 2. The Fall 2009 grade distribution of Dr. Watkins' Chemistry 1201 class as compared with that of a sample taken from the same class.

	Class Population N ≈ 350	Participating Students n = 135
A	21 %	33 %
B	31 %	38 %
C	24 %	19 %
D	6 %	6 %
F	18 %	5 %

It is also likely that participants in the study were students who are highly motivated to do well in the science curriculum.

After completing the high school background survey using the course management system *Moodle,* students completed a pre-test assessment. An edited version of the chemical concept inventory created by Dr. M. Potgieter of the University of Pretoria served as the pre-test and post-test. The original inventory was composed of 82 questions. The testing instrument is described by Potgieter as consisting of items obtained from literature which were paired in a two-tiered fashion (Potgieter *et al*., 2008). Many of the questions were presented with pictorial representations since prior research indicated that "most students' difficulties and misconceptions in chemistry stem from inadequate or inaccurate models of the molecular world" (Lijnse *et al*., 1990).

It should be noted that this testing instrument does not take into account other non-cognitive factors such as study habits, motivation, and self-confidence, which according to Angel and LaLonde, could be equally important factors in student success.

The test was edited to match the concepts which were relevant to the CHEM 1201 students, as determined by Dr. Watkins' syllabus (Appendix B), resulting in the removal of two questions (one question dealing with galvanic cells, one question dealing with organic synthesis) for a final inventory of 33 questions. Each concept question was paired with a "certainty of response" index question. A group of three East Baton Rouge Parish chemistry teachers then met to pair each question on Dr. Potgieter's inventory with the appropriate GLE for chemistry. Each teacher was asked to match each question to the appropriate GLE(s). After all of the teachers had completed this task, the results were compared. Any disagreements were resolved through discussion and a voting process. It was found that Dr. Potgieter's test covered 58% of the GLEs as outlined by the state of Louisiana.

Students registered to take the pre-test in the Computer Based Testing lab on Louisiana State University's campus. The test was administered in late August, before the students had begun the college level chemistry coursework. Students were given an unlimited amount of time to complete the test, and they were given a periodic table and scratch paper which was collected upon exiting the testing site. The completion of this assignment was considered bonus in Dr. Watkins' class.

Table 3. A comparison of concept question break down between the original test and the edited test.

Topic (subset of questions)	Number of Test Items on Original Test	Number of Test Items on Edited Test
Atoms, ions & molecules	4	4
Mole concept	3	3
Phases of Matter	5	5
Solutions	3	3
Reactions	5	4
Chemical Equilibrium	3	2
Acids & Bases	4	4
Electrochemistry	2	1
Organic Chemistry	4	3
Mathematical Skills	5	5
Language Skills	4	3

Throughout the semester, students received instruction in three 50 minute lectures Monday, Wednesday and Friday, on a variety of topics as outlined in the class syllabus (Appendix C). To reinforce concepts taught in class, students were assigned a weekly homework set, which was completed online through a website, *Mastering Chemistry.com*. Homework accounted for 10% of the student's overall grade. All students were encouraged to attend weekly peer-led Supplemental Instruction sessions, and four hours of review (led by Dr. Watkins) before each exam. Four (4) one hour exams were administered on Tuesday nights throughout the semester, with the average of their best three (3) exams counting for 60% of the student's grade.

At the end of the semester during the last week of November, the post-test was administered. The post-test was given under identical circumstances as the pre-test. Students were reminded that the post-test would serve as a good review of the material that would be covered on the final exam and were again offered bonus points for completion of the assignment.

All participants in this study gave electronic consent to participate (Appendix D). The consent form and this study were approved by the Institutional Review Board of Louisiana State University.

RESULTS

In order to ensure that Dr. Potgieter's concept inventory was a valid instrument to test student knowledge of the GLEs, a group of East Baton Rouge Parish chemistry teachers met to discuss each of the test questions. The pairing of each question to GLEs is as follows:

Table 4. Concept inventory questions matched with their corresponding GLE number. (GLE numbers can be matched to the GLE covered using Appendix B.)

Question	Grade Level Expectation	Question	Grade Level Expectation	Question	Grade Level Expectation
1	16	**12**	38	**23**	35
2	5, 22	**13**	20, 37	**24**	25, 28
3	1	**14**	37	**25**	34
4	15	**15**	21	**26**	22, 23, 28
5	41	**16**	38	**27**	27, 28
6	41	**17**	N/A	**28**	N/A
7	N/A	**18**	N/A	**29**	N/A
8	43	**19**	31, 38	**30**	4
9	29	**20**	29, 37	**31**	14
10	43	**21**	33	**32**	29, 37
11	38, 39	**22**	N/A	**33**	N/A

Seven of the questions from Dr. Potgieter's test were not paired with a GLE, while nine were paired with multiple GLEs. In many cases, a particular GLE was covered by multiple questions. Forty (40) of the forty-seven (47) GLEs were determined to be "testable", by the teachers. Only GLEs which dealt directly with chemistry were considered "testable"; GLEs which were interdisciplinary, dealt with historical events, or required a laboratory setting were defined as "un-testable" for this study. Of the forty (40) testable GLEs, 58% were covered in the concept inventory. The remaining GLEs which were not covered by concept inventory were either too specific to match any particular test item, or required a more basic knowledge which was not directly tested by the concept inventory.

The goal of analysis was to determine if pre-test score, post-test score and/or normalized gain were predictors of student performance in the class. Normalized gain (g) reflects the fraction of available improvement that was attained by the student between the pre-test and the post-test and is calculated as follows:

Equation (1) $$g = \frac{post\ test\ score - pre\ test\ score}{100 - pre\ test\ score}$$

Normalized gain was used to determine if students were able to increase their knowledge of the GLEs throughout the course of the semester. Two measures were used to assess student performance in CHEM 1201. The first was the average of the best three of four hourly exams (Figures 1-3). The second measure was the student's final exam score (Figures 4-6). Final course grades were not used in analysis, as they were biased by bonus opportunities and homework points.

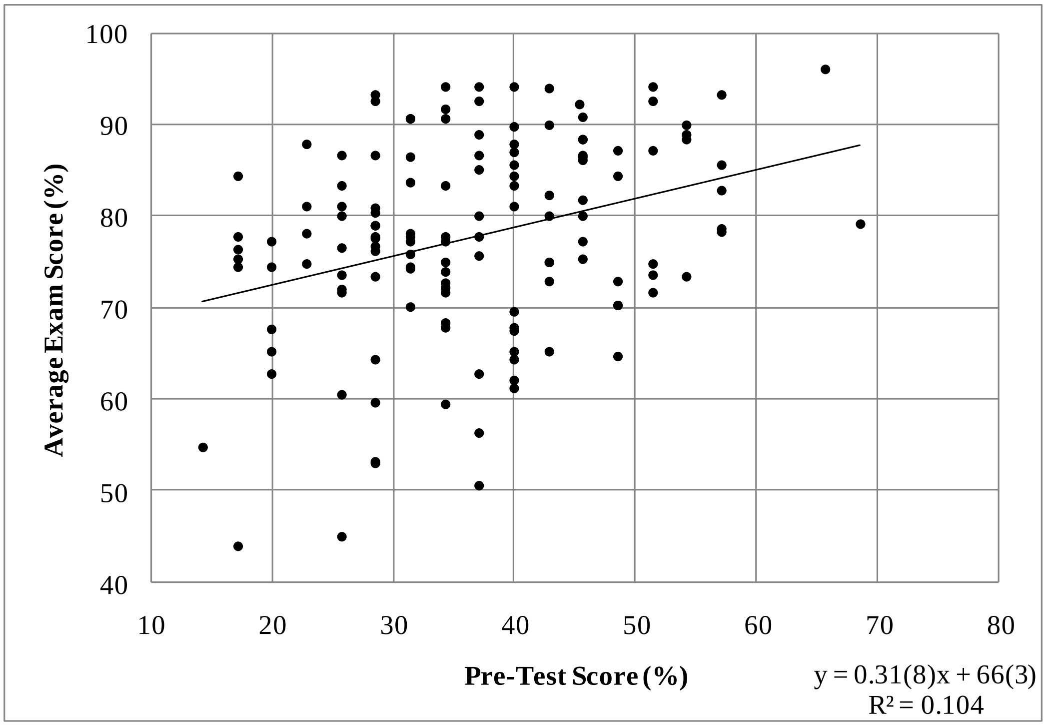

Figure 1. The relationship between pre-test score and average exam score for the entire sample.

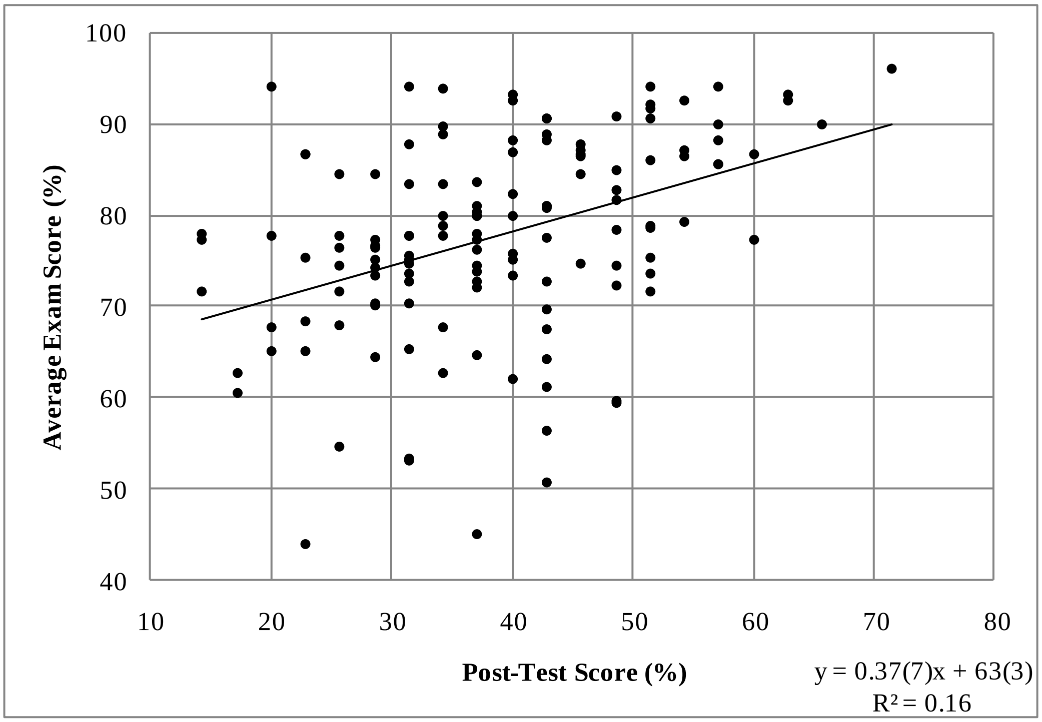

Figure 2. The relationship between post-test score and average exam score for the entire sample.

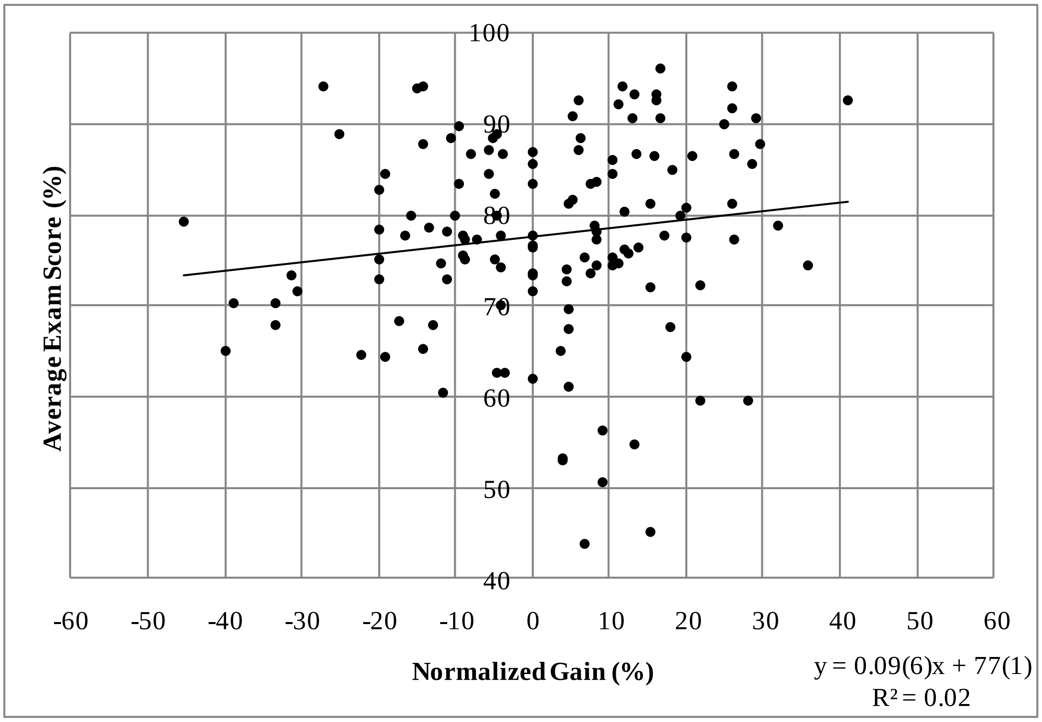

Figure 3. The relationship between normalized gain and average exam score for the entire sample.

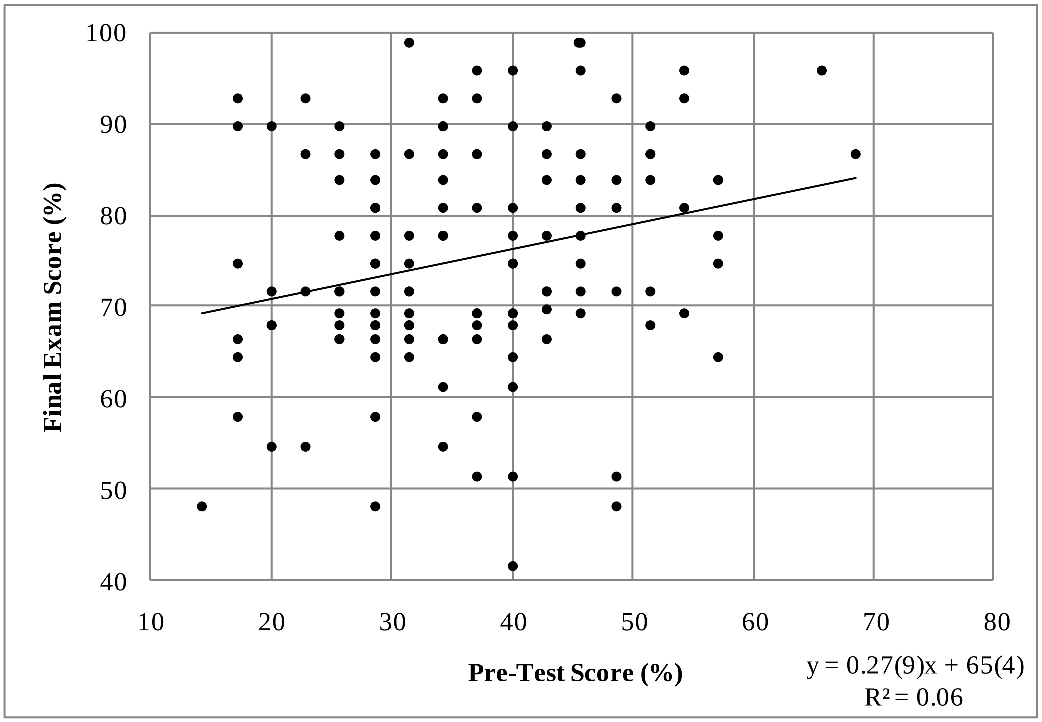

Figure 4. The relationship between pre-test score and final exam score for the entire sample.

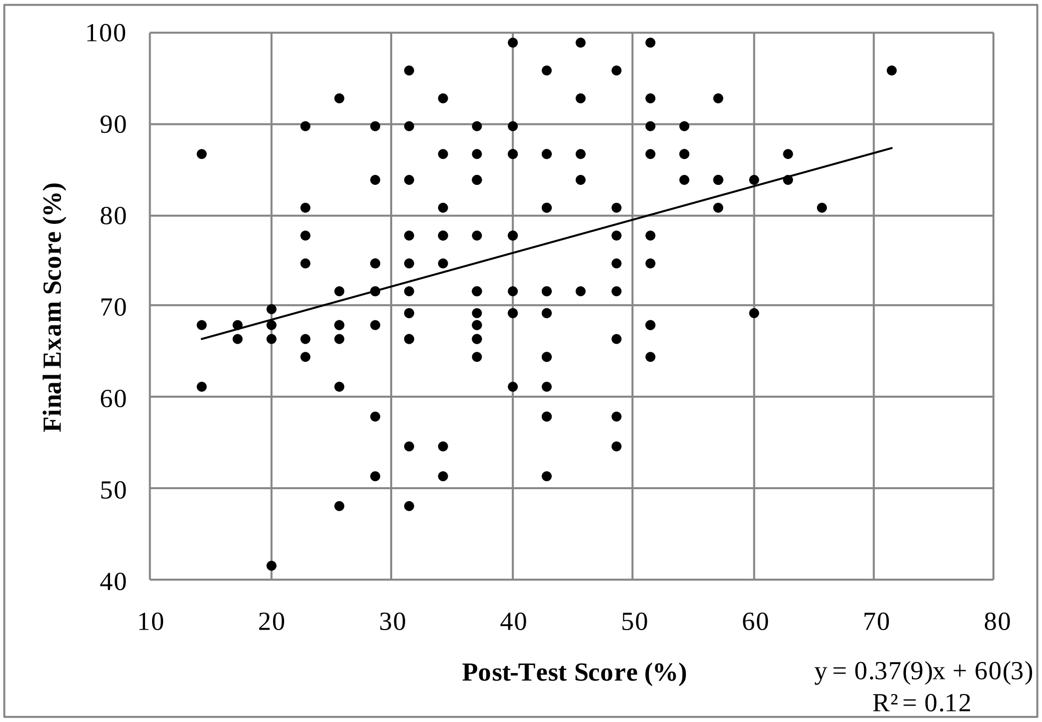

Figure 5. The relationship between post-test score and final exam score for the entire sample.

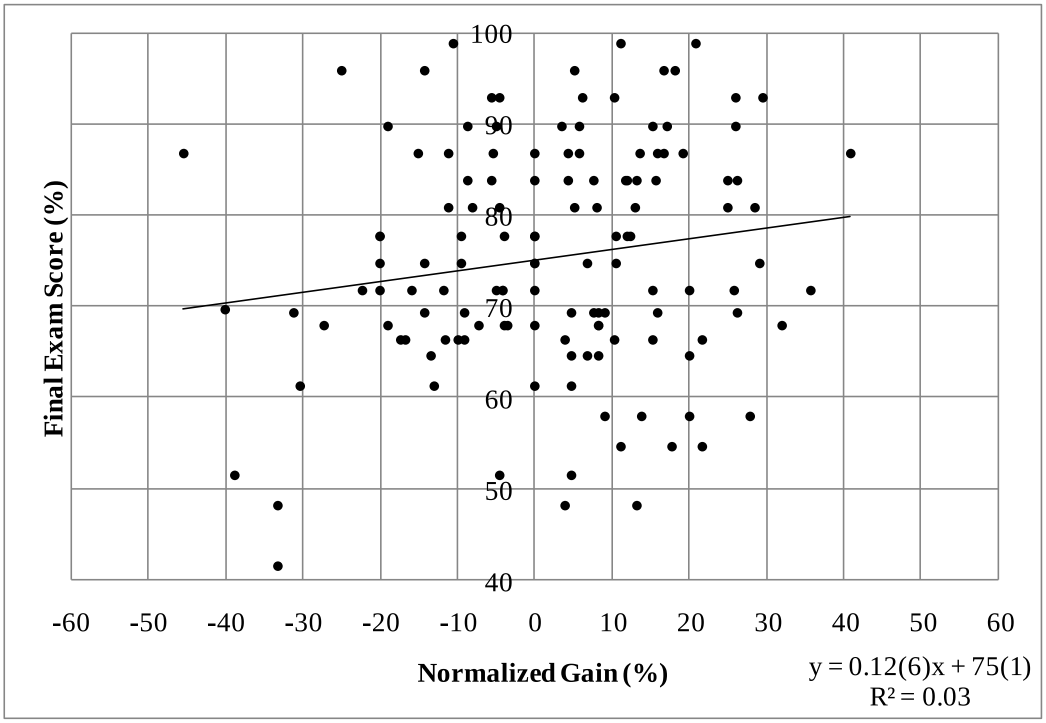

Figure 6. The relationship between normalized gain and final exam score for the entire sample.

Overall, the population of 135 students showed no notable correlation between any of the measures discussed with the exception of relationship between post-test score and hourly exam score (r = .40). Correlation was calculated using the Pearson correlation formula:

Equation (2)

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

For a more in-depth analysis, students were separated into groups based on their biographic data. Two groups were created consisting of in-state public school students (n = 71), and all other students including in-state private school students and out of state/international students (n = 64). The assumption was made that students who attended in-state public schools were taught using the GLEs as a guideline. Teachers from in-state public schools are held accountable to students' performance on GLEs through the use of benchmark exams, which tie each individual exam question to a GLE. There is no reason to believe that the second group, consisting of all private school and out of state students, are influenced by the Louisiana Department of Education GLEs. In Louisiana, private schools have the freedom to educate their students in the manor they see fit and are not required to use the GLEs. The mean pre-test score, as well as the variance in the mean, represented by error bars, was calculated for each group.

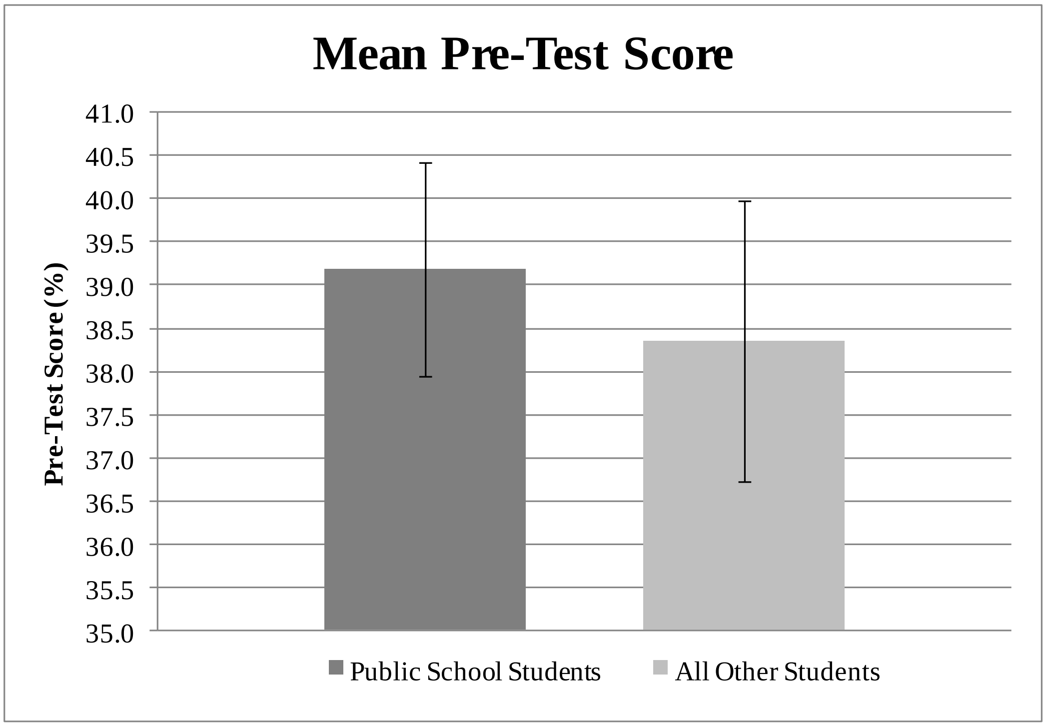

Figure 7. The pre-test mean for each group, and the error associated with each.

A two sample t-test was used to confirm the obvious result that there is no statistical difference between the two groups mean pre-test score (P(T<=t) two tail 0.68). A two tailed test was used because it tests for a significant difference in the mean in either the negative or positive direction. The formula used for the two sample t-test is as follows:

Equation (3)

$$t = \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{{\sigma_X}^2}{n_X} - \frac{{\sigma_Y}^2}{n_Y}}}$$

Group averages were also statistically similar for the post-test score (P(T<=t) two tail 0.73), normalized gain (P(T<=t) two tail 0.82) and the average exam score(P(T<=t) two tail 0.24) , but were statistically different on the final exam (P(T<=t) two tail 0.03).

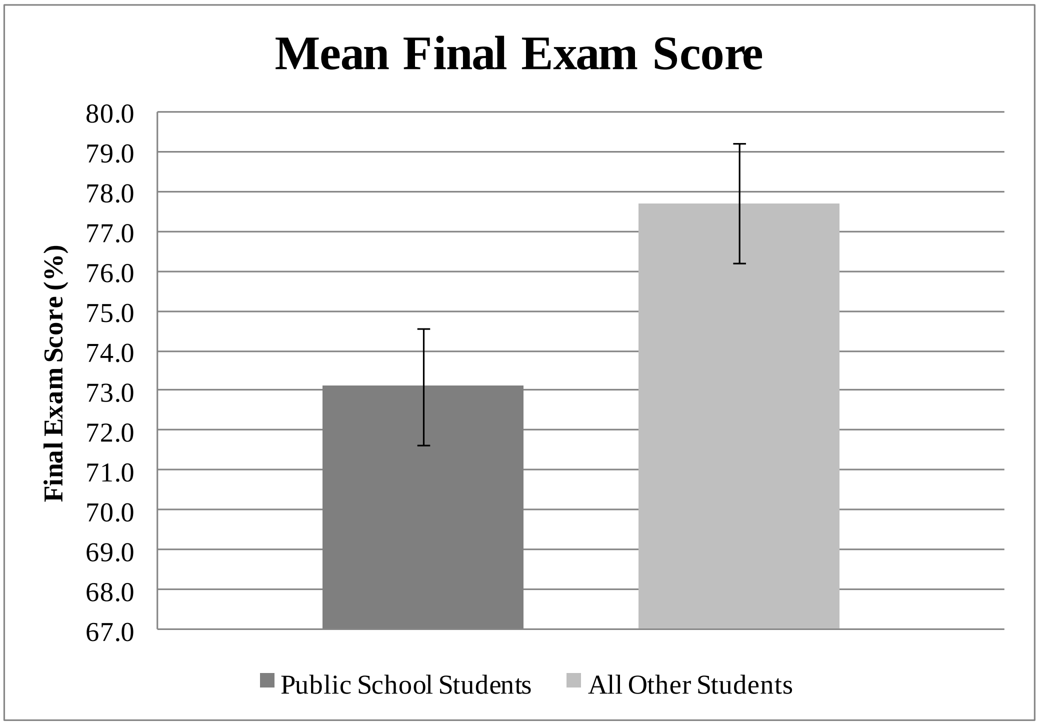

Figure 8. The mean final exam score for each group, and the error associated with each.

Figures 9 through 20 show the results of analysis when grouped as discussed. The mean value for each set of points is represented by a large box, the size of which is an approximate indication of the uncertainty of the mean value in each direction. The equation of the linear regression line for each model is provided in the lower right hand corner. The error is reported using the following notation: mean = 2.04, standard deviation = 0.07 is written as 2.04(7). The slope can be used a general guide to the relationship between each of the variables. However, because most of the measurements have such a high degree of uncertainty it is difficult to extract any meaningful information from it.

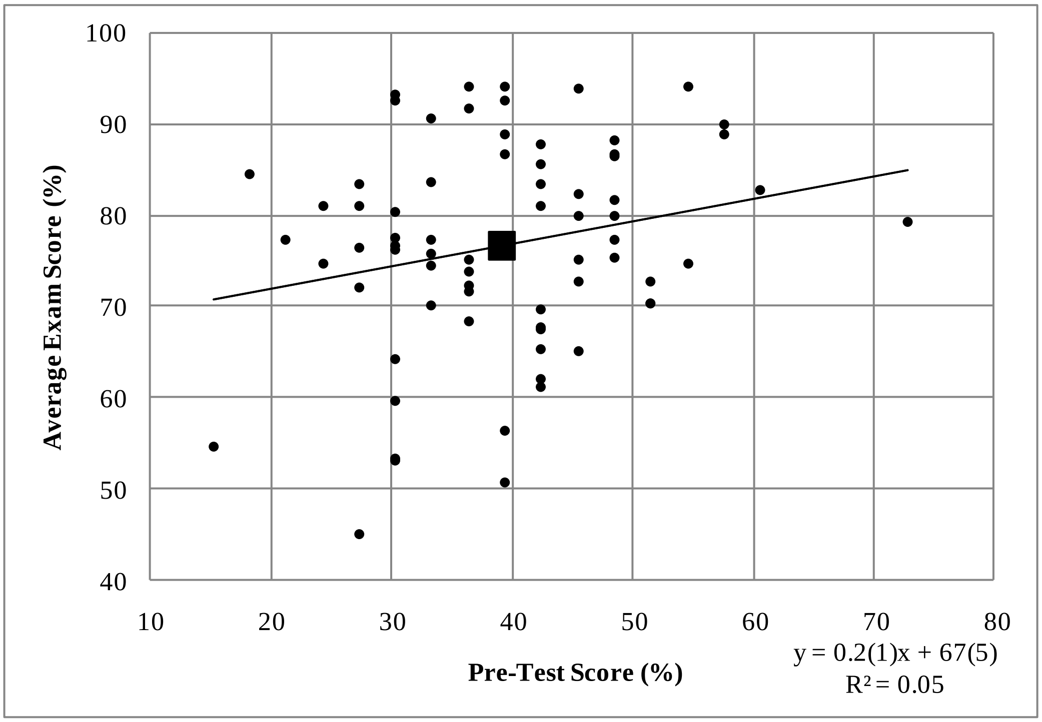

Figure 9. The relationship between pre-test score and average exam score for in state public school students.

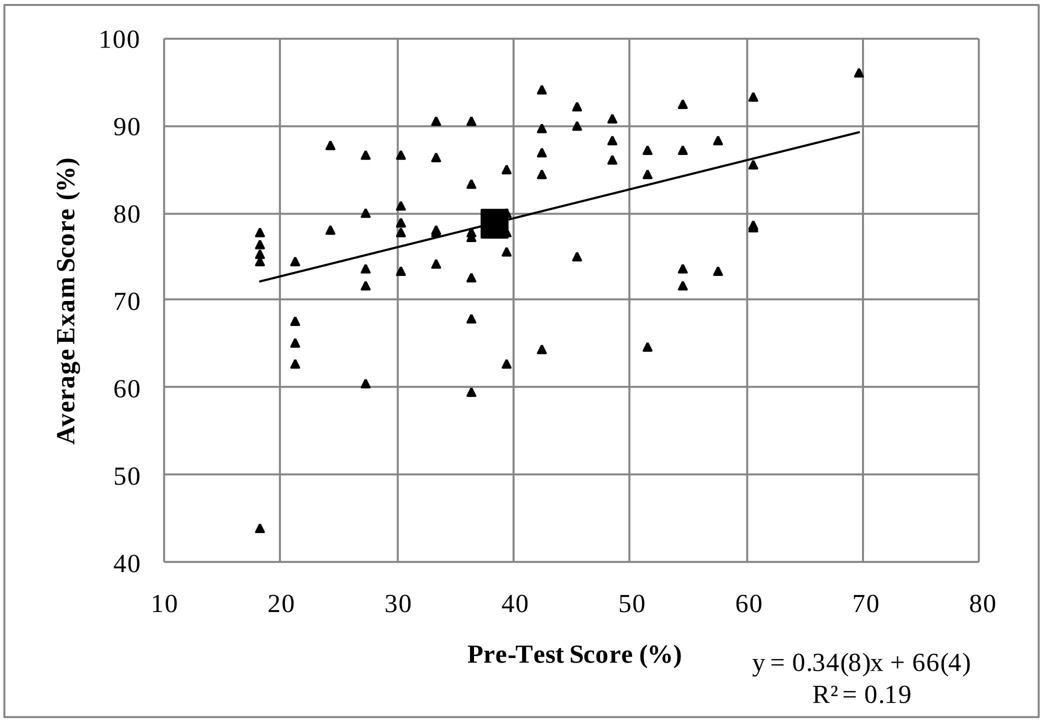

Figure 10. The relationship between pre-test score and average exam score for all other students.

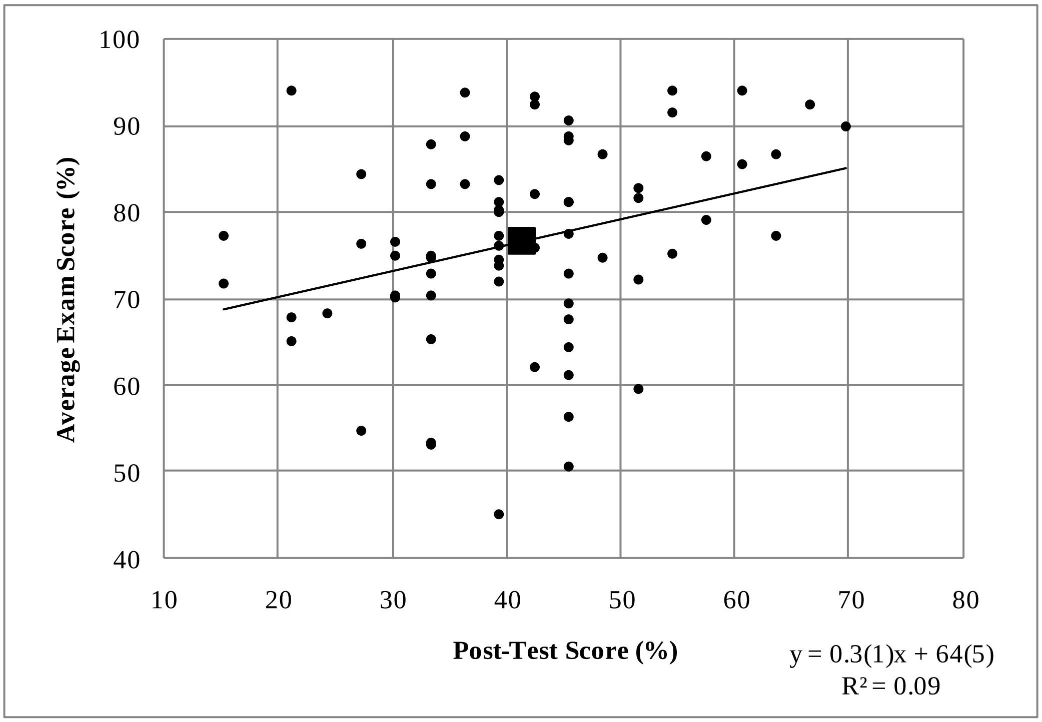

Figure 11. The relationship between post-test score and average exam score for in state public school students.

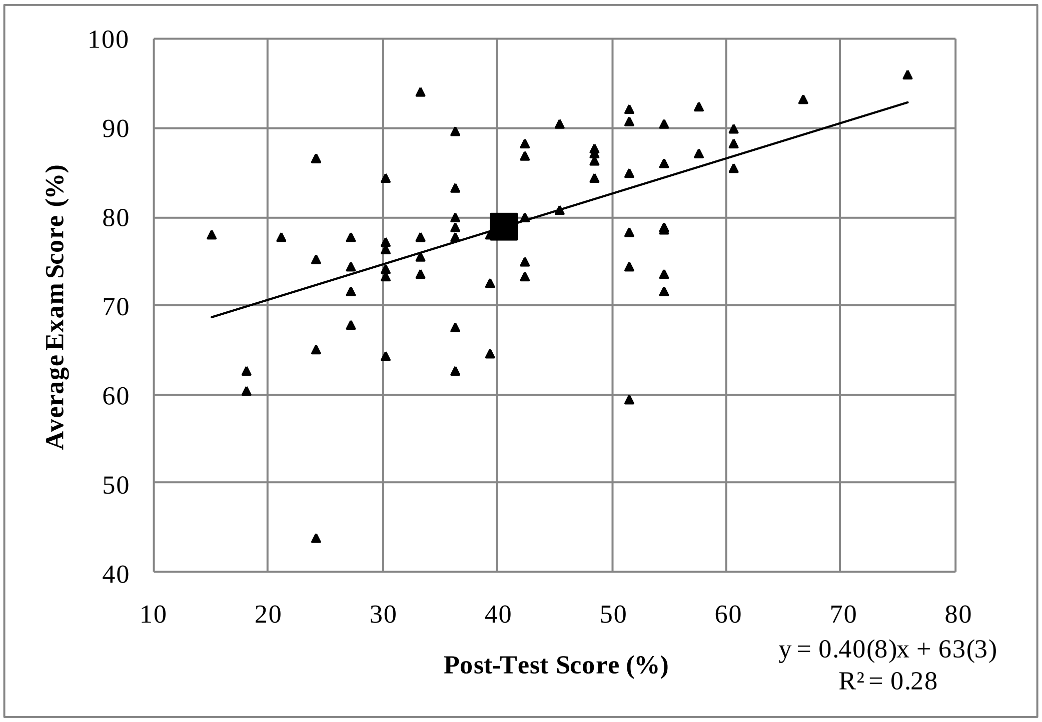

Figure 12. The relationship between post-test score and average exam score for all other students.

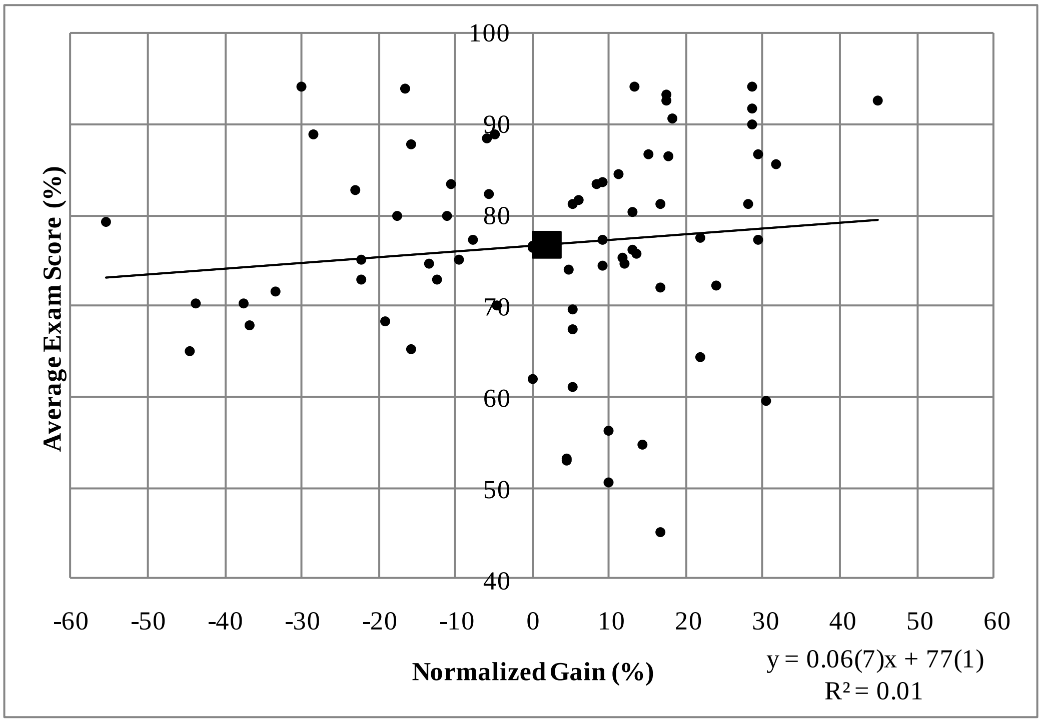

Figure 13. The relationship between normalized gain and average exam score for in state public school students.

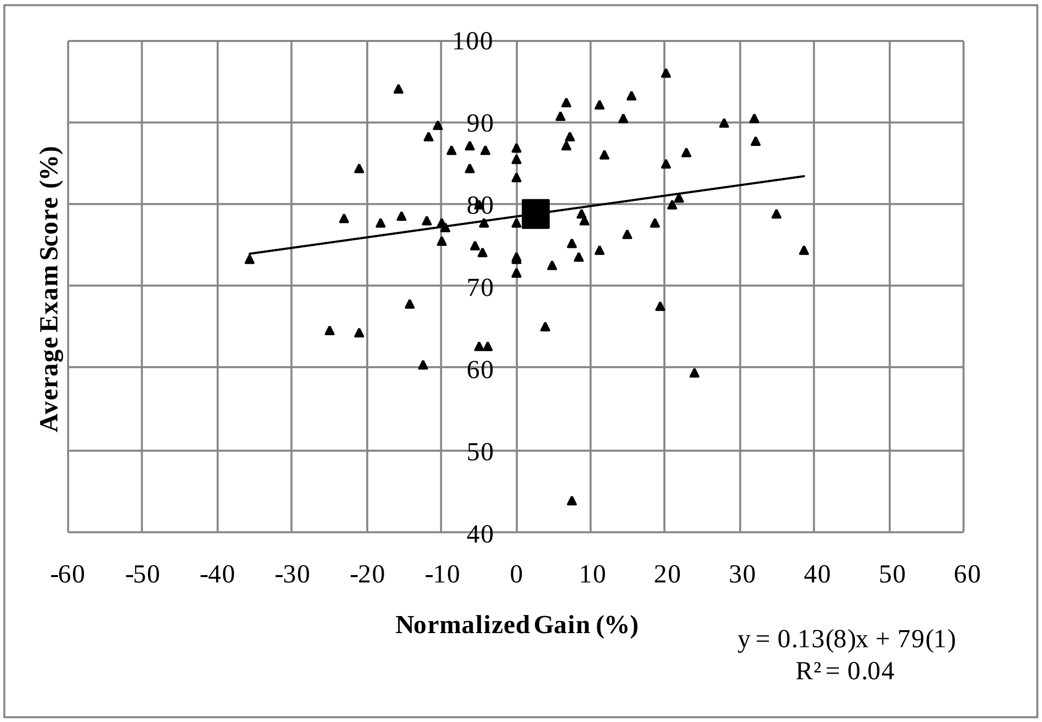

Figure 14. The relationship between normalized gain and average exam score for all other students.

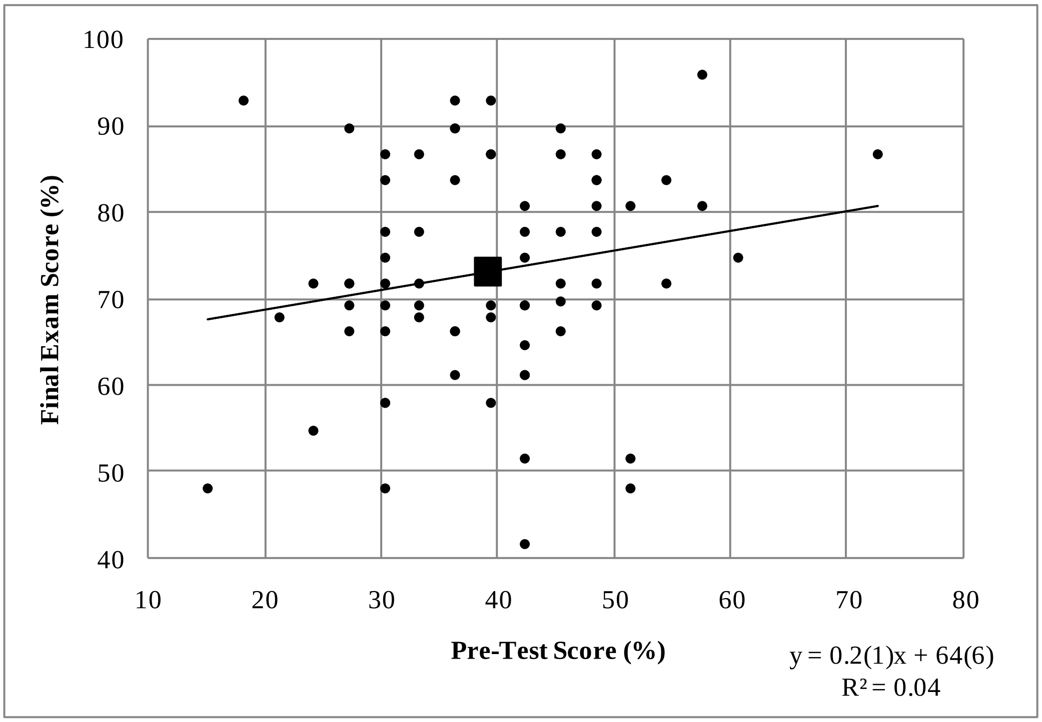

Figure 15. The relationship between pre-test score and final grade for in state public school students.

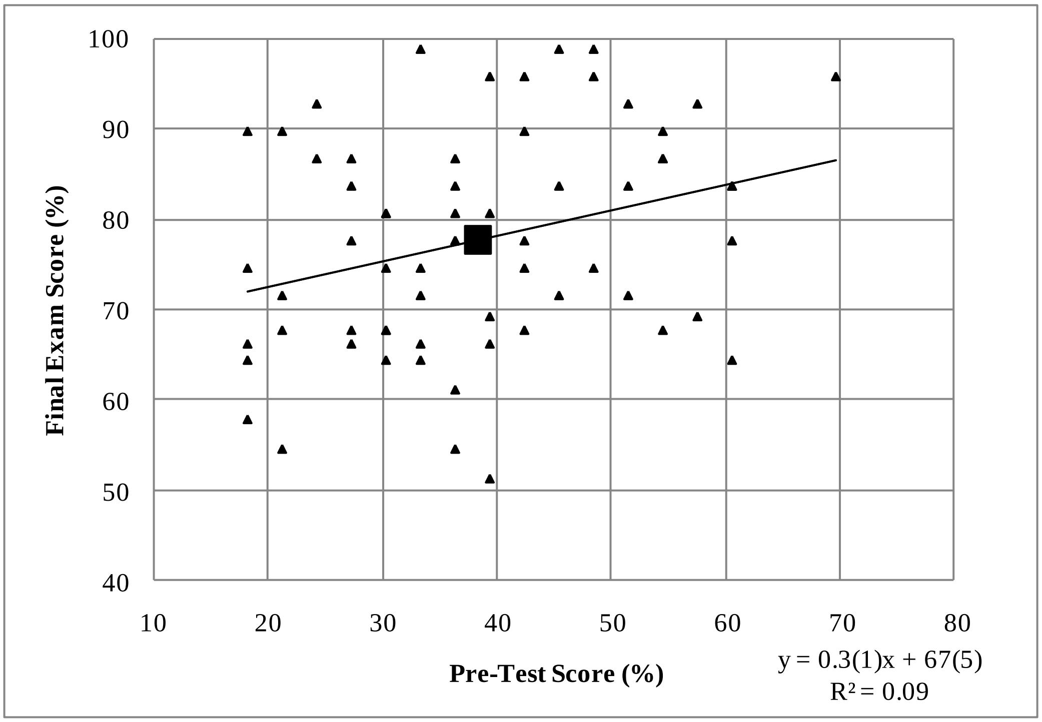

Figure 16. The relationship between pre-test score and final grade for all other students.

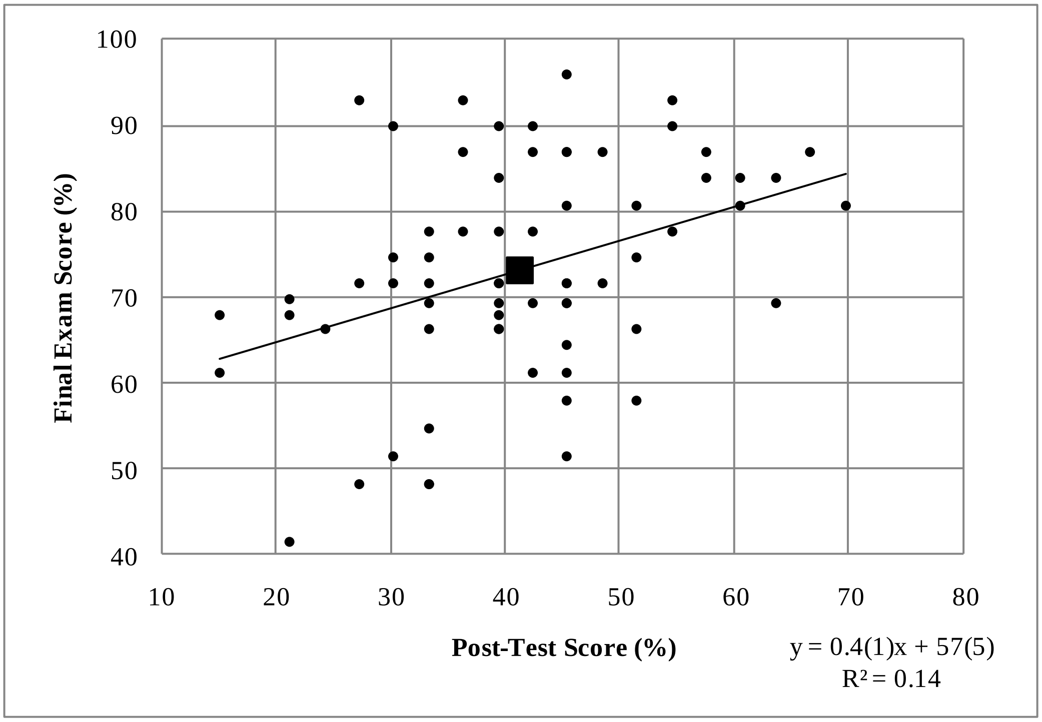

Figure 17. The relationship between post-test score and final grade for in state public school students.

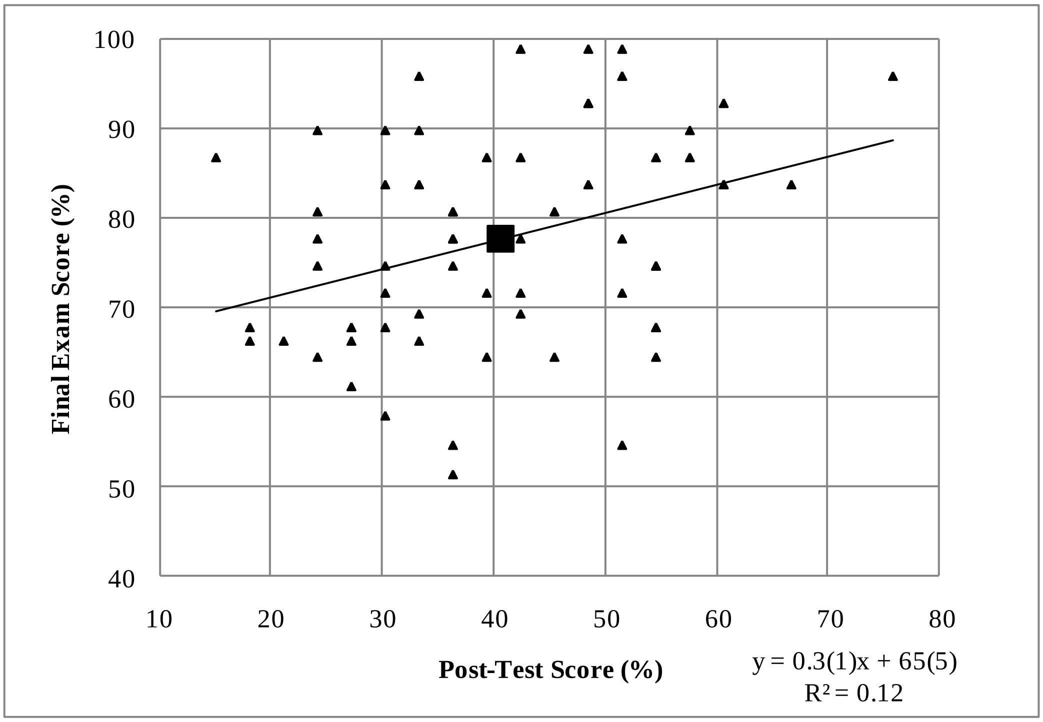

Figure 18. The relationship between post-test score and final grade for all other students.

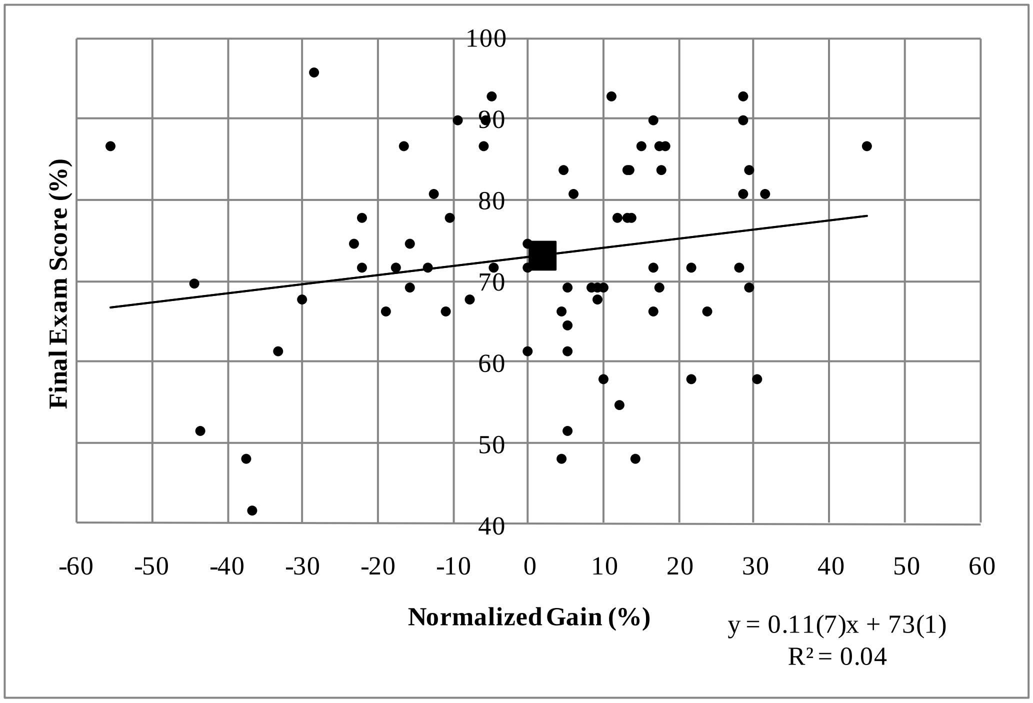

Figure 19. The relationship between normalized gain and final grade for in state public school students.

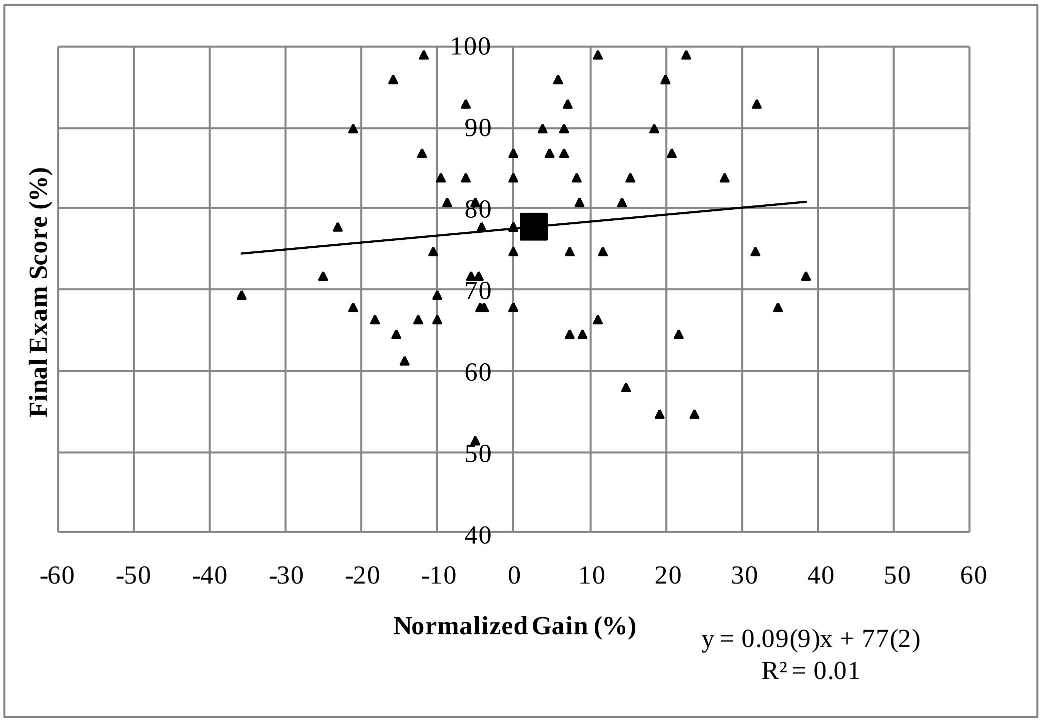

Figure 20. The relationship between normalized gain and final grade for all other students.

Using Microsoft Excel, the Pearson correlation coefficient (see Equation 2) was calculated for each of the relationships described in the Figures 9-20. The results of these calculations are as follows:

Table 5. The Pearson correlation coefficients for all variable pairings for each group of students.

	In State Public School Students	All Other Students
Pre-test Score & Average Exam Score	0.22	0.43
Post-test Score & Average Exam Score	0.30	0.52
Normalized Gain & Average Exam Score	0.11	0.19
Pre-test Score & Final Grade	0.19	0.30
Post-test Score & Final Grade	0.37	0.34
Normalized Gain & Final Grade	0.19	0.11

Based on the Pearson correlation coefficients and R^2 values, it is obvious that no strong relationship exists between any of the variable pairings for either group of students. The most notable relationships existed between the post-test score and average exam score and the pre-test score and final exam score for all other students. However, neither of these statistics is exceptionally strong nor are they convincing within such a small population.

DISCUSSION

The purpose of this study was to determine if the chemistry GLEs did an adequate job of preparing Louisiana high school students for introductory chemistry at the college level. Previous studies have found that mathematical ability plays the largest role in success in a college chemistry course, followed by knowledge of basic chemical concepts (McFate &Olmsted, 1999; Wagner *et al*., 2002). Since public high school teachers are required to use the GLEs as a guideline for their content coverage, it would be valuable to know if these guidelines help students to establish a base of conceptual chemistry knowledge before entering college.

It is interesting to note that both in-state public school students and out-of-state/private school students have the same basic knowledge when entering a college level chemistry class, as demonstrated by their statistically similar average pre-test scores. The average post-test score and average hourly exam score for both groups are also statistically the same; however, it is notable that the mean final exam grade for each group is statistically different, with private school/out-of-state students performing better on this exam overall. This may mean that private school students are better adjusted to the pressures that come with a rigorous final exam week due to prior experience in high school.

No significant correlation was found between knowledge of the GLEs (pre-test or post-test score) and academic success in college chemistry. This may imply that a general knowledge of the GLEs is not necessary in order to be successful in college chemistry. However, it has been documented that knowledge of stoichiometry was a key factor in college chemistry success (Tai, 2006). It would be wise for further studies to investigate which GLEs in particular had the highest correlation to success in college chemistry.

There was also no correlation between knowledge of the GLEs gained during the college course (normalized gain) and student performance in the college chemistry class. This could be because the content coverage in each of these classes is quite different. However, the argument could be made that the high school classroom should mimic that of the college chemistry classroom, with the exception that the material covered should be at a lower level of understanding. This discrepancy between the institutions should be further investigated in an effort to increase student performance and the meaningfulness of the high school chemistry curriculum.

It should be noted that this study does not take into account other factors that contribute to student performance, particularly in the first year of college. Each student must make an adjustment to the higher order thinking skills necessary in order to succeed in a university setting, while adjusting to dramatic changes in overall lifestyle. These factors were not measured and could play a large role in student success.

Though it has been noted in the past that mathematical ability is the strongest predictor of success in introductory college chemistry, this study did not explore this relationship. The test instrument addressed a limited number of mathematical concepts, and was not intended for use as an assessment of mathematical ability. It would be beneficial for future studies to look at the relationship between knowledge of the mathematics GLEs and introductory college chemistry grades.

Overall, it is evident that the GLEs address many topics not covered in introductory college chemistry. If high school chemistry is intended to be a college preparatory class, it is important that the content coverage be similar. While not all high school chemistry students are college bound, the problem solving and logic skills they gain from a high school chemistry course modeled after an introductory college chemistry course are beneficial in any career path. The results of this study support the argument for a deeper understanding of smaller number of topics, as opposed to general knowledge of a wider variety of topics.

SUMMARY AND CONCLUSIONS

The Louisiana Department of Education's Grade Level Expectations (GLEs) were tested as a predictor of student success in introductory college level chemistry. No significant correlations were found between knowledge of the GLEs (pre-test, post-test, normalized gain) and student performance (average exam score, final exam score).

Additional analysis was done by grouping students according to the demographic information provided about their high school setting. In-state public school students, who are educated using the GLEs as a baseline, performed at the statically equivalent level as out-of-state and in-state private school students on the pre-test, indicating a similar understanding of key concepts knowledge when the students entered college chemistry. Both groups of students also achieved comparable results on the post-test and on their average exam score. There was however, a notable difference in their final exam score with the out-of-state and private school students performing statistically higher than the in-state public school students.

It is also interesting to note that neither group showed a statistical improvement in average score from pre-test to post-test. This suggests that students gained no additional knowledge of the topics addressed by the GLEs during the course of the semester. If high school chemistry is intended to prepare students for the college classroom, adjustments need to be made in order to match the GLEs to more appropriate content.

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APPENDIX A
SURVEY OF HIGH SCHOOL INSTRUCTIONAL PRACTICES

Please rate the amount of time you spent on selected Chemistry topics using the following scale:

A = none at all
B = A few weeks
C = A month
D = A semester
E = Reoccurring topic throughout the year

1. Atoms and Ions
2. Mole Concept
3. Phases of Matter
4. Solutions
5. Chemical Reactions
6. Acids & Bases
7. Chemical Equilibrium
8. Electrochemistry
9. Organic Chemistry

Background information:

1. Where did you attend high school?
    a. East Baton Rouge Parish
    b. Another Louisiana Parish
    c. In the United States but outside of Louisiana
    d. Outside of the United States
2. Did you attend a public high school or a private high school?
    a. Public high school
    b. Private high school
3. How long has it been since you graduated high school?
    a. 6 months
    b. 7-12 months
    c. 2-3 years
    d. 3 or more years
4. What was the highest Chemistry course you took during high school?
    a. Chemistry
    b. Chemistry AP
    c. Chemistry II
5. Have you even taken CHEM 1201 before?
    a. Yes
    b. No

APPENDIX B
LOUISIANA DEPARTMENT OF EDUCATION: GRADE LEVEL EXPECTIONS FOR CHEMISTRY

Measurement and Symbolic Representation

1. **Convert metric system units involving length, mass, volume, and time using dimensional analysis (i.e., factor-label method) (PS-H-A1)***
2. Differentiate between accuracy and precision and evaluate percent error (PS-H-A1)
3. Determine the significant figures based on precision of measurement for stated quantities (PS-H-A1)
4. **Use scientific notation to express large and small numbers (PS-H-A1)***
5. **Write and name formulas for ionic and covalent compounds (PS-H-A2)***
6. Write and name the chemical formula for the products that form from the reaction of selected reactants (PS-H-A2)
7. Write a balanced symbolic equation from a word equation (PS-H-A2)

Atomic Structure

8. Analyze the development of the modern atomic theory from a historical perspective (PS-H-B1)
9. Draw accurate valence electron configurations and Lewis dot structures for selected molecules, ionic and covalent compounds, and chemical equations (PS-H-B1)
10. Differentiate among *alpha*, *beta*, and *gamma* emissions (PS-H-B2)
11. Calculate the amount of radioactive substance remaining after a given number of half-lives has passed (PS-H-B2)
12. Describe the uses of radioactive isotopes and radiation in such areas as plant and animal research, health care, and food preservation (PS-H-B2)
13. Identify the number of bonds an atom can form given the number of valence electrons (PS-H-B3)

The Structure and Properties of Matter

14. **Identify unknowns as elements, compounds, or mixtures based on physical properties (e.g., density, melting point, boiling point, solubility) (PS-H-C1)***
15. **Predict the physical and chemical properties of an element based only on its location in the periodic table (PS-H-C2)***
16. **Predict the stable ion(s) an element is likely to form when it reacts with other specified elements (PS-H-C2)***
17. Use the periodic table to compare electronegativities and ionization energies of elements to explain periodic properties, such as atomic size (PS-H-C2)
18. Given the concentration of a solution, calculate the predicted change in its boiling and freezing points (PS-H-C3)
19. Predict the conductivity of a solution (PS-H-C3)
20. **Express concentration in terms of molarity, molality, and normality (PS-H-C3)***
21. **Design and conduct a laboratory investigation in which physical properties are used to separate the substances in a mixture (PS-H-C4)***
22. **Predict the kind of bond that will form between two elements based on electronic structure and electronegativity of the elements (e.g., ionic, polar, nonpolar) (PS-H-C5)***

23. **Model chemical bond formation by using Lewis dot diagrams for ionic, polar, and nonpolar compounds (PS-H-C5)***
24. Describe the influence of intermolecular forces on the physical and chemical properties of covalent compounds (PS-H-C5)
25. **Name selected structural formulas of organic compounds (PS-H-C6)***
26. Differentiate common biological molecules, such as carbohydrates, lipids, proteins, and nucleic acids by using structural formulas (PS-H-C6)
27. **Investigate and model hybridization in carbon compounds (PS-H-C6)***
28. **Name, classify, and diagram *alkanes*, *alkenes*, and *alkynes* (PS-H-C6)***
29. **Predict the properties of a gas based on gas laws (e.g., temperature, pressure, volume) (PS-H-C7)***
30. Solve problems involving heat flow and temperature changes by using known values of specific heat and latent heat of phase change (PS-H-C7)

Chemical Reactions

31. **Describe chemical changes and reactions using diagrams and descriptions of the reactants, products, and energy changes (PS-H-D1)***
32. Determine the concentration of an unknown acid or base by using data from a titration with a standard solution and an indicator (PS-H-D2)
33. **Calculate pH of acids, bases, and salt solutions based on the concentration of hydronium and hydroxide ions (PS-H-D2)***
34. **Describe chemical changes by developing word equations, balanced formula equations, and net ionic equations (PS-H-D3)***
35. **Predict products (with phase notations) of simple reactions, including acid/base, oxidation/reduction, and formation of precipitates (PS-H-D3)***
36. Identify the substances gaining and losing electrons in simple oxidation-reduction reactions (PS-H-D3)
37. **Predict the direction of a shift in equilibrium in a system as a result of stress by using LeChatalier's principle (PS-H-D4)***
38. **Relate the law of conservation of matter to the rearrangement of atoms in a balanced chemical equation (PS-H-D5)***
39. **Conduct an investigation in which the masses of the reactants and products from a chemical reaction are calculated (PS-H-D5)***
40. Compute percent composition, empirical formulas, and molecular formulas of selected compounds in chemical reactions (PS-H-D5)
41. **Apply knowledge of stoichiometry to solve mass/mass, mass/volume, volume/volume, and mole/mole problems (PS-H-D5)***
42. Differentiate between activation energy in endothermic reactions and exothermic reactions (PS-H-D6)
43. **Graph and compute the energy changes that occur when a substance, such as water, goes from a solid to a liquid state, and then to a gaseous state (PS-H-D6)***
44. Measure and graph energy changes during chemical reactions observed in the laboratory (PS-H-D6)
45. Give examples of common chemical reactions, including those found in biological systems (PS-H-D7)

Forces and Motion

46. Identify and compare intermolecular forces and their effects on physical and chemical properties (PS-H-E1)

Interactions of Energy and Matter

47. Assess environmental issues related to the storage, containment, and disposal of wastes associated with energy production and use (PS-H-G4)

*** Indicates a GLE that was tested by the concept inventory**

APPENDIX C
DR. WATKINS' SYLLABUS FOR CHEMISTRY 1201, FALL 2009

Text: *Chemistry: The Central Science, Brown,* LeMay & Bursten, 11th Ed., Prentice Hall, 2008

Chapter 1: Introduction: Matter and Measurement
Students are responsible for reading & understanding chapter 1.

Chapter 2: Atoms, Molecules, and Ions
Students are responsible for reading & understanding sections 2.1-2.2

- 2.3 The Modern View of Atomic Structure
- 2.4 Atomic Weights
- 2.5 The Periodic Table
- 2.6 Molecules and Molecular Compounds
- 2.7 Ions and Ionic Compounds
- 2.8 Naming Inorganic Compounds
- 2.9 Some Simple Organic Compounds

Chapter 3: Stoichiometry: Calculations with Chemical Formulas and Equations

- 3.1 Chemical Equations
- 3.2 Some Simple Patterns of Chemical Reactivity
- 3.3 Formula Weights
- 3.4 Avogadro's Number and the Mole
- 3.5 Empirical Formulas from Analyses
- 3.6 Quantitative Information from Balanced Equations
- 3.7 Limiting Reagents

Chapter 4: Aqueous Reactions and Solution Stoichiometry

- 4.1 General Properties of Aqueous Solution
- 4.2 Precipitation Reactions
- 4.3 Acid-Base Reactions
- 4.5 Concentrations of Solutions
- 4.6 Solution Stoichiometry & Chemical Analysis

Chapter 5: Thermochemistry

- 5.1 The Nature of Energy
- 5.3 Enthalpy
- 5.4 Enthalpies of Reaction

Chapter 6: Electronic Structure of Atoms

- 6.1 The Wave Nature of Light
- 6.2 Quantized Energy and Photons
- 6.3 Line Spectra and the Bohr Model
- 6.4 The Wave Nature of Matter
- 6.5 Quantum Mechanics and Atomic Orbitals
- 6.6 Representations of Orbitals

- 6.7 Many-Electron Atoms
- 6.8 Electron Configurations
- 6.9 Electron Configurations and the Periodic Table

Chapter 7: Periodic Properties of the Elements

- 7.1 Development of the Periodic Table
- 7.2 Effective Nuclear Charge
- 7.3 Sizes of Atoms and Ions
- 7.4 Ionization Energy
- 7.5 Electron Affinities
- 7.6 Metals, Nonmetals, and Metalloids
- 7.7 Group Trends for the Active Metals
- 7.8 Group Trends for Selected Nonmetals

Chapter 8: Basic Concepts of Chemical Bonding

- 8.1 Chemical Bonds, Lewis Symbols, and the Octet Rule
- 8.2 Ionic Bonding (skip Born Haber cycle & lattice energy)
- 8.3 Covalent Bonding
- 8.4 Bond Polarity and Electronegativity
- 8.5 Drawing Lewis Structures
- 8.6 Resonance Structures
- 8.7 Exceptions to the Octet Rule
- 8.8 Strengths of Covalent Bonds

Chapter 9: Molecular Geometry and Bonding Theories

- 9.1 Molecular Shapes
- 9.2 The VSEPR Model
- 9.3 Molecular Shape and Molecular Polarity
- 9.4 Covalent Bonding and Orbital Overlap
- 9.5 Hybrid Orbitals
- 9.6 Multiple Bonds

Chapter 10: Gases

- 10.1 Characteristics of Gases
- 10.2 Pressure
- 10.3 The Gas Laws
- 10.4 The Ideal-Gas Equation
- 10.5 Further Applications of the Ideal-Gas Equation
- 10.6 Gas Mixtures and Partial Pressures
- 10.7 Kinetic-Molecular Theory
- 10.8 Molecular Effusion and Diffusion

Chapter 11: Intermolecular Forces, Liquids, and Solids

- 11.1 A Molecular Comparison of Gases, Liquids and Solids
- 11.2 Intermolecular Forces

11.3 Some Properties of Liquids
11.4 Phase Changes
11.5 Vapor Pressure
11.6 Phase Diagrams

APPENDIX D
ELECTRONIC CONSENT FORM

Project Title: Determination of the core GLEs required for mastery of an introductory college chemistry course
Performance Site: Louisiana State University
Investigators: The following investigator is available for questions:
Ms. Micah Davies
(225)751-0436
Woodlawn Middle School

Purpose of Study: The purpose of this project is to determine which of the Louisiana State Department's chemistry GLEs are most crucial for success in a college level introductory chemistry class.

Subject Inclusion: Individuals in Dr. Watkins Fall 2009 CHEM 1201

Study Procedures: Subjects will participate in an online survey to collect high school education background information. They will then complete a pre-test, during the first week of school, and post-test, near the end of the semester. The scores on these tests will be used to determine which GLEs are most crucial for success in a college level introductory chemistry course.

Benefits: All subjects will have the opportunity to earn points for each activity completed including the survey, pre-test and post-test.

Risks: The research is not expected to cause any harm or discomfort.

Right to Refuse: Participation is voluntary, and a student will become part of the study only if the student agrees to participate. At any time, the subject may withdraw from the study without penalty or loss of any benefit to which they might otherwise be entitled.

Privacy: The school records of participants in this study may be reviewed by investigators. Results of the study may be published, but no names or identifying information will be included for publication. Subject identity will remain confidential unless disclosure is required by law.

Signatures: I will participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

By clicking continue, I am agreeing to participate in this study.

Institutional Review Board Dr. Robert Mathews, Chair 203 B-1 David Boyd Hall Baton Rouge, LA 70803 P: 225.578.8692 F: 225.578.6792 irb@lsu.edu | lsu.edu/irb

VITA

Micah Moriah Davies was born to Michael and Sheryl Davies in November 1985 in Houston, Texas. She attended elementary and middle school in East Baton Rouge Parish, and graduated as valedictorian of her class from Woodlawn High School in 2003. The following fall she entered Louisiana State University in Baton Rouge, where she earned a Bachelor of Science in chemistry in December 2007. She entered Louisiana State University Graduate School in June 2008 and is a candidate for the Master of Natural Sciences degree. She is currently teaching chemistry at Denham Springs High School in Denham Springs, Louisiana.