DETERMINING THE EFFECTIVE PREDICTORS OF PERFORMANCE IN A SECOND SEMESTER ALGEBRA-BASED PHYSICS COURSE.

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CHAPTER 1

INTRODUCTION

Higher education leads to higher lifetime earnings but comes at an ever increasing cost. Yet programs such as "Declining by Degrees [1]" demonstrate that many students do not receive what they pay for. Consequently, the stakeholders in education are increasing the demand to demonstrate student-learning gains. For example, the recent engineering accreditation program, ABET 2000 [2] [3] placed strong emphasis on assessment. The program level assessment concerns have impact at the classroom and individual instructor level. Most research institution instructors are concerned about student learning but are rewarded more for research. Yet instruction can be a research enterprise. What can individual instructors do to identify what course components contribute most to the desired student learning?

Personal experiences as a student and an instructor motivated this study. A statistics course on regression required a class project. Physics 1313, an inquiry based physics course serving primarily elementary education majors, provided a natural object for this study. The project examined unique variation between course components and the midterm exam. The course component with the highest unique variation with the exam was the best exam performance predictor. The effect of online quizzes was interesting because during the previous summer it was determined that exam scores with online quizzes were equivalent to exam scores without pre-lab quizzes. The goal of the project was to determine if pre-lab quizzes were good predictors of exam performance.

The results proved surprising. The quizzes and the exams shared little unique variation. This indicated the online quizzes were a poor predictor of exam performance. What was surprising was the only predictor that shared a large unique variation with the exam scores was homework. Online quizzes, labs, and moon observations shared little unique variation with the exam scores (less than 1 percent). It was expected that homework would be a predictor of exam performance because homework questions and exam questions had the same format; but it was expected other components would share more variation with the exam scores. As a result of this research, online quizzes in Physics 1313 were eliminated in the spring 2007 semester.

The successful application of regression techniques in Physics 1313 raises the question if similar studies to measure the effectiveness of course components have been performed on entry-level physics courses? An extensive literature review revealed that research on the effectiveness of course components is open for study. Prior studies have been limited to a few predictor variables in the first semester of physics. Only the relationship between these predictor variables and the exams has been explored. The relationship between the different course components has not been explored. The relationship between the course components and other non-course component factors (ability, learning styles, and student physics attitude) has not been examined. Until recently there has not been a standard exam for second semester conceptual knowledge. Essentially, no research has been done for the second semester introductory physics course.

This topic is important because Physics tends to be a challenging subject. There is a need to identify possible variables that could lead to student success. If relationships between variables are known it might be possible identify students who might encounter trouble. Due to the lack of thorough prior research and a need to know relationships among variables, investigating the exam predictors in a second semester algebra-based Physics course proves to be a compelling thesis project.

CHAPTER 2

Background Information

2.1 Introduction to the Literature Review

It is important to know the factors that predict exam performance because it becomes possible to help students before they encounter problems. Factors that have been shown useful for predicting exam performance in first semester physics courses include: math ability [4] [5], student attitude about physics [6] [7] [8] [8] [9], high school physics background [5] [10] [11] [12] [13], and gender [12] [14] [15] [16] [17] [18] [19] [20] [21]. These factors are not controlled by the instructor. Factors that the instructor can control include teaching style [20] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32]and course components. This literature review will focus on work that has evaluated the effectiveness of course components. Most reviewed studies examine the relationship between performance on course components and exams.

2.2 Literature Review

Griffith's [33] study examined the correlation between homework and several variables in both algebra and calculus-based physics courses. This study ran for two semesters. Griffith found that the homework had larger significant correlations with quantitative exams questions than qualitative exam questions. He also found the homework had significant positive correlations with the math pre-test for the calculus-based physics course, but the results were a non-significant negative correlation for the algebra-based physics course. There were no correlations between a science reasoning test and performance on the homework for both the algebra and calculus-based physics courses.

Pritchard [34] examined whether online homework was a predictor of final exam performance in an introductory mechanics course. The web-based homework system, MasteringPhysics, offered problems hints, simpler problems, criticism for incorrect answers, and penalties for every hint. The predictor variables were: the time students take to complete the problem (T), hints given (h), incorrect answers with advice (ia), and solutions requested (s).

They found the fraction of problems completed in less than 2.5 minutes (pfr) had a negative correlation with exam performance (r = -0.37). This indicated the more problems completed in less than 2.5 minutes the worse the exam performance. This suggested a lack of effort, so the authors removed these scores from the analysis and used it as a separate predictor variable. Pritchard did not state what variables were significant predictors, but the final exam prediction equation was:

$$f = -0.394T - 0.228h - 0.078ia - 0.062s - 0.472pfr + 0.991 \tag{2.1}$$

Pollack's [35] focus was factors that affected student gain on the Force and Motion Conceptual Evaluation [36] (FCME) in a first semester calculus-based physics course. The FCME is a standard exam given in first semester physics courses. The course structure included use of personal response systems (clickers), McDermott's Tutorials in Physics, [37] homework, traditional homework, and attendance. Pollack found low correlations between the normalized gain on the FCME and course components. The squared correlation coefficient indicated the tutorial homework shared 4.8 percent variation with the gain. Every other course element shared a smaller amount of common variation with the gain. Non-course component factors such as a math pre-test (6.25 percent) and student physics attitude (4 percent) proved to explain more variation than most course components. The analysis was questionable because the author did not state significance

Bonham's [38] study compared exam performance in calculus-based physics courses. One course completed homework online, the other course used traditional homework. The online questions, which used WebAssign, were typically open ended calculations, but there were some multiple choice questions and short essays. The traditional homework questions were end of the chapter questions. The results indicated that students using WebAssign performed better ($p<0.05$) on the homework average and the quantitative exam problems than the traditional homework students.

Bonham ran a hierarchical regression in a calculus-based physics course where ability variables were entered in the first step, and the homework was entered in the second step. The variables entered in the first step included university GPA, SAT math score, FMCE pre-test, and homework method. Entering homework method (traditional, online) into the regression is questionable because homework method is a categorical variable. This predictor set accounted for 46 percent of the variation of the exam scores. The next predictor set included homework average, gender, and ethnicity. Gender and ethnicity are categorical predictors, so entering these variables in the regression is questionable. The new predictor accounted for 53 percent of the variation in exam scores.

Once all of the variables were entered in the regression the standardized regression coefficients indicated that ability variables were better predictors of exam performance than homework. The best predictor of both qualitative and quantitative exam performance was the SAT math score, followed by GPA, FMCE pre-test, and homework. These four predictors all reached statistical significance ($p<0.001$).

Bonham had similar results in an algebra-based physics course. Higher scores on physics exams in courses where the homework is completed online is consistent with Bonham's calculus-based physics course, Morote's [39], and the Dufresne's [40] results. Dufresne argued that students scored higher on exams when the homework is online because more time is spent on the homework, the students know immediately if their answer is correct and the student can attempt problems repeatedly. In Bonham's study 46.2 percent of the students in the web-based courses spent over four hours a week working on homework, while only 4.2 percent of the traditional homework students did.

The hierarchical regression results in Bonham's study were similar to the calculus-based physics results. GPA, SAT math score, and the categorical predictor homework method were entered in the first step. These variables accounted for 48 percent of the variation. Homework and the categorical predictor's gender and ethnicity were entered in the second step. The variation now accounted for by the predictors was 51 percent, indicating the new set of predictors added 3 percent to the explained variation. Bonham did not mention if this increase was significant.

After all the predictors were entered in the regression the unstandardized regression coefficients indicated that the best predictor of exam performance was the ability variables. The SAT math score was the best predictor, followed by university GPA, and homework. This indicates that student ability is a better predictor of exam performance than the performance of the students. Another conclusion is the results were similar even though the analysis was done on different courses. This says that similar predictors work for different courses, so the analysis might be extended to other courses.

CHAPTER 3

Method

3.1 Why Physics 1214

The purpose of this study is to evaluate Physics course components and other variables that can be used to predict Physics 1214 exam performance. This might allow the professor to identify students who may struggle in the course by finding significant predictors of exam performance. It should be noted that if a variable is a predictor it does not indicate that variable caused the exam performance. It only indicates that a relationship exists. It also should be noted that if a variable is not significant then that does not mean that the variable is not important. A professor might have another goal for that variable besides predicting exams. Clickers, for example, might be used as a way of taking attendance and the professor might not care if a relationship exists between clicker scores and exam performance.

The study was carried out in Physics 1214, but conclusions might be extended to other lower-level Physics courses because it takes similar skills to succeed in these courses. After performing this study it will be interesting to see if the results are different from first semester physics courses. Students in a second semester physics course have already successfully passed a physics course, so they might have a better idea of what to do to succeed than a first semester Physics student. This might lead to different variables being predictors of exam performance. It is also interesting to see if the results are the same, because students tend to have less incoming knowledge concerning second semester topics as compared to first semester topics. [41] [42]

I chose Physics 1214 for several reasons. It is a second semester algebra-based physics course and no studies similar to this study exist for a second semester physics course. Second, Physics 1214 incorporated components including homework, labs, pre-class quizzes, HBL activities, and the personal response system clickers (PRS) that provide excellent quantitative data. Finally the sample population of students was sufficient to allow many statistical analysis , but not so large that managing the data was troublesome.

3.2 Measured Variables

In this section the variables that were measured are briefly discussed. More detail on the variables is given in the method section of chapter five.

Dependent variables -Physics 1214 exam average

Independent variables-

Pre-test assessment Predictor Variables: (1) Homework average, (2) Lab average, (3) HBL average

Homework is typically given in Physics because faculty believe it is training for the exam. There seems to be a relationship between homework and exams in first semester Physics. Homework has shown an important predictor of exam performance in first semester Physics courses. [40] [33] [38] This seems to be true whether the homework is completed online or on paper. Any study that involves predicting exam performance should include homework.

All homework was completed online using the MasteringPhysics web system. This allowed the students immediate feedback. Students were allowed to attempt incorrect solutions again with a small penalty. The fall semester only had quantitative problems. The spring semester included both quantitative problems and multiple choice questions.

Labs are considered an integral part of a student's education process because the lab allows the student to see the principles studies in class. It would seem that there should be a relationship between the performance in lab and exam performance. There has not been a study to examine this relationship.

The lab average was the average calculated for the lab portion of the course. This average consisted of the average of ten labs and one lab exam.

Another predictor variable was the Hypothesis Based Learning (HBL) [43] [44] average. In these writing intensive activities the students were shown something interesting, and then were free to investigate their explanation for the interesting event on their own. The HBL average was determined from HBL activities in the spring semester. There has not been an investigation of integrating HBL in the classes. HBL would be an example of students applying their Physics content knowledge, so there should be a relationship between HBL performance and exam performance.

Aptitude Predictor Variables: (1) MPEX (2) University GPA (3) Math ability (ACT subscore), (4) Science ability (ACT subscore), (5) Physics 1 grade

The Maryland Physics Expectations Survey (MPEX) was administered as a pre-test and a post-test. The post-test may not be a good variable to use as a predictor variable because it is taken at the end of a course. It is hard to predict an event if the event has already occurred. This variable was chosen mostly because it might be interesting to see how the student attitude after a semester of instruction is related to their performance. The MPEX measures how much students think like expert physicists. This survey is discussed in more detail in this chapter, but there has been a relationship between gains in a student attitude and gains in first semester Physics performance. [35]

The student's university GPA was taken at the beginning of the semester that they were enrolled in Physics 1214. GPA is measure of student motivation.

Students who work hard enough to have a good GPA will probably continue working hard in Physics. GPA has shown to be an excellent predictor for a first semester Physics exam. [38]

Science and math ability have been theorized to be important in Physics performance. Bonham found that the SAT math score was the best predictor variable. [38] Others have found math ability to be important predictors [4] [5], and Griffith found it non-significant [33]. There has not been a lot of research on the research of science ability and exam performance.

The math and science ACT subscore from when the student enrolled in the university were used as predictor variables. The next predictor variable was the first semester physics course final cumulative grade.

Effort Predictor Variables (1) Lab attendance (2) Exam Help Session Attendance, (3) Time Spent in the Physics Helproom, (4) Clicker average/class attendance, (5) Pre-class quiz average

Most of these variables have not been investigated in Physics before this study. The only variable that the was found in the literature was lecture attendance, which was not related to gain in a first semester Physics course. [35] No other variable has been investigated yet, but they are all a measure of the effort and motivation that a student puts in a class. Randy Moore argued that student motivation is one of the most important factors in success. He argued that motivation can be measured by attendance in labs, help sessions, course participation, and voluntary summer sessions. [45] [46] [47] He showed high correlations between attendance and and performance in introductory biology courses. Physics probably does not work differently. If a student is willing to put effort in a class, then one would expect that student to score highly on a Physics exam.

The clicker average was the average score of the clicker questions. The clicker questions were multiple choice questions that were asked during class. The students received full credit for attempting the questions. This meant the clickers were used to take class attendance.

The lab attendance measured how many time students missed lab. Students were allowed one drop. There are only ten labs, so every lab after this would significantly lower the students lab grade. The students who are willing to come to lab every time to ensure their grade does not drop should perform well on exams.

Exam help sessions were offered at night within a week of the exam. Students were not required to attend the help sessions. The number of times that students attended the help session was a predictor variable. There has not been a study in Physics to test help sessions, but Moore found that there was a large correlation between the number of biology help sessions attended and final grade. He also found that students who attended at least one help session usually earned a higher course grade. [48] While attending only one help session would not help on all course material, he speculated that students who attend help sessions were motivated and also would complete the other course related activities.

The Physics Department has a helproom where students can get help on physics from graduate students. The total time that the students spent in the helproom was an additional predictor variable. There has not been any research on the role of a helproom, but it should work in a similar manner to what Moore found for the help sessions. Motivated students who are doing what the course assignments probably will take advantage of the helproom.

The pre-class quizzes were only measured in the fall semester. These questions were essay questions. Students received full credit for attempting these problems. This meant their score was either 1 for an attempt or a 0 if they did not attempt the question. An average score was determined from these scores. This score is a measure of student effort. It is very easy to earn a high grade on the course component with little effort. The students who are willing to make sure they do not miss these assignment should also be willing to do the work in the course.

Learning Style

Students understand information differently depending on their learning style. It has been demonstrated using both the Myers-Briggs and the Felder-Silverman model that course performance differences can occur depending on learning style. [49] [50] It should be investigated if differences occur in Physics.

The Index of learning styles measures student learning styles using the Felder-Silverman learning style model. This predictor variable will be discussed in more detail in a later section.

3.3 Data Collection

The participants in this study were students enrolled in the Physics 1214 course during the Fall 2007 and Spring 2008 semester. The population is non-physical science majors (zoology, biology, animal science, etc.). The enrollment for Physics 1214 averages two hundred students.

The study was explained to the students in ten minutes on the first day of class. Survey data was collected during the first lab. The MPEX post-test was given the last week of lab, a lab which normally does not take the entire allowed time.

The instructor provided course averages for each student. Once all data were obtained the student names were replaced with identifier tags. This process was approved by the IRB (AS0758).

Due to limited participation in the fall, the MPEX and ILS were given during the first day of lecture in the Spring. The MPEX was also given as a post-test in the last week of lecture. Administering the surveys in class ensured higher participation. It also addressed the concern that the Fall students who had participated in lab surveys may not done so seriously because they could leave lab early. No such perceived reward existed because class was conducted after all the students completed the surveys.

3.4 Maryland Physics Expectations Survey

The Maryland Physics Expectations Survey (MPEX) [51] is a thirty-four question survey that examines student attitudes about physics. The survey creators defined student attitude about physics by how much the student responds like an ”expert physicist”. The expert physicist response was determined from university instructors that attended a workshop at Dickenson College. For an answer to be considered an ”expert response” eighty percent of the instructors had to agree on the answer.

The answers to survey questions range from strongly disagree to strongly agree on a five point Likert scale. The survey is traditionally given as a pre-test and post-test to measure student attitude changes after one semester of instruction. The results are aligned with the expert's response. A favorable response would agree with an expert, and an unfavorable response would disagree. The higher the MPEX score the more one responds like an expert. Remarkably students tend to shift away from the expert's response after one semester of instruction.

The MPEX questions are grouped into six categories. Each category addresses a specific question. The categories along with favorable and unfavorable responses are:

(1) Independence Link - This link examines the process used to learn physics.

Research Question - Do students passively receive information from an instructor or do they use an active process to gain their own understanding?

Favorable Response - The students take responsibility for constructing their own understanding.

Unfavorable Response - The students take what is given by the teacher or textbook without evaluation.

Independence Questions-1, 8, 13, 14, 17, 27

(2)Coherence Link - The coherence link examines the structure of physics.

Research Question -Is physics a collection of isolated facts or is it a single coherent system?

Favorable Response - Physics is a connected, consistent framework.

Unfavorable Response - Physics is nothing more than a set of unrelated facts.

Coherence Questions-12, 15, 16, 21, 29

(3) Concept Link - The concept link determines student beliefs about the content of physics knowledge.

Research Question -Is physics a bunch of formulas or is physics the concepts behind the formulas?

Favorable Response - The student focuses on understanding ideas and concepts.

Unfavorable Response - The student focuses on memorizing and using formulas.

Concepts Questions-4, 19, 26, 27, 32

(4) Reality Link - The reality link examines the connection between the material learned in the classroom and physical reality.

Research Question -Is physics related or unrelated to activities in everyday life?

Favorable Response - The ideas in physics are relevant and useful.

Unfavorable Response - Ideas learned in the classroom have little relevance in the real world.

Reality Questions-10, 18, 22, 25

(5) Math Link - The math link determines student beliefs about the relationship between math and physics.

Research Question - Are the formulas mathematical calculations that represent nothing physical or do the calculations represent physical reality?

Favorable Response - Mathematics is a convenient way to represent physical phenomena.

Unfavorable Response - There is no relation between physics and math.

Math Questions-2, 6, 8, 16, 20

(6) Effort Link - The effort link measure the activities that students should do to be successful in physics.

Research Question -Are the students expected to think carefully and evaluate what they are doing?

Favorable Response - Students make an effort to use available information.

Unfavorable Response - Students do not use available information.

Effort Questions-3, 6, 7, 24, 31

3.5 Learning Styles

Students do not learn in an identical manner. A teaching method that is effective for one student may be ineffective for another. The reason for this is each student has a different learning style.

Larkin [52] defines learning style as a biologically and developmentally imposed set of personal characteristics that make a particular teaching method effective for some and ineffective for others. Dunn [40] [52] describes learning styles as the way that each learner begins to concentrate, process, and retain new and difficult information. Dunn states, "Learning style is a combination of affective, cognitive, environmental, and physiological responses and is a function of heredity and experience, including strengths and limitations that develop individually over a life span."

An instructor should care about their students' learning styles. Students with different learning styles will respond to instruction differently [53] [54] [55] [56] [57]. The method that information is presented may increase student performance. For example, one study [58] demonstrated that students in an atomic physics course gained a deeper conceptual understanding when a computer graphically demonstrated concepts such as atomic orbitals and molecular dynamics. This technique demonstrated these students understand the concepts better visually.

3.6 Choosing a Learning Style Model for Research

I considered several good review articles to help select a learning style model. [59] [60] [61]. Three criteria when choosing a model are.

(1) Use in literature - It is important to choose a learning style model that is used in the field. There are many research models, so it would not be a good idea to pick a model that may not be familiar to fellow researchers.

(2) Reliability of the survey - Because the reliability of several learning style models was questioned, I considered reliability to be important.

(3) Focus of the model - Each model has its own focus, so it was important to ensure that the focus of the learning style model matched the research goals.

There has been little research on learning styles research in Physics Education Research. I based my selection on engineering education research. The Kolb model [23] [52] [62], Myers-Briggs [52] [53] [54] [55] [56] [60] [62] [63], Dunn and Dunn [52] [22] [64] [65] [66] [67], and Felder Silverman models [30] [62] [64] [50] [68]met my first criteria.

The learning style model that I used in this study was the Felder-Silverman model. It has been shown to be reliable [69] [70] [71]in engineering education research, it was self scored, and it was free to use by academic institutions. An additional reason to choose the Felder-Silverman model is the dimensions match up well with the way that Physics is taught. Dimensions focus on doing activities which is something most Physics teachers try to do. Lab activities are an example of this, as well as clickers, discussion sections are other forms of active learning. Another dimension focuses on visual or verbal learning. Most Physics professors try to do demonstrations. Another dimension focuses on learners who like the "big picture". Physics professors worry about the students understanding the "big picture".

The Kolb model was not chosen because it only has two dimensions which leads to four different styles. The dimensions are basically the active/reflective dimension and the sensing/intuitive dimension. By choosing the Felder-Silverman over the Kolb model two dimensions and an additional twelve learning styles are gained. Myers-Briggs is a well known personality test. The problem with the Myers-Briggs is it is to long. A similar argument can be made against the Dunn and Dunn model. Both of the surveys have at over fifty questions.

3.7 The Felder-Silverman Model

The five dimensions of the Felder Silverman model [30] [62] [64] [50] [68]are:

(1)Sensing/Intuitive: This dimension describes how people perceive the world. Sensors are people who gather data directly through their senses. They like facts and data, and prefer solving problems using standard methods that do not involve complications. They work slowly but are not careless. Intuition involves indirect perception such as imagination and hunches and intuitors are those who like principles, theories, innovation, complications, and they dislike repetition. Intuitors like complications and grasp concepts quickly. They work quickly but can be careless. Everyone uses both dimensions, but people tended to favor one of the two dimensions.

(2) Visual/Verbal (Auditory): There are three possible ways that people receive information. Visual refers to sights, pictures, diagrams and symbols. Auditory refers to sounds and words. Visual learners tend to remember what they see, and auditory learners tend to remember what they hear. Most students that are in college are visual, yet most traditional teaching techniques are auditory.

(3) Active/Reflective: Active learners involve doing something (explaining, discussing, and testing) with the external world with the information that is presented. Active learners are more likely to be experimentalists. Active learners prefer to work in groups. They do not function well in lectures because they are forced to be passive. A reflective learner examines the information introspectively. Reflective learners tend to become theorists. Lectures are not good for either style. Reflective learners do not function well in lectures because there is not an opportunity to think about the information that is presented. The categories are independent, but there is a large overlap between active learners and sensors, and reflective learners and intuitive people.

(4) Sequential/Global: Sequential learners prefer things to be taught in a step-by-step method. They can work with material that they partially understand. Global learners want to know the big picture. If they partially understand something they will struggle. Global learners sometimes will perform better if the simple material is skipped and the focus is on more difficult material. Global learners tend to struggle more in school. They feel bad that they struggle with material that their fellow students perform well on.

(5) Inductive/Deductive: Induction is a reasoning process that goes from particulars to generalities. This is the natural human learning style. People do not come into the world with a set of principles. They observe the world and then draw inferences. Deduction is a reasoning process that goes from generalities to particulars. Deduction is the natural teaching style for the sciences. Instructors start with principles and then work down to applications. Most Physics instructors teach using deduction.

3.8 The Index of Learning Styles

Felder designed a 44 question survey called the Index of Learning Styles [72] (ILS) to measure learning styles. This survey tests the first four dimensions (active/reflective, sensing/intuitive, visual/verbal, sequential/global) of the Felder-Silverman Model. Felder chose not to measure the inductive/deductive dimension because collecting data on this dimension proved difficult. The ILS is shown to be reliable. [69] [70] [71] Students are grouped into learning style categories based on the four measured dimensions.

The method to score the ILS is given in Appendix B.4.

3.9 The Learning Styles of the Sample

The learning styles of the participants in the survey are shown in table 3.1 and table 3.2. A 1 X 2 Chi-square analysis was used to determine if there are significant differences in the number of student learning styles for each of the learning style dimensions.

	Sensing/Intuitive	Active/Reflective	Visual/Verbal	Global/Sequential
Male	20/9**	20/9**	22/7*	18/11
Female	17/19	17/19	31/5*	8/28*
Total	37/28	37/28	53/12*	26/39

* = p<0.001
** = p <0.05

Table 3.1: Learning styles for Fall 2007 participants.

It is interesting to note that every student who was an active student is also a sensing student, and every student who is a reflective student is also an intuitive student. There are significant differences for male students in the active/reflective dimension. Male students are typically active students. There are significant differences for male students in the sensing/intuitive dimension, where male students were sensing. Both male and female students are visual students. Female students tended to be sequential learners.

	Sensing/Intuitive	Active/Reflective	Visual/Verbal	Global/Sequential
Male	63/35**	63/35**	84/14*	31/67*
Female	57/27*	57/27*	70/14*	15/69*
Total	120/62*	120/62*	154/28*	46/136*

* = $p<0.001$
** = $p<0.01$

Table 3.2: Learning styles for Spring 2008 participants.

Just like in the fall results every student who was active was sensing, and every student who was reflective was also intuitive (Table 3.2). The results are consistent with the fall results. More results reached significance probably because the sample size was larger. Both male and female students were typically sensing, active, visual, and sequential.

CHAPTER 4

Research Questions and Results

4.1 Method Fall 2007 Semester

The participants for this study were sixty-six volunteers enrolled in a second semester algebra-based Physics course during the fall 2007 semester. Thirty-two of the students were male, and thirty-four students were female.

The criterion variable for all research questions was the average exam score for the three exams. To be consistent with the weighting from the course, the final was weighted 1.6 times greater than the first two exams. The exams consist of conventional homework style problems. Measures from four course components were also recorded: (1) homework average, (2) lab average, and (3) clicker score average, and (4) pre-class quiz average. All course component averages are derived at the end of the semester. The ability variables used in this study included: (1) GPA at the beginning of the fall 2007 semester, (2) ACT science score, and (3) ACT math score. Finally, two different surveys were administered. The MPEX and the ILS were given in the first week. The MPEX was also given the last week of the semester. Lab attendance and class attendance was also measured. Only students who completed the course are included in this study. A Backward Stepwise Regression was used to eliminate non-significant predictor variables. The fifth research question uses all significant exam predictors from the previous four research questions.

A complete review of the statistical methods used in the study is given in Appendix C.

4.2 Method Spring 2008 Semester

The spring participants were 201 volunteers enrolled in a second semester algebra-based Physics course during the spring 2008 semester. 108 of the students were male, and 93 students were female.

The data collection for the Spring 2008 semester is similar to the Fall 2007 semester. The average exam score is the performance measure with the final being weighted 1.5 times greater than the other exams. The same predictor variables were collected during the spring semester as the fall semester with a few exceptions. The pre-class quizzes were not collected, but instead Hypothesis Based Learning (HBL) data was measured. The HBL activities were open inquiry activities where the students would develop an explanation for observations. Other new data that was collected included: Physics 1 grade, help session attendance, and time spent in the Physics helproom.

The exams in the spring semester consisted of three sections. The first section consisted of homework-style problems where students calculated a numerical answer. The second section was multiple choice conceptual problems. The final section of the exam consisted of essay problems. The analysis for the spring semester included analysis on the total exam score, the homework-style section, the multiple choice problems, and the essay section

4.3 Research Question 1

Research Question 1: What Physics 1214 course component averages are significant predictors of Physics 1214 exam performance?

$$Y_{fall} = \beta_{HW}x_{HW} + \beta_{Lab}x_{Lab} + \beta_{Click}x_{Click} + \beta_{quiz}x_{quiz} \tag{4.1}$$

$$Y_{spring} = \beta_{HW}x_{HW} + \beta_{Lab}x_{Lab} + \beta_{Click}x_{Click} + \beta_{HBL}x_{HBL} \tag{4.2}$$

Backward Stepwise Regression was used to determine the course components that significantly predicted exam performance. The unique variation or squared semi-partials of each predictor variable with the average exam score was determined. The larger the squared semi-partial, the better the variable was at predicting exam performance. All four course components were initially entered in the regression, with the worst non-significant predictor removed until only significant predictors remained. The homework was completed online using MasteringPhysics. The lab average was determined using the labs at Oklahoma State University. These labs are standard "cookbook style" labs where students follow a set of instructions to complete the lab. The clicker score was determined from multiple choice in-class clicker questions. Students received full credit on the clicker questions if they attempted the problem, so it measured attendance. The pre-class quizzes were short answer conceptual questions that were completed online prior to class. Full credit was given if the students had a reasonable attempt at these problems.

Pre-class quizzes were not collected during the Spring 2008 semester. Hypothesis Bases Learning (HBL) activities were collected. These activities focused more on science process rather than correct answers. Students would see a observation and then try to devise a test using the scientific method to test the observation.

4.3.1 Fall 2007 Research Question 1 Results

Backward stepwise regression analysis determined the significant course component predictors of exam performance. In the first step all course components were entered into the regression. After three steps of elimination, the only variable entered into the regression in the last step was the lab score. The lab score was the only significant predictor of exam performance. It accounted for a significant 23.8 percent of the variation in exam scores [$F(1,64) = 20.019$; $p < 0.001$]. The results are summarized in table 4.1.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
Homework	0.222	0.294	0.187	0.1.719	0.091
Clicker	-0.021	-0.034	-0.025	-0.228	0.821
Pre-Class Quiz	-0.090	-0.147	-0.086	-0.785	0.435
Lab	1.221	0.450	0.415	3.807	<0.001

Step 2 – Remove Clicker

	B	β	Partial Correlation	t	p-value
Homework	0.219	0.290	0.186	1.719	0.091
Pre-Class Quiz	-0.101	-0.164	-0.105	-0.975	0.334
Lab	1.208	0.446	0.417	3.859	<0.001

Step 3 – Remove Pre-Class Quiz

	B	β	Partial Correlation	t	p-value
Homework	0.128	0.169	0.160	1.478	0.144
Lab	1.171	0.432	0.408	3.771	<0.001

Step 4 – Remove Homework

	B	β	Partial Correlation	t	p-value
Lab	1.323	0.488	0.488	4.474	<0.001

Table 4.1: Fall 2007 Results-Course Component Backward Stepwise Regression Results.

Table 4.2 displays bivariate correlations, and means and standard deviations, for the variables in research question one. As noted there, some predictor variables were significantly correlated, and correlated with the criterion variable, with predictors sharing variance ranging from 10.6 percent to 58.2 percent, and predictors sharing variance with the criterion variable ranging from 3.7 percent to 23.8 percent.

	Exam	Homework	Clicker	Pre-Class Quiz	Lab
Exam	0.697 (0.133)	0.312	0.193	0.203	0.488*
Homework		0.873(0.176)	0.557*	0.763*	0.331*
Clicker			0.808(0.215)	0.655*	0.353*
Pre-Class Quiz				0.745(0.235)	0.326*
Lab					0.912(0.049)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.2: Fall 2007 Results-Correlations for Course Components.

4.3.2 Spring 2008 Research Question 1 Results

Backward stepwise regression analysis was used to find significant course component predictors of exam performance. All of the course components were entered into the regression in the first step. The average clicker score was the worst exam performance predictor. The average clicker score was eliminated from the regression after the first step. The second step indicated homework, HBL, and labs were significant predictors of exam performance. They accounted for 24.3 percent of the variation in exam scores, a significant amount [$F(3,197) = 21.111$; $p < 0.001$]. The results are summarized in table 4.3.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
Homework	0.172	0.212	0.197	3.182	0.002
Clicker	0.023	0.048	0.045	0.719	0.473
HBL	0.163	0.159	0.158	2.547	0.012
Lab	0.392	0.347	0.331	5.339	<0.001

Step 2 – Remove Clicker

	B	β	Partial Correlation	t	p-value
Homework	0.182	0.224	0.217	3.506	0.001
HBL	0.167	0.162	0.162	2.613	0.010
Lab	0.401	0.354	0.342	5.525	<0.001

Table 4.3: Spring 2008-Course Component Backward Stepwise Regression Results.

Bivariate correlations, means and standard deviations, for the variables in research question one are shown in table 4.4. As noted there, some predictor variables were significantly correlated, and correlated with the criterion variable, with predictors sharing variance ranging from 0 percent to 9.3 percent, and predictors sharing variance with the criterion variable ranging from 2.8 percent to 17.2 percent.

	Exam	Homework	Clicker	HBL	Lab
Exam	0.624 (0.110)	0.310*	0.201*	0.167*	0.414*
Homework		0.866(0.135)	0.305*	-0.020	0.250*
Clicker			0.783(0.223)	0.072	0.222*
HBL				0.816(0.107)	0.027
Lab					0.909(0.097)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.4: Spring 2008-Correlations for Course Components.

The spring professor designed the exams so that it consisted of homework style problems, multiple choice questions, and essays. The analysis was repeated where the course components were used to predict performance on each portion of the exam. Each section of the exam was successfully predicted using some of the course components ([F_{HW}(3,197) = 12.607; p < 0.001], [F_{MC}(3,196) = 19.880; p < 0.001], [F_{Essay}(2,198) = 24.902; p < 0.001]). The course components explained 16.1 percent of the homework-style variation, 23.3 percent of the variation in multiple choice problems, and 20.1 percent of the variation in essay scores.

The homework and labs were significant predictors on all portions of the exam. The HBL average was a significant predictor on the homework style problems and the multiple choice questions. The clickers were not predictors on any three portions of the exam.

The order of significant predictors was the same for the multiple choice and essay sections of the exam. The clickers were not a predictor, followed by the HBL, homework average, and the lab average. The HBL was a better predictor than the homework for the homework-style problems. The results are summarized in tables 4.5-4.8.

Step 1 – All Variables Entered (Homework-Style Problems)

	B	β	Partial Correlation	t	p-value
Homework	0.261	0.173	0.161	2.464	0.015
Clicker	-0.039	-0.043	-0.040	-0.613	0.541
HBL	0.381	0.199	0.198	3.034	0.003
Lab	0.583	0.277	0.265	4.054	<0.001

Step 2 – Remove Clicker

	B	β	Partial Correlation	t	p-value
Homework	0.244	0.161	0.156	2.390	0.018
HBL	0.375	0.196	0.196	3.001	0.003
Lab	0.570	0.271	0.262	4.014	<0.001

Table 4.5: Spring 2008-Course Component Backward Stepwise Regression Results-Homework-Style Problems.

Step 1 – All Variables Entered (Multiple Choice)

	B	β	Partial Correlation	t	p-value
Homework	0.247	0.231	0.215	3.439	0.001
Clicker	0.044	0.068	0.064	1.020	0.309
HBL	0.231	0.169	0.169	2.697	0.008
Lab	0.457	0.306	0.292	4.668	<0.001

Step 2 – Remove Clicker

	B	β	Partial Correlation	t	p-value
Homework	0.267	0.249	0.241	3.849	<0.001
HBL	0.238	0.174	0.174	2.780	0.006
Lab	0.472	0.316	0.306	4.890	<0.001

Table 4.6: Spring 2008-Course Component Backward Stepwise Regression Results-Multiple Choice Questions.

Step 1 – All Variables Entered (Essay)

	B	β	Partial Correlation	t	p-value
Homework	0.144	0.275	0.257	4.025	<0.001
Clicker	-0.008	-0.025	-0.024	-0.373	0.710
HBL	0.034	0.052	0.051	0.808	0.420
Lab	0.220	0.302	0.289	4.527	<0.001

Step 2 – Remove Clicker

	B	β	Partial Correlation	t	p-value
Homework	0.140	0.268	0.260	4.083	<0.001
HBL	0.033	0.050	0.050	0.783	0.435
Lab	0.217	0.298	0.288	4.534	<0.001

Step 3 – Remove HBL

	B	β	Partial Correlation	t	p-value
Homework	0.139	0.267	0.258	4.067	<0.001
Lab	0.218	0.300	0.290	4.567	<0.001

Table 4.7: Spring 2008-Course Component Backward Stepwise Regression Results-Essay Questions.

	Exam	Homework	Clicker	HBL	Lab
Homework-style	0.554 (0.204)	0.225*	0.086	0.200*	0.316*
Multiple Choice	0.506 (0.145)	0.324*	0.218*	0.179*	0.384*
Essay	0.866 (0.071)	0.342*	0.129**	0.052	0.366*
Homework		0.866(0.135)	0.305*	-0.020	0.250*
Clicker			0.783(0.223)	0.072	0.222*
HBL				0.816(0.107)	0.027
Lab					0.901(0.097)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.8: Spring 2008-Correlations for Course Components.

4.3.3 Research Question 1 Analysis

Regression results indicated that the course components could be used to predict Physics 1214 exam performance. The lab average was the best course component predictor in both of the semesters. The lab uniquely explained 23.8 percent of the exam variation in the fall semester, and 12.1 percent of the exam variation in the spring.

Analysis on the performance in labs has not been done before in any study, so there is no literature with which to compare this surprising result. The question is why did this result occur. It was the best significant predictor for both semesters, so the results are consistent. One problem with regression is that it only gives the relationship between variables, it does not explain why the relationship occurred. Reasons can be speculated and then tested using different analysis.

One possible reason that the lab was the best predictor is it is a measure of student motivation. It is not hard to earn a decent grade in lab, but you do have to give good consistent effort to earn a high grade. The students who are willing to give the effort rather than settle for a low A or high B are probably the same students who will do whatever it takes to earn a high grade on the exam.

Another possible reason the lab was a good predictor is because the environment is more controlled than the homework environment. Students usually do not bring their textbook and there is no internet access in the labs. The equipment is several feet from the nearest group, so interactions between groups is minimal. This limits the student resources to their lab partner or the teaching assistant. The student also faces a time limit because they need to finish the lab before they leave. This environment is more similar to the exam than the homework. The students may collaborate with whoever they wish when they complete the homework. This means the homework grade may be less of an indication of the individual student knowledge than the lab average.

The homework was a significant predictor during the spring semester explaining 4.7 percent of the variation in exam scores. The homework average was not a significant predictor during the fall semester, but it was the last variable that was eliminated. The spring result is similar to other studies [40] [33] [38]. Most of the studies in the literature review found the homework to be a predictor of exam performance. This makes sense because the goal of homework is for students to learn problem solving techniques that are then applied in an exam. It is surprising that the homework was also not a predictor in the fall. There are no obvious differences between the homework that was assigned in the fall and spring. Both semesters got their homework from the problems in the textbook. The students then completed their homework online using the MasteringPhysics system.

The HBL average was a significant predictor in the spring semester, but it was the worst significant predictor explaining 2.6 percent of the exam variation. It would make sense that HBL was a good predictor because it forced the students to think critically about Physics. There was a large writing component to this assignment which forced the student to think about how their solutions were presented. The students also did not have a large collaborative opportunity because the only people they could get help from is their immediate neighbor. They could not seek help from the internet because this was the first time that these HBL activities have been attempted, so there was no website to find answers.

The clickers were nonsignificant predictors both semesters. The clickers essentially measured student attendance. If the student attempted the problem then they received credit. The student had to be in class to attempt the problem. This result is consistent with a study found in the literature for first semester Physics. [35] This seems to go against what seems logical about attendance. It seems that the more people attend the better their score should be, but that does not seem to be the case. Perhaps it is not the number that is important but the fact that students are willing to miss class. Attendance is an effort measurement. Students who are not willing to miss class probably are also willing to do what it takes to get a good grade. ANOVA analysis for the spring semester found that the average of the students who had perfect attendance (0.6582) scored better (p=0.007) on the exam than students who were willing to miss class at least one time (0.6112). ANOVA analysis also revealed significant (p=0.031) GPA differences between students with perfect attendance (3.37) and students who are willing to miss class at least once (3.13). A more interesting result showed that student who had perfect attendance had significantly higher exam scores (0.6582 versus 0.5775, p=0.002) and GPA (3.37 versus 2.91, p=0.001)than students who were willing to miss class once. There was not enough data to do similar analysis in the fall semester.

These results indicate that there is not a predictive relationship between attendance and exam performance, but attendance is still important. Attendance is an effort measurement. The students have to be willing to go to class. The importance of attendance is also found in biology where Moore argued that attendance reflects motivation, and motivation is one of the most important factors in student performance. [47] Future research should examine this issue more.

The pre-class quizzes were also a non-significant predictor of exam performances. These quizzes might be good predictors if they were graded for accuracy. It is possible that the results might mirror the lab results. Even if students can earn a grade easily, the students who are willing to put in the effort to make sure they get a high score might perform better on exams. Future research might focus on analyzing if these variables are successful predictors if they are graded for correctness.

The homework average and lab average were significant predictors of the multiple choice questions, homework style problems, and essays even though these type of exam questions are different styles. The HBL average successfully predicted multiple choice questions and homework style problems. This indicated that the same predictors successfully predicted different styles of exam questions. This possibly occurred because the three sections of the exam were highly correlated. This indicates that students who performed well on one section of the exam performed well on the other sections of the exam. The correlations are shown in table 4.9.

	Homework-style	Multiple Choice	Essay
Homework-style	0.553 (0.204)	0.761*	0.539*
Multiple Choice		0.506(0.145)	0.606*
Essay			0.866(0.071)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.9: Spring 2008-Correlations among test sections.

After analyzing the data several interesting things became apparent. The spring semester had more significant predictors than the fall semester. This may have been due to the small sample size in the fall semester. Another interesting thing that was the order of importance of the predictors was the same even though the exam format was different. The exams were just homework style problems in the fall, but the spring exams included essays, multiple-choice questions, and problems. The lab was the best predictor, followed by the homework. The clickers were always the worst predictor of exam performance.

It is possible to predict exam performance using the course components. If a professor wants to identify students who might potentially have trouble on exams then they should look at students who are performing poorly on the labs or homework. The significant exam performance predictors are summarized in the figure 4.1.

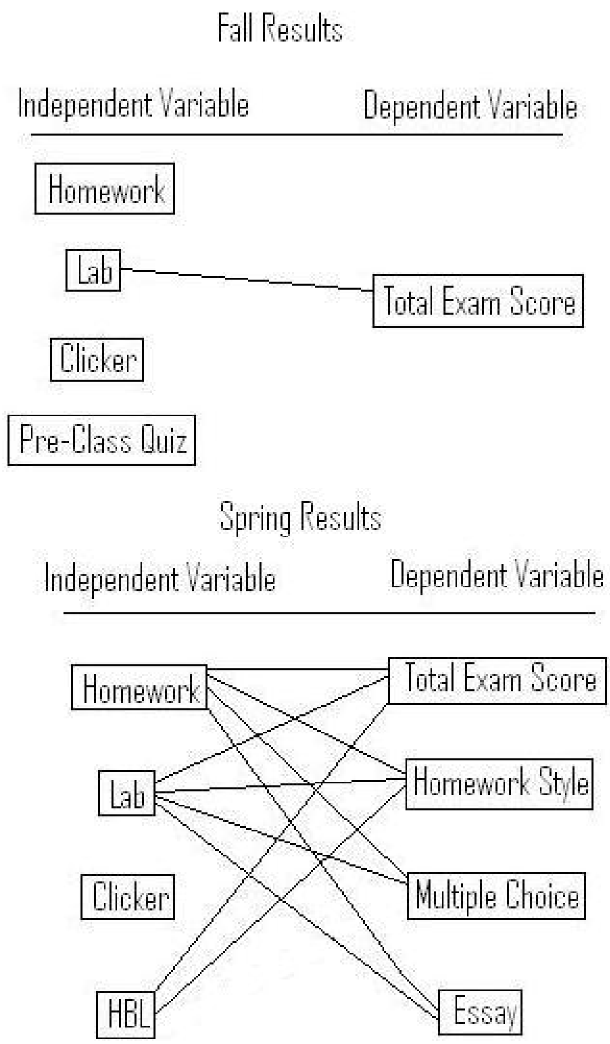

Figure 4.1: Significant Predictors of Exam performance

4.4 Research Question 2

Research Question 2: What ability variables are significant predictors of Physics 1214 exam performance?

$$Y = \beta_{GPA}x_{GPA} + \beta_{Math}x_{Math} + \beta_{Science}x_{Science} \tag{4.3}$$

Backward Stepwise Regression was used to eliminate the non-significant ability variables until only significant predictor variables remained. The ability variables used include: ACT math score, ACT science score, and GPA. The GPA was taken at the beginning of the semester that the students participated in the study.

4.4.1 Fall 2007 Research Question 2 Results

The significant ability variable exam performance predictors were found using Backward Stepwise Regression. The ability variables that were entered in the first step included: GPA at the beginning of the semester, ACT math score, and ACT science score. The squared semi-partial of the ACT math score was not significant, so that variable was not included in further analysis. The GPA and ACT science score were significant predictors of exam performance and accounted for a significant 56.5 percent of the variation in exam scores [$F(2,52) = 33.716$; $p < 0.001$]. The results are summarized in table 4.10.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
GPA	0.113	0.523	0.476	5.241	<0.001
ACT Math	0.005	0.185	0.125	1.374	0.115
ACT Science	0.009	0.285	0.206	2.272	0.204

Step 2 – Remove ACT Math

	B	β	Partial Correlation	t	p-value
GPA	0.125	0.574	0.577	6.239	<0.001
ACT Science	0.013	0.401	0.403	4.352	<0.001

Table 4.10: Fall 2007-Ability variables Backward Stepwise Regression Results.

Table 4.11 displays bivariate correlations, means, and standard deviations for the ability variables. Predictors shared variation with other predictors ranged from 2.2 percent to 46.2 percent, and predictors shared variation with the criterion variables ranged from 23.9 percent to 40.6 percent.

	Exam	ACT Math	ACT Science	GPA
Exam	0.703 (0.130)	0.581*	0.489*	0.637*
ACT Math		25.91(4.51)	0.680*	0.397**
ACT Science			25.31(3.99)	0.149
GPA				0.745(0.235)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.11: Fall 2007-Ability variables correlations.

4.4.2 Spring 2008 Research Question 2 Results

Backward Stepwise Regression was used to determine the significant ability variable predictors of Spring 2008 exam performance. The ability variables were the same as the fall semester. The ACT math score was not a significant predictor of exam performance. It was eliminated in further analysis. The GPA and ACT science score were the only significant predictors of exam performance. They accounted for 56.5 percent of the variation in exam scores, a significant amount [F(2,160) = 78.313; p <0.001]. The results are summarized in table 4.12.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
GPA	0.116	0.586	0.512	9.131	<0.001
ACT Math	0.004	0.098	0.075	1.344	0.181
ACT Science	0.003	0.128	0.099	1.765	0.079

Step 2 – Remove ACT Math

	B	β	Partial Correlation	t	p-value
GPA	0.120	0.606	0.545	9.697	<0.001
ACT Science	0.005	0.179	0.161	2.860	0.005

Table 4.12: Spring 2008-Ability variables Backward Stepwise Regression Results.

Table 4.13 displays bivariate correlations, means and standard deviations, for the ability variables used in research question two. Predictor-to-predictor shared variation ranged from 18.9 percent to 37.0 percent, and criterion-to-predictor shared variation ranged from 19.8 percent to 46.9 percent.

	Exam	GPA	ACT Math	ACT Science
Exam	0.628 (0.108)	0.685*	0.430*	0.445*
GPA		3.188(0.545)	0.435*	0.438*
ACT Math			25.025(3.569)	0.608*
ACT Science				24.387(3.827)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.13: Ability variables correlations.

The analysis was repeated for the three sections of the exam. The ability variables significantly predicted each of the sections of the exam ([F_{HW}(1,196) = 93.597; p < 0.001], [F_{MC}(2,159) = 57.077; p < 0.001], [F_{Essay}(1,196) = 74.905; p < 0.001]). The variables explained 32.3 percent of the variation in homework-style problems, 41.8 percent of the variation in multiple choice problems, and 27.6 percent of the variation in essay questions.

The GPA was a significant predictor for all three sections of the exam and was always the best predictor. The ACT science score was a significant predictor only for the multiple choice section of the exam. The ACT math score was not a significant predictor for any exam sections. The results are summarized in the tables below in tables 4.14-4.17.

Step 1 – All Variables Entered (Homework-Style Problems)

	B	β	Partial Correlation	t	p-value
GPA	0.217	0.571	0.499	7.860	<0.001
ACT Math	0.001	0.017	0.013	0.209	0.835
ACT Science	0.002	0.042	0.032	0.508	0.612

Step 2 – Remove ACT Math

	B	β	Partial Correlation	t	p-value
GPA	0.219	0.575	0.517	8.163	<0.001
ACT Science	0.003	0.051	0.046	0.721	0.472

Step 3 – Remove ACT Science

	B	β	Partial Correlation	t	p-value
GPA	0.212	0.569	0.569	9.675	<0.001

Table 4.14: Ability variables backward stepwise regression results-Homework-Style Problems.

Step 1 – All Variables Entered (Multiple Choice)

	B	β	Partial Correlation	t	p-value
GPA	0.135	0.512	0.448	7.413	<0.001
ACT Math	0.004	0.094	0.073	1.203	0.231
ACT Science	0.006	0.154	0.118	1.960	0.052

Step 2 – Remove ACT Math

	B	β	Partial Correlation	t	p-value
GPA	0.140	0.532	0.479	7.910	<0.001
ACT Science	0.008	0.203	0.183	3.016	0.003

Table 4.15: Ability variables backward stepwise regression results-Multiple Choice.

Step 1 – All Variables Entered (Essay)

	B	β	Partial Correlation	t	p-value
GPA	0.068	0.588	0.513	8.137	<0.001
ACT Math	-0.001	-0.032	-0.025	-0.389	0.698
ACT Science	0.001	0.068	0.052	0.825	0.410

Step 2 – Remove ACT Math

	B	β	Partial Correlation	t	p-value
GPA	0.067	0.581	0.522	8.301	<0.001
ACT Science	0.001	0.051	0.046	0.731	0.466

Step 3 – Remove ACT Science

	B	β	Partial Correlation	t	p-value
GPA	0.061	0.526	0.526	8.655	<0.001

Table 4.16: Ability variables backward stepwise regression results-Essay Questions.

	Exam	GPA	ACT math	ACT science
Homework-style	0.557 (0.207)	0.597*	0.291*	0.303*
Multiple Choice	0.512 (0.144)	0.620*	0.410*	0.435*
Essay	0.871(0.063)	0.604*	0.265*	0.306*
GPA		0.866(0.135)	0.436*	0.438*
ACT science			25.025(3.569)	0.608*
ACT math				24.387(3.827)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.17: Correlations for Ability Variables.

4.4.3 Research Question 2 Analysis

The ability variables were better predictors of exam performance than the course components. The ability variables explained over 50 percent of the variation in exam scores. The course components only explained around 20 percent of the variation in exam scores.

The university GPA at the beginning of the semester that the student enrolled in Physics 1214 was the best course component predictor in both of the semesters that were tested. The GPA uniquely explained 32.6 percent of the exam variation in the fall semester, and 29.7 percent of the exam variation in the spring. The results are not too different from literature. In first semester Physics courses GPA was shown in Bonham's study to be the second best predictor. [38] The courses in this study and Bonham's study were run in a similar manner where homework was completed online. The online homework used in the literature was Webassign as opposed to Mastering Physics in the courses studied here. The major difference between this study and Bonham's study is how the math ability was measured. They used the SAT and it was by far the best predictor. This study used the ACT to measure math ability. So perhaps the reason that this study is different from the study in literature is that the SAT math score might be a much better predictor of Physics exam performance than the ACT math score. Future research could investigate if there are differences in prediction ability between the ACT math and the SAT math exams.

It should not be surprising the GPA was a good predictor variable. GPA is a measure of how much a student is willing to work. If a student is willing to work hard they will have a high GPA. A student who works hard in their other courses is likely to continue working hard in Physics. It is also not surprising that GPA is a better predictor than the ACT score. The GPA reflects how hard a student is working currently at the university, and the ACT reflects the ability of the students when they were in high school.

The ACT science score was a significant predictor during both semesters. The ACT science in the fall semester explained 15.8 percent of the variation in exam scores, and it explained 2.6 percent of the exam score variation in the spring semester. This is consistent with literature results. There has not been a study in literature using the ACT or SAT, but investigators have shown that science reasoning tests designed by the authors could be used to predict exam performance. [33] [14]

The ACT math score was a non-significant predictor in the both semesters. This is interesting because professors worry that the math ability of students is related to course performance, and this would indicate that are better exam predictors than math ability. This does not mean that there is no relationship between math ability and exam performance. There are large significant correlations between the ACT math score and the average exam score. The reason that the ACT math score is not a significant predictor is the exam variation that the ACT math score explains is already explained by the GPA and the ACT science score. This is demonstrated by the small ACT math squared semi-partial which indicates the ACT math score by itself explains a small amount of exam variation.

This result might be the most surprising result of this study. Most Physics professors feel that strong math skills is required for success in Physics. The literature results are mixed. Some literature agrees with this. Bonham [38]found the SAT math score was the best predictor variable. Other research found grades in math courses were sometimes a successful predictor. [5] [4] Other research showed math pre-test scores were not successful predictors. [33] One possible explanation to the inconsistent results is math may not be as good of a predictor of exam success as once thought. Most mathematical concepts that is used in these courses is algebra and trigonometry. Students should have seen these concepts before they encounter them in Physics. If students have not seen these math concepts, it is still not a major problem because these concepts are usually reviewed in the Physics class. Math score may not be a good predictor since the mathematical concepts are not extremely difficult and are reviewed in class. Future research should investigate this surprising result in more detail. The physics exam takes place within the framework of a course, so it might be better to use performance in math courses as a predictor of success on physics exams.

It is interesting that the order of importance of the predictors was the same for both semesters even though the exam format was different. The GPA was the best predictor, followed by the ACT science score. The ACT math score was always the worst predictor of exam performance. It was also interesting that the same predictors were significant on all three portions of the exam. This is not too surprising since the three section were highly correlated.

It is possible to predict exam performance using the ability variables. If a professor wants to identify students who might potentially have trouble on exams then they should look at students who have a low GPA or who performed poorly on the ACT science exam. These variables explained more variation in exam scores than the course components. This is not surprising because these variables measure the ability of a student. The results of this research question are summarized in figure 4.2.

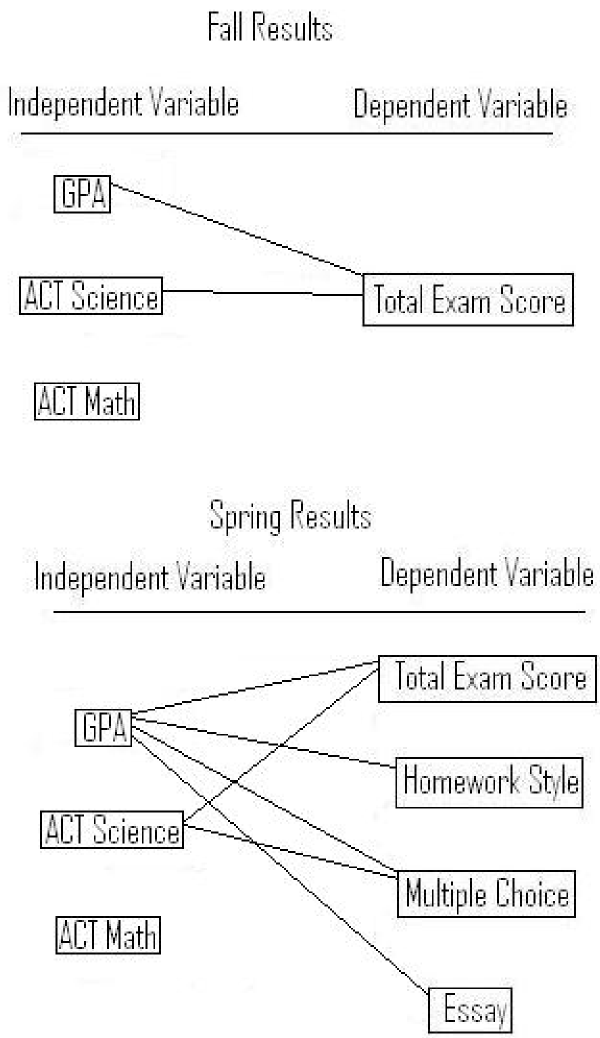

Figure 4.2: Fall 2007-Significant Predictors of Exam performance

4.5 Research Question 3

Research Question 3: What behavioral variables are significant predictors of Physics 1214 exam performance?

$$Y = \beta_{MPEXPOST}x_{MPEXPOST} + \beta_{MPEXPRE}x_{MPEXPRE} + \beta_{ACT/REF}x_{ACT/REF} + \beta_{SEN/IN}x_{SEB/IN} + \beta_{SEQ/GLO}x_{SEQ/GLO} + \beta_{VIS/VER}x_{VIS/VER} \quad (4.4)$$

The behavioral variables used to predict exam performance in this study were the MPEX and the ILS. The MPEX was taken in the first and last week of the semester, and the ILS was taken in the first week. A Backward Stepwise Regression was used to determine the successful Physics exam performance predictors.

4.5.1 Fall 2007 Research Question 3 Results

Backward Stepwise Regression was used to find the behavioral variables that can predict exam performance. The MPEX was given as both a pre- and post-test. The Index of Learning Styles was given at the beginning of the semester. Each of the four learning style scales was used to predict exam performance. After all non-significant predictor variables were eliminated, only the active/reflective dimension and the MPEX pre-test remained. They accounted for 26.9 percent of the variation in exam scores, a significant amount [$F(2,60) = 11.046$; $p < 0.001$]. The results are summarized in table 4.18.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.112	0.067	0.596	0.553
MPEX Pre	0.001	0.136	0.081	0.721	0.474
SEN/IN	-0.009	-0.153	-0.127	-1.127	0.265
ACT/REF	-0.025	-0.460	-0.421	-3.744	<0.001
VIS/VER	-0.002	-0.028	-0.025	-0.221	0.826
SEQ/GLO	0.012	0.198	0.167	1.482	0.144

Step 2 – Remove VIS/VER

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.109	0.066	0.589	0.558
MPEX Pre	0.001	0.139	0.083	0.741	0.462
SEN/IN	-0.009	-0.155	-0.129	-1.154	0.253
ACT/REF	-0.026	-0.471	-0.470	-4.218	<0.001
SEQ/GLO	0.012	0.195	0.165	1.479	0.145

Step 3 – Remove MPEX Post

	B	β	Partial Correlation	t	p-value
MPEX Pre	0.002	0.243	0.234	2.129	0.037
SEN/IN	-0.008	-0.143	-0.124	-1.124	0.265
ACT/REF	-0.025	-0.473	-0.471	-4.276	<0.001
SEQ/GLO	0.010	0.176	0.157	1.428	0.159

Step 4 – Remove SEN/IN

	B	β	Partial Correlation	t	p-value
MPEX Pre	0.002	0.275	0.274	2.486	0.016
ACT/REF	-0.024	-0.464	-0.463	-4.199	<0.001
SEQ/GLO	0.007	0.114	0.114	1.034	0.305

Step 5 – Remove SEQ/GLO

	B	β	Partial Correlation	t	p-value
MPEX Pre	0.002	0.269	0.269	2.435	0.018
ACT/REF	-0.024	-0.459	-0.459	-4.156	<0.001

Table 4.18: Fall 2007-Backward stepwise regression results

Table 4.19 displays bivariate correlations, means, and standard deviations for the behavioral variables used in research question three. Some correlations reached statistical significance, with the variation between predictors ranging from 0 percent to 58.4 percent, and the variation between the criterion and predictor variables ranging from 0.1 percent to 21.4 percent.

	Exam	MPE Post	MPE Pre	SEN/IN	ACT/REF	VIS/VER	SEQ/GLO
Exam	0.703 (0.134)	0.185	0.246**	-0.099	-0.463*	-0.206	0.082
MPE Post		97.887(14.997)	0.764*	- 0.039	0.010	0.005	-0.160
MPE Pre			102.258(14.818)	-0.209	-0.005	-0.041	-0.053
SEN/IN				7.065(2.356)	-0.004	0.141	0.451*
ACT/REF					6.065(2.475)	0.399*	0.038
VIS/VER						8.113(2.348)	0.161
SEQ/GLO							6.274(2.263)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.19: Fall 2007-Correlations between the variables

4.5.2 Spring 2008 Research Question 3 Results

Backward Stepwise Regression was used to see what behavioral variables can predict exam performance. All of the variables were entered in the regression in the first step. Unfortunately each step failed the linear assumption of regression, so any analysis on this data is questionable. The results are summarized in table 4.20.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.166	0.137	1.465	0.146
MPEX Pre	0.000	-0.020	-0.017	-0.178	0.859
SEN/IN	0.001	0.032	0.029	0.311	0.757
ACT/REF	-0.001	-0.025	-0.024	-0.259	0.796
VIS/VER	0.000	-0.001	-0.001	-0.006	0.995
SEQ/GLO	-0.001	-0.029	-0.027	-0.286	0.775

Step 2 – Remove VIS/VER

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.166	0.137	1.471	0.144
MPEX Pre	0.000	-0.020	-0.017	-0.180	0.858
SEN/IN	0.001	0.032	0.029	0.313	0.755
ACT/REF	-0.001	-0.025	-0.025	-0.267	0.790
SEQ/GLO	-0.001	-0.029	-0.027	-0.288	0.775

Step 3 – Remove MPEX Pre

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.124	0.122	1.625	0.106
SEN/IN	0.001	0.025	0.023	0.312	0.756
ACT/REF	-0.004	-0.086	-0.085	-1.132	0.259
SEQ/GLO	-0.001	-0.025	-0.024	-0.319	0.750

Step 4 – Remove SEN/IN

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.124	0.120	1.610	0.109
ACT/REF	-0.004	-0.086	-0.084	-1.129	0.261
SEQ/GLO	-0.001	-0.017	-0.017	-0.228	0.820

Step 5 – Remove SEQ/GLO

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.123	0.121	1.625	0.106
ACT/REF	-0.004	-0.085	-0.084	-1.126	0.262

Step 6 – Remove ACT/REF

	B	β	Partial Correlation	t	p-value
MPEX Post	0.001	0.148	0.148	1.999	0.047

Table 4.20: Backward stepwise regression results

Bivariate correlations are displayed for the behavioral variables used in research question three. Means and standard deviations are given on the diagonal. A few correlations reached statistical significance, with variation between predictors ranging from 0 percent to 27.4 percent, and criterion-predictor variation ranging from 0 percent to 2.4 percent.

	Exam	MPE Post	MPE Pre	SEN/IN	ACT/REF	VIS/VER	SEQ/GLO
Exam	0.656 (0.098)	0.156**	0.071	0.007	-0.053	-0.004	-0.007
MPE Post		98.034(11.578)	0.523*	- 0.095	-0.178**	0.005	-0.041
MPE Pre			96.378(11.661)	0.029	-0.061	-0.096	-0.045
SEN/IN				7.748(2.377)	-0.079	0.088	0.380*
ACT/REF					6.252(2.037)	0.193**	-0.096
VIS/VER						7.924(2.333)	-0.001
SEQ/GLO							6.588(2.068)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.21: Correlations between the variables

The process was repeated on each of the three sections of the exam. Unfortunately every step failed the linear assumption of regression, so analysis on this data is questionable.

	Exam	MPE Post	MPE Pre	SEN/REF	ACT/REF	VIS/VER	SEQ/GLO
Homework-style	0.595 (0.200)	0.219*	0.037	-0.035	-0.078	0.005	0.007
Multiple Choice	0.543 (0.137)	0.062	0.036	0.031	0.033	- 0.002	0.041
Essay	0.879 (0.061)	-0.066	0.056	0.062	-0.046	- 0.106	0.083
MPE Post		98.034(11.578)	0.523*	- 0.095	-0.178**	0.005	-0.041
MPE Pre			96.378(11.661)	0.029	-0.061	-0.096	-0.045
SEN/IN				7.748(2.377)	-0.079	0.088	0.380*
ACT/REF					6.252(2.037)	0.193**	-0.096
VIS/VER						7.924(2.333)	-0.001
SEQ/GLO							6.588(2.068)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.22: Correlations Results.

4.5.3 Research Question 3 Analysis

The behavioral variables explained the variation in exam scores just as well as the course components in the fall, but in the spring did a poor job of explaining the variation in exam scores. The behavioral variables explained 26.9 percent of the variation in exam scores in the fall, and just 2.2 percent in the spring. The reason the spring results may have done a horrible job predicting exam performance was because the spring results failed the linear assumption of regression (Appendix C.6), so any analysis of the spring results is questionable.

In the fall the active/reflective dimension was the best predictor of exam scores. The active/reflective dimension uniquely explained 21.1 percent of the exam variation in the fall semester. It had a negative correlation with the exam scores which suggested the more reflective a student was the higher they scored on the exam. This might have occurred because exams seem to favor reflective students because active students are forced to be passive during exams. This also may have showed that it is important to be an abstract thinker in Physics because a lot of ideas in Physics is abstract.

The active/reflective dimension was a significant predictor in the fall, so it might seem likely that the sensing/intuitve dimension would be a significant predictor. Every student who was a sensing student was also an active student, and every student who was a reflective student was also intuitive. The reason that the results were not the same was the two dimensions were not highly correlated. For example, this means a student with a high active score was not necessarily a high scoring sensing student.

There has not been Physics research on learning styles, so there is no way of knowing if this is consistent with the first semester studies. It is a not surprising that there was no relationship between exam performance and the visual/verbal dimension. Classes in physics are taught utilizing both dimensions, so there should not be much of a relationship. It is also not surprising there is no relationship with the sequential/global dimension. Physics courses are typically taught in a way that utilizes both dimensions. Professors are typically worried about the "big picture", but classes are also often taught in a structured manner where one idea logically leads to the next idea. Since one dimension is not a particularly favored, then there should not be a major surprise that there is no relationship.

The MPEX pre-test was a significant predictor in the fall semester. It explained 7.2 percent of the variation in exam scores. This indicated that students who thought like expert physicists at the beginning of the semester performed better on exams. The idea that Physics attitude is important is somewhat consistent with literature. Perkins [6] found that gain in some Physics courses was related to Physics attitude. This results should make sense. Students who think like a Physicist should perform better. These students are thinking in a similar manner to the professor who designed the test. This might mean they are more likely to give the answer that the professor expects. The MPEX results also indicate that these students seek understanding rather than memorization. This is another possible explanation for the predictive relationship.

The MPEX post-test was barely a significant predictor in the spring semester. The MPEX post-test explained 2.2 percent of the variation in exam scores. The other variables were not significant predictors of exam performance. Since the linearity assumption failed, this result is questionable.

The relative order of eliminated predictors were similar. The visual/verbal dimension was the worst predictor, followed by a MPEX score (post-test for fall, pretest for spring) the sensing/intuitive dimension, and the sequential/global dimension.

Most of the behavioral variables are poor predictors of exam performance. A possible reason for this is Physics is a class that is traditionally taught using all learning methods. There are active components in Physics labs, discussion sections, and clickers, but the lectures are often designed to favor reflective learning. A similar argument can be made for the sensing/intuitive dimension. The other two dimensions have already been discussed. A professor would probably be better examining the ability variables to predict exam performance. If a professor wanted to use the behavioral variables then they should use the active/reflective dimension.

4.5.4 More Analysis on Learning Styles

Since learning styles proved to be a poor predictor of Physics 1214 exam performance, it was decided to investigate the role of learning styles in more detail. A one-way ANOVA was used on each course component to determine if significant performance differences occurred due to learning style. Most ANOVA assumptions (independence, normality, and homogeneity of variance)were passed. The analysis was repeated in the few occasions when the homogeneity of variance assumption failed.

4.5.5 Results-Active/Reflective Dimension

The data was analyzed using a one-way ANOVA where each course component was tested for performance differences due to the active/reflective learning style. The only significant result in the fall semester was exam performance [$F(1,63) = 7.650$; $p = 0.007$]. This analysis indicated that reflective students had a higher average exam score than active students. There were no differences in performance due to learning style for any of the other course components.

In the spring semester the only significant result was homework [$F(1,180) = 9.516$; $p = 0.002$] where active students scored higher than reflective students. There were no performance differences due to the active/reflective dimension for any of the other course components. The results are summarized in table 4.23 and table 4.24.

The homework, clicker, and homework style exam problems failed the homogeneity of variance assumption for ANOVA, but the previous results were confirmed using the non-parametric statistic Mann Whitney. The advantage of using this statistic is the data does not have to pass the homogeneity of variance test. There was a significant difference on homework performance [Z = -3.190; p =0.001] where active students scored higher than reflective students. There was not a significant performance difference for clickers [Z = -0.745; p =0.456] or homework-style exam problems [Z = -1.372; p =0.170].

Course Component	Average Score	F-Value	P-Value
Active-Homework	0.8825	0.139	0.711
Reflective-Homework	0.8659		
Active-Clicker	0.8202	0.267	0.607
Reflective-Clicker	0.7926		
Active-Quiz	0.7470	0.223	0.638
Reflective-Quiz	0.7729		
Active-Lab	0.9118	0.488	0.487
Reflective-Lab	0.9204		
Active-Exam	0.6626	7.650	0.007
Reflective-Exam	0.7497		

Table 4.23: Fall 2007-ANOVA analysis for active/reflective dimension.

Course Component	Average Score	F-Value	P-Value
Active-Homework	0.8909	9.516	0.002*
Reflective-Homework	0.8316		
Active-Clicker	0.8056	2.172	0.142*
Reflective-Clicker	0.7554		
Active-HBL	0.8268	2.197	0.140
Reflective-HBL	0.8027		
Active-Lab	0.9079	0.008	0.930
Reflective-Lab	0.9093		
Active-Exam	0.6233	0.909	0.342
Reflective-Exam	0.6399		
Active-Homework Style	0.5445	1.986	0.161*
Reflective-Homework Style	0.5902		
Active-Multiple Choice	0.5141	0.075	0.785
Reflective-Multiple Choice	0.5078		
Active-Essay	0.8640	1.236	0.268
Reflective-Essay	0.8762		

*- Failed homogeneity of variance test

Table 4.24: Spring 2008-ANOVA analysis for active/reflective dimension.

4.5.6 Results-Sensing/Intuitive Dimension

Course component performance differences due to the sensing/intuitive learning style was tested using a one-way ANOVA. For both semesters every student who was an active student from the previous analysis was a sensing student, while every student who was a reflective student was an intuitive student. This meant the analysis from the previous section did not change. The significant result in the fall was exam performance [F(1,63) = 7.650; p =0.007]. This indicated that intuitive students had a higher average exam score than sensing students. There were no differences in performance due to learning style for any of the other course components.

The significant result in the spring semester was homework [F(1,180) = 9.516; p =0.002] where sensing students scored higher than intuitive students. The sensing/intuitve dimension did not cause significant performance differences for any other course component.

The homework, clicker, and homework style exam problems failed the homogeneity of variance assumption for ANOVA. The non-parametric statistic Mann Whitney confirmed the ANOVA results. There were significant differences on homework performance [Z = -3.190; p =0.001], but there was no performance differences on clickers [Z = -0.745; p =0.456] or homework-style exam problems [Z = -1.372; p =0.170].

4.5.7 Results-Visual/Verbal Dimension

The data was analyzed using a one-way ANOVA. Performance differences for each course components was tested for significant differences due to the visual/verbal learning style dimension. No results were significant for either semester. This indicated that there were no differences in performance due to the visual /verbal learning style dimensions for any of the course components. The results are summarized in Table 4.25 and table 4.26.

The homework failed the homogeneity of variance test in the fall semester, but the results were confirmed using Mann-Whitney [Z = -0.245; p =0.806]

Course Component	Average Score	F-Value	P-Value
Verbal-Homework	0.9131	0.668	0.417*
Visual-Homework	0.8668		
Verbal -Clicker	0.8301	0.154	0.696
Visual -Clicker	0.8033		
Verbal -Quiz	0.7839	0.204	0.653
Visual -Quiz	0.7524		
Verbal -Lab	0.9327	1.829	0.181
Visual -Lab	0.9116		
Verbal -Exam	0.7551	2.616	0.111
Visual -Exam	0.6877		

*- Failed homogeneity of variance test

Table 4.25: Fall 2007-ANOVA analysis for visual/verbal dimension.

Course Component	Average Score	F-Value	P-Value
Verbal -Homework	0. 8612	0.190	0.663
Visual -Homework	0. 8724		
Verbal -Clicker	0.7321	2.215	0.138
Visual -Clicker	0.7987		
Verbal -HBL	0.7993	1.137	0.288
Visual -HBL	0.8221		
Verbal -Lab	0.8877	1.411	0.236
Visual -Lab	0. 9121		
Verbal -Exam	0.6218	0.136	0.712
Visual -Exam	0.6303		
Verbal -Homework Style	0.5369	0.412	0.522
Visual -Homework Style	0.5643		
Verbal -Multiple Choice	0.4981	0.298	0.586
Visual -Multiple Choice	0.5145		
Verbal -Essay	0.8653	0.055	0.814
Visual -Essay	0.8687		

Table 4.26: Spring 2008-ANOVA analysis for visual/verbal dimension.

4.5.8 Results-Global/Sequential Dimension

The data was analyzed using a one-way ANOVA where each course components was tested for performance differences due to the global/sequential learning style. The significant results were homework performance [F(1,63) = 10.475; p =0.002] and pre-class quiz performance [F(1,63) = 8.420; p =0.005]. There were no differences in performance due to learning style for any of the other course components.

The homework, pre-class quizzes, and clickers failed homogeneity of variance tests so these results were confirmed using the non-parametric statistic Mann-Whitney. There were significant performance differences on the homework due to learning style [Z = -2.758; p =0.0062]. The sequential students performed better than global students. There also was significant performance differences on the pre-class quiz due to learning style [Z = -2.607; p =0.009]. This indicated that sequential students scored higher on the pre-class quizzes than global students. There were no performance differences on the clicker average [Z = -1.443; p =0.149].

The only course components in the spring semester that had significant differences due to the global/sequential dimension were the clickers and the labs. Sequential students tended to score higher on both course components than global students. There were no significant performance differences for any of the other course components.

Clickers, labs, and essay questions failed the homogeneity of variance test, but the results were confirmed using the Mann-Whitney test. Sequential students scored higher on clickers [Z = -2.267; p = 0.023] and on the lab [Z = -2.224; p =0.026]. There were no differences on the essay questions [Z = -0.032; p = 0.974].

Course Component	Average Score	F-Value	P-Value
Global-Homework	0.7944	10.475	0.002*
Sequential-Homework	0.9294		
Global-Clicker	0.7544	2.880	0.095*
Sequential -Clicker	0.8442		
Global-Quiz	0.6677	8.420	0.005*
Sequential -Quiz	0.8185		
Global -Lab	0.9040	2.459	0.122
Sequential -Lab	0.9232		
Global -Exam	0.6910	0.203	0.654
Sequential -Exam	0.7062		

*- Failed homogeneity of variance test

Table 4.27: Fall 2007-ANOVA analysis for global/sequential dimension.

Course Component	Average Score	F-Value	P-Value
Global -Homework	0.8413	3.419	0.066
Sequential -Homework	0.8807		
Global -Clicker	0.7174	6.725	0.010*
Sequential -Clicker	0.8125		
Global -HBL	0.8040	1.213	0.272
Sequential -HBL	0.8236		
Global -Lab	0.8740	7.535	0.007*
Sequential -Lab	0.9200		
Global -Exam	0.6184	0.553	0.458
Sequential -Exam	0.6326		
Global -Homework Style	0.5386	0.657	0.419
Sequential -Homework Style	0.5674		
Global -Multiple Choice	0.4924	1.108	0.294
Sequential -Multiple Choice	0.5186		
Global -Essay	0.8634	0.275	0.601*
Sequential -Essay	0.8698		

*- Failed homogeneity of variance test

Table 4.28: Spring 2008-ANOVA analysis for global/sequential dimension.

4.5.9 Learning Style Conclusions

The ANOVA results indicated that performance differences occurred a few times due to student learning style, but the majority of the time there was no difference due to learning styles. This means that an instructor may not need to be concerned with student learning styles when teaching Physics. No learning style seems to have an advantage over another learning style. The students tend to earn the same grade regardless of learning styles. As discussed earlier, a possible explanation why the learning styles performed the same was most Physics professors utilize multiple teaching methods in their courses.

Further investigation should be conducted using a different learning style model to see if there are similar results.

4.6 Research Question 4

Research Question 4: What other variables are the significant predictors of Physics 1214 exam performance?

$$Y = \beta_{LABATT} x_{LABATT} + \beta_{HELPATT} x_{HELPATT} + \beta_{PHYS1} x_{PHYS1} + \beta_{HELPROOM} x_{HELPROOM} \quad (4.5)$$

The variables used in this research question were analyzed only for the spring semester. These variables were variables that were suggested during the oral qualifier exam, that is why the analysis is only for the spring semester. The variables used in this question include: lab attendance, attendance in exam help sessions, the time that the student spent in the Physics helproom, and the Physics 1114 grade.

The lab attendance score was the number of times that the students missed lab. The attendance in the help sessions was the number of help sessions that the students attended. The Oklahoma State Physics Department Society of Physics Students held help sessions before each of the four exams. Students who attended signed a sheet at the help session to indicate their attendance. The students received no extra credit for attending the help sessions and were not required to attend. The time the students spent in the helproom was the total time in hours that each individual student spent in the helproom. The Physics department provides a room where students can ask teaching assistants for help on Physics problems or concepts. Students who used the helproom signed a sheet indicating when they arrived and left. The Physics 1114 grade was the total grade at the end of the semester.

4.6.1 Spring 2008 Research Question 4 Results

Backward Stepwise Regression was used to find variables that predict exam performance. All of the variables were entered in the regression in the first step. Initially the worst predictor of exam performance was the lab attendance, followed by help session attendance, and time spent in the Physics helproom. The only significant predictor was the Physics 1 grade. It accounted for 50.6 percent of the variation in exam scores, a significant amount [F(1,157) = 161.043; p <0.0001]. The results are summarized in the table below.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.002	0.013	0.013	0.243	0.808
Help Attendance	-0.007	-0.053	-0.046	-0.856	0.394
Physics 1 Grade	0.818	0.733	0.709	13.159	<0.001
Helproom Time	0.002	0.113	0.100	1.851	0.066

Step 2 – Remove Lab Attendance

	B	β	Partial Correlation	t	p-value
Help Attendance	-0.005	-0.038	-0.033	-0.596	0.552
Physics 1 Grade	0.809	0.702	0.684	12.255	<0.001
Helproom Time	0.002	0.113	0.101	1.803	0.073

Step 3 – Remove Help Attendance

	B	β	Partial Correlation	t	p-value
Physics 1 Grade	0.803	0.696	0.687	12.336	<0.001
Helproom Time	0.002	0.097	0.096	1.717	0.088

Step 4 – Remove Help room Time

	B	β	Partial Correlation	t	p-value
Physics 1 Grade	0.821	0.712	0.712	12.690	<0.001

Table 4.29: Spring 2008-Backward stepwise regression results

Bivariate correlations, means, and standard deviations are displayed for the variables used in research question four. It should be noted that some correlations reached statistical significance, with predictor-to-predictor shared variance ranging from 0.3 percent to 20.0 percent, and criterion-to-predictor variance ranging from 0.5 percent to 54.5 percent.

	Exam	Lab Attendance	Help Attendance	Physics 1 Grade	Helproom Time
Exam	0.630 (0.108)	-0.070	0.149**	0.738*	0.206*
Lab Attendance		0.696(0.674)	-0.108	-0.130	0.058
Help Attendance			0.595(0.822)	0.208*	0.447*
Physics 1 Grade				0.788(0.097)	0.159**
Helproom Time					2.347(6.216)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.30: Spring 2008-Correlations between the variables

The process was repeated using the three sections of the exam. Performance was successfully predicted on all three sections ([F_{HW}(1,157) = 128.152; p < 0.001], [F_{MC}(2,155) = 68.860; p < 0.001], [F_{Essay}(1,157) = 49.776; p < 0.001]), but the Physics 1114 grade was usually the only significant predictor variable. These variables explained 44.9 percent of the variation in the homework-style problems, 47.0 percent of the variation in multiple choice problems, and 24.1 percent of the variation in essay questions.

The Physics 1114 grade was a significant predictor on all three sections of the exam. The time spent in the Physics helproom was barely a significant predictor for the multiple choice section. The lab attendance and help session attendance were not significant predictor variable for any of the sections of the exam.

The order that the variables were eliminated was the same for the homework-style problems and the essay questions. The time spent in the helproom was eliminated first, followed by help session attendance, and the lab attendance. The results are shown in the tables below.

Step 1 – All Variables Entered (Homework-Style Problems)

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.018	0.059	0.058	0.977	0.330
Help Attendance	-0.006	-0.025	-0.022	-0.372	0.711
Physics 1 Grade	1.472	0.697	0.675	11.439	<0.001
Help room Time	-0.001	-0.024	-0.021	-0.355	0.723

Step 2 – Remove Help room Time

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.017	0.056	0.055	0.941	0.348
Help Attendance	-0.009	-0.036	-0.035	-0.589	0.557
Physics 1 Grade	1.467	0.695	0.676	11.485	<0.001

Step 3 – Remove Help Attendance

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.018	0.059	0.058	0.996	0.321
Physics 1 Grade	1.453	0.688	0.682	11.620	<0.001

Step 4 – Remove Lab Attendance

	B	β	Partial Correlation	t	p-value
Physics 1 Grade	1.433	0.670	0.670	11.320	<0.001

Table 4.31: Backward stepwise regression results-Homework-Style Problems.

Step 1 – All Variables Entered (Multiple Choice)

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.010	0.045	0.044	0.771	0.442
Help Attendance	-0.005	-0.027	-0.024	-0.412	0.681
Physics 1 Grade	1.026	0.684	0.662	11.487	<0.001
Help room Time	0.003	0.122	0.107	1.864	0.064

Step 2 – Remove Help Attendance

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.011	0.049	0.048	0.837	0.404
Physics 1 Grade	1.021	0.681	0.666	11.574	<0.001
Help room Time	0.003	0.110	0.108	1.878	0.062

Step 3 – Remove Lab Attendance

	B	β	Partial Correlation	t	p-value
Physics 1 Grade	1.007	0.657	0.649	11.099	<0.001
Help room Time	0.003	0.118	0.116	1.992	0.048

Table 4.32: Backward stepwise regression results-Multiple Choice Questions.

Step 1 – All Variables Entered (Essay)

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.007	0.068	0.067	0.984	0.327
Help Attendance	-0.002	-0.020	-0.017	-0.257	0.797
Physics 1 Grade	0.373	0.548	0.531	7.800	<0.001
Help room Time	0.000	0.006	0.005	0.076	0.939

Step 2 – Remove Help room Time

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.007	0.069	0.068	1.006	0.316
Help Attendance	-0.001	-0.017	-0.017	-0.250	0.803
Physics 1 Grade	0.373	0.548	0.533	7.864	<0.001

Step 3 – Remove Help Attendance

	B	β	Partial Correlation	t	p-value
Lab Attendance	0.007	0.070	0.070	1.033	0.303
Physics 1 Grade	0.371	0.545	0.540	7.995	<0.001

Step 4 – Remove Lab Attendance

	B	β	Partial Correlation	t	p-value
Physics 1 Grade	0.362	0.491	0.491	7.055	<0.001

Table 4.33: Backward stepwise regression results-Essay Questions.

	Exam	Lab Attendance	Help Attendance	Physics 1 Grade	Helproom Time
Homework-style	0.561 (0.205)	-0.031	0.103	0.680*	0.079
Multiple Choice	0.513 (0.146)	-0.032	0.166**	0.692*	0.221*
Essay	0.872 (0.066)	-0.001	0.089	0.536*	0.088
Lab Attendance		0.696(0.674)	-0.108	-0.130	0.058
Help att			0.595(0.822)	0.208*	0.447*
Physics 1 Grade				0.788(0.097)	0.159**
Helproom Time					2.347(6.216)

Note: Means (standard deviations) are placed on the diagonal. ** $p < .05$ * $p < .01$

Table 4.34: Correlation Results.

4.6.2 Research Question 4 Analysis

Overall these variables did a poor job of explaining the variation in exam scores. The lab attendance, help session attendance, and time spent in the helproom were all non-significant predictors of exam performance. The Physics 1114 grade was an excellent predictor of exam performance. It explained 50.6 percent of the variation in exam scores. There is not research in literature indicating if prior performance in first semester Physics relates to performance in second semester Physics, but there is similar research. Sadler [10] found that the high school Physics course is a good predictor of university Physics performance. Both Sadler's study and my study demonstrated that prior Physics performance can predict future Physics performance. This result also demonstrates the importance of student motivation. If a student works hard in the past then they will probably continue working hard in future courses.

The attendance variables also did a poor job of predicting each section of the exam. The Physics 1114 grade predicted all three sections of the exam. The only other variable to predict a section of the exam was the time spent in the helproom, which predicted the multiple choice section of the exam. Just like the previous three research questions it seems that if a variable is a good predictor of one section of the exam then it will predict the other sections of the exam even though the style of the sections is different.

These variables seemed to explain close to the same amount (around 45 percent) of the variation in homework-style problems and multiple choice questions, but explained 24.1 percent of the variation of essay questions. This indicates that these variables did not do as good of a job at predicting essay questions.

A possible reason that the variables other than Physics 1114 grade may have been poor predictors is low student participation. Twenty eight students attended at least two help sessions, and nineteen students spent more the 7.5 hours in the Physics helproom. The reason the lab attendance was a bad predictor was students rarely missed more than one time. The students had one drop, but any other absence would be a zero. When there is only ten labs and one exam a single unexcused absence would almost cost the student a letter grade. This caused students to rarely miss more than one time.

Research should focus on the motivation of the student. Rather than investigating the number of absences, the focus should be if there are differences in performance if a student is willing to attend a help session at least once. If a student is willing to attend a help session, even though they are not required to attend, may indicate their motivation is higher. This might lead to higher exam scores. ANOVA analysis on the spring semester found no performance differences if a student attends at least one help session versus not attending any help session. When the number is increased to two help sessions there were significant performance differences (p=0.002). Students who attended at least two help sessions performed better (0.6838) than students who attended less than two help sessions (0.6114). This gets back to student motivation. Attending only two help sessions would not help the students on all four exams, but it does indicate that a student is willing to work to earn their grade.

Similar research focused on performance differences between people who are willing to spend at least one hour in the helproom compared to people who do not attend helproom office hours. ANOVA results indicated that there were no performance differences between people willing to spend one hour compared to people who do not go to office hours. There also were no performance differences for students who spend five hours in the helproom. There were significant (p=0.008) performance differences for students who spend at least 7.5 hours (0.6870) as compared to students who spend less than 7.5 hours (0.6125). This again indicates that students who are motivated will earn high grades.

The results for both the help session and the time spent in office hours shows that while these variables may not be predictors, they still give valuable insight into student motivation. The number may not be important, but the motivated students who are willing to put the effort in the course do perform better than students who do not put the extra effort into the class. The predictor variables are summarized in figure 4.3.

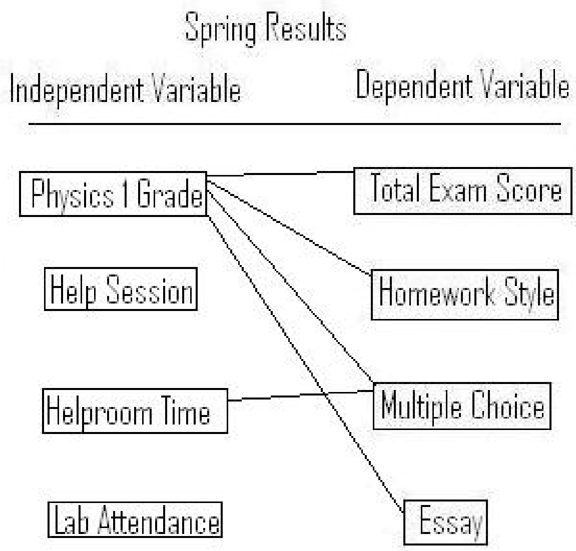

Figure 4.3: Significant Predictors of Exam performance

4.7 Research Question 5

Research Question 5: What are the significant predictors of Physics 1214 exam performance?

$$Y_{fall} = \beta_{MPEXPRE}x_{MPEXPRE} + \beta_{ACT/REF}x_{ACT/REF} + \beta_{LAB}x_{LAB} + \beta_{SCIENCE}x_{SCIENCE} + \beta_{GPA}x_{GPA} \quad (4.6)$$

$$Y_{spring} = \beta_{HOMEWORK}x_{HOMEWORK} + \beta_{LAB}x_{LAB} + \beta_{HBL}x_{HBL} + \beta_{SCIENCE}x_{SCIENCE} + \beta_{GPA}x_{GPA} + \beta_{MPEXPO}x_{MPEXPO} + \beta_{PHYS1}x_{PHYS1} \quad (4.7)$$

The predictor variables used in this research question are the significant exam predictors from the previous four research questions. A Backward Stepwise Regression is used to eliminate all non-significant exam predictor variables.

4.7.1 Fall 2007 Research Question 5 Results

In the final analysis all significant predictor variables from the previous questions were entered into the regression. Backward Stepwise Regression eliminated non-significant variables until only significant variables remained. The variables included in the analysis included: lab average, GPA, ACT science score, the sensing/intuitive dimension and the MPEX pre-test.

The first non-significant predictor that was eliminated was the lab average, followed by the MPEX pre-test, and the active/reflective dimension. The only significant exam performance predictors were the GPA and ACT science score. They accounted for 56.5 percent of the variation in exam scores, a significant amount [$F(2,52) = 33.719$; $p < 0.001$]. The results are summarized in table 4.35.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
Lab	0.127	0.047	0.034	0.375	0.709
GPA	0.102	0.467	0.344	3.756	<0.001
ACT Science	0.011	0.339	0.306	3.346	0.002
MPEX Pre	0.001	0.165	0.154	1.679	0.100
ACT/REF	-0.011	-0.198	-0.178	-1.947	0.058

Step 2 – Remove Lab

	B	β	Partial Correlation	t	p-value
GPA	0.108	0.494	0.452	4.978	<0.001
ACT Science	0.012	0.352	0.341	3.764	<0.001
MPEX Pre	0.001	0.161	0.151	1.665	0.102
ACT/REF	-0.011	-0.199	-0.180	-1.982	0.053

Step 3 – Remove MPEX Pre

	B	β	Partial Correlation	t	p-value
GPA	0.115	0.532	0.502	5.564	<0.001
ACT Science	0.012	0.382	0.374	4.149	<0.001
ACT/REF	-0.008	-0.152	-0.143	-1.583	0.120

Step 4 – Remove ACT/REF

	B	β	Partial Correlation	t	p-value
GPA	0.125	0.577	0.571	6.239	<0.001
ACT Science	0.013	0.403	0.398	4.352	<0.001

Table 4.35: Fall 2007-Backward stepwise regression results.

Table 4.36 displays bivariate correlations, and means and standard deviations, for the variables in research question five. Some predictor variables were significantly correlated, and correlated with the criterion variable. Some correlations reached statistical significance, with predictor-to-predictor shared variance ranging from 0.4 percent to 38.7 percent, and criterion-to-predictor variance ranging from 6.7 percent to 41.0 percent.

	Exam	Lab	GPA	ACT Science	MPE Pre	ACT/REF
Exam	0.706 (0.132)	0.530*	0.670*	0.481*	0.259**	-0.388*
Lab		0.918(0.049)	0.622*	0.372*	0.062	-0.284**
GPA			3.151(0.605)	0.149	0.189	-0.314**
ACT Science				25.509(3.916)	0.120	-0.181
MPEX Pre					99.943(14.730)	0.187
ACT/REF						6.057(2.484)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.36: Fall 2007-Correlations between the variables.

4.7.2 Spring 2008 Research Question 5 Results

The variables included in the analysis included: homework average, lab average, HBL average, GPA, ACT science score, Physics 1 grade, and the MPEX post-test. Backward Stepwise Regression was used to eliminate all non-significant predictor variables until only significant predictor variables remained.

The first variable removed was the MPEX post-test, followed by the HBL average, and then the ACT Science score. The significant predictors were the homework average, lab average, GPA, and the Physics 1 grade. The results are summarized in table 4.37.

Step 1 – All Variables Entered

	B	β	Partial Correlation	t	p-value
Homework	-0.188	-0.162	-0.140	-2.647	0.009
HBL	0.087	0.087	0.082	1.550	0.124
Lab	0.615	0.302	0.268	5.062	<0.001
GPA	0.048	0.231	0.128	2.425	0.017
ACT Science	0.004	0.147	0.125	2.355	0.020
Physics 1 Grade	0.447	0.395	0.203	3.838	<0.001
MPEX Post	0.001	0.073	0.069	1.295	0.198

Step 2 – Remove MPEX Post

	B	β	Partial Correlation	t	p-value
Homework	-0.179	-0.152	-0.132	-2.540	0.012
HBL	0.083	0.085	0.082	1.585	0.115
Lab	0.516	0.267	0.241	4.655	<0.001
GPA	0.044	0.214	0.126	2.427	0.017
ACT Science	0.003	0.128	0.108	2.089	0.039
Physics 1 Grade	0.512	0.449	0.246	4.759	<0.001

Step 3 – Remove HBL

	B	β	Partial Correlation	t	p-value
Homework	-0.184	-0.156	-0.135	-2.595	0.011
Lab	0.513	0.265	0.240	4.599	<0.001
GPA	0.041	0.198	0.117	2.253	0.026
ACT Science	0.003	0.113	0.097	1.861	0.065
Physics 1 Grade	0.554	0.486	0.275	5.287	<0.001

Step 4 – Remove ACT Science

	B	β	Partial Correlation	t	p-value
Homework	-0.106	-0.117	-0.105	-2.055	0.042
Lab	0.446	0.225	0.202	3.961	<0.001
GPA	0.040	0.196	0.119	2.324	0.021
Physics 1 Grade	0.605	0.537	0.311	6.089	<0.001

Table 4.37: Spring 2008-Backward stepwise regression results.

Bivariate correlations, means, and standard deviations are displayed for the variables used in research question five. Some correlations reached statistical significance, with predictor-to-predictor shared variance ranging from 0 percent to 63.4 percent, and criterion-to-predictor variance ranging from 2.1 percent to 51.8 percent. The results are summarized in table 4.38.

	Exam	Homework	HBL	Lab	GPA	ACT Science	Phys 1	MPEX Post
Exam	0.640 (0.108)	0.183**	0.146	0.536*	0.690*	0.450*	0.720*	0.199**
Homework		0.902(0.094)	0.082	0.275*	0.319*	0.009	0.446*	0.055
HBL			0.821(0109)	-0.015	0.023	-0.093	0.187**	0.158**
Lab				0.922(0.053)	0.415*	0.125	0.398*	0.106
GPA					3.255(0.520)	0.456*	0.796*	0.019
ACT Science						24.548(3.955)	0.422*	0.035
Phys 1							0.798(0.096)	0.203**
MPEX Post								96.754(11.364)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.38: Spring 2008-Correlations between the variables.

The analysis was repeated for each of the three sections of the exam. The predictor variables were successful at predicting each of the sections of the exam ([$F_{HW}(3,155) = 55.384$; $p < 0.001$], [$F_{MC}(3,130) = 49.527$; $p < 0.001$], [$F_{Essay}(2,155) = 85.583$; $p < 0.001$]). The variables explained 51.7 percent of the variation in homework-style problems, 53.3 percent of the variation in multiple choice problems, and 52.5 percent of the variation in essay questions.

The Physics 1114 grade was always the best predictor of exam performance, and the lab grade was the second best predictor for all three sections of the exam. The essay questions had no other significant performance predictors. The ACT science score was a predictor of the multiple choice questions, and the homework successfully predicted the homework-style exam problems. There were no other significant predictors of any of the sections of the exam.

Step 1 – All Variables Entered (Homework-Style Problems)

	B	β	Partial Correlation	t	p-value
Homework	-0.577	-0.287	-0.250	-4.572	<0.001
HBL	0.193	0.102	0.098	1.783	0.077
Lab	0.979	0.249	0.218	3.984	<0.001
GPA	0.038	0.095	0.055	1.004	0.317
MPEX Post	0.001	0.042	0.040	0.729	0.467
Physics 1 Grade	1.345	0.616	0.332	6.061	<0.001

Step 2 – Remove MPEX Post

	B	β	Partial Correlation	t	p-value
Homework	-0.293	-0.169	-0.150	-2.652	0.009
HBL	0.182	0.098	0.096	1.688	0.093
Lab	0.647	0.170	0.153	2.693	0.008
GPA	0.024	0.061	0.037	0.650	0.517
Physics 1 Grade	1.336	0.619	0.350	6.175	<0.001

Step 3 – Remove GPA

	B	β	Partial Correlation	t	p-value
Homework	-0.289	-0.169	-0.149	-2.676	0.008
HBL	0.170	0.090	0.089	1.594	0.113
Lab	0.603	0.265	0.248	4.468	<0.001
Physics 1 Grade	1.410	0.659	0.587	10.566	<0.001

Step 4 – Remove HBL

	B	β	Partial Correlation	t	p-value
Homework	-0.293	-0.171	-0.151	-2.701	0.008
Lab	0.595	0.261	0.245	4.392	<0.001
Physics 1 Grade	1.452	0.679	0.616	11.038	<0.001

Table 4.39: Spring 2008-Backward stepwise regression results-Homework Style Problems.

Step 1 – All Variables Entered (Multiple Choice)

	B	β	Partial Correlation	t	p-value
Homework	-0.105	-0.066	-0.057	-0.973	0.333
HBL	0.133	0.102	0.098	1.662	0.099
Lab	0.549	0.211	0.190	3.233	0.002
GPA	0.040	0.144	0.084	1.427	0.156
ACT Science	0.005	0.148	0.126	2.139	0.034
Physics 1 Grade	0.645	0.422	0.229	3.882	<0.001
Helproom Time	0.003	0.106	0.103	1.754	0.082

Step 2 – Remove Homework

	B	β	Partial Correlation	t	p-value
HBL	0.137	0.105	0.101	1.714	0.089
Lab	0.535	0.205	0.186	3.161	0.002
GPA	0.040	0.146	0.085	1.450	0.156
ACT Science	0.006	0.162	0.141	2.401	0.034
Physics 1 Grade	0.590	0.386	0.223	3.778	<0.001
Helproom Time	0.003	0.105	0.103	1.745	0.082

Step 3 – Remove GPA

	B	β	Partial Correlation	t	p-value
HBL	0.125	0.096	0.096	1.567	0.119
Lab	0.575	0.220	0.203	3.431	0.001
ACT Science	0.007	0.181	0.161	2.723	0.007
Physics 1 Grade	0.749	0.489	0.397	6.707	<0.001
Helproom Time	0.002	0.095	0.094	1.588	0.115

Step 4 – Remove HBL

	B	β	Partial Correlation	t	p-value
Lab	0.566	0.217	0.200	3.359	0.001
ACT Science	0.006	0.165	0.149	2.497	0.014
Physics 1 Grade	0.789	0.515	0.429	7.214	<0.001
Helproom Time	0.003	0.102	0.101	1.697	0.102

Step 5 – Remove Helproom Time

	B	β	Partial Correlation	t	p-value
Lab	0.569	0.218	0.201	3.356	0.001
ACT Science	0.006	0.159	0.143	2.382	0.019
Physics 1 Grade	0.816	0.533	0.449	7.486	<0.001

Table 4.40: Spring 2008-Backward stepwise regression results-Multiple Choice Questions.

Step 1 – All Variables Entered (Essay Questions)

	B	β	Partial Correlation	t	p-value
Homework	-0.081	-0.066	-0.059	-1.038	0.301
Lab	0.478	0.178	0.160	2.814	0.006
GPA	0.032	0.116	0.070	1.234	0.219
Physics 1 Grade	0.846	0.557	0.323	5.666	<0.001

Step 2 – Remove Homework

	B	β	Partial Correlation	t	p-value
Lab	0.460	0.171	0.155	2.722	0.007
GPA	0.035	0.128	0.078	1.362	0.175
Physics 1 Grade	0.793	0.522	0.322	5.651	<0.001

Step 3 – Remove GPA

	B	β	Partial Correlation	t	p-value
Lab	0.437	0.268	0.260	4.704	<0.001
Physics 1 Grade	0.940	0.614	0.597	10.779	<0.001

Table 4.41: Spring 2008-Backward stepwise regression results-Essay Questions.

	Homework-Style	Homework	HBL	Lab	GPA	Phys 1	MPEX Post
Homework-Style	0.575 (0.206)	0.107	0.206*	0.448*	0.601*	0.694*	0.209*
Homework		0.895(0.102)	0.120	0.316*	0.325*	0.442*	-0.010
HBL			0.818(0.109)	-0.015	0.057	0.213*	0.130
Lab				0.922(0.052)	0.431*	0.399*	0.091
GPA					3.246(0.514)	0.788*	0.026
Phys 1						0.796(0.094)	0.203*
MPEX Post							97.373(11.580)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.42: Spring 2008-Correlations between the variables-Homework Style.

	Multiple Choice	Homework	HBL	Lab	GPA	ACT Science	Phys 1	Helproom Time
Multiple Choice	0.520 (0.145)	0.242*	0.201*	0.453*	0.618*	0.429*	0.687*	0.196**
Homework		0.901(0.091)	0.075	0.244*	0.327*	0.022	0.449*	0.087
HBL			0.819(0.111)	0.045	0.067	-0.055	0.194**	0.107
Lab				0.922(0.056)	0.399*	0.173**	0.389*	0.069
GPA					3.230(0.528)	0.462*	0.789*	0.042
ACT Science						24.396(3.918)	0.436*	0.011
Phys 1							0.794(0.095)	0.148**
Helproom Time								2.194(5.911)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.43: Spring 2008-Correlations between the variables-Multiple Choice.

	Essay	Homework	Lab	GPA	Phys 1
Essay	0.516 (0.145)	0.250*	0.425*	0.608*	0.688*
Homework		0.888(0.118)	0.233*	0.286*	0.434*
Lab			0.921(0.054)	0.413*	0.386
GPA				3.208(0.525)	0.785*
Phys 1					0.790(0.095)

Note: Means (standard deviations) are placed on the diagonal. ** p < .05 * p < .01

Table 4.44: Spring 2008-Correlations between the variables-Essay.

4.7.3 Research Question 5 Analysis

The results (summarized in figure 4.4) indicated that the ability of the student was the best method of predicting exam performance. The only variables that predicted exam performance in the fall was the university GPA and the ACT science score. The GPA was the best predictor variable. Students who performed well in university courses prior to taking Physics continued to perform well. No course component was a significant exam performance predictor. These results are somewhat consistent with Bonham's results for a first semester algebra-based Physics course. [38] Bonham found that ability variables were the best predictor, but his ability variables were different. He found that the SAT math was the best predictor. Possible reasons for this difference was discussed in the research question 2 analysis. In the spring the ability variables GPA and Physics 1114 grade were significant predictor variables. The significant course component predictors were the lab grade and the homework average. The overall best predictor in the spring was the Physics 1114 grade. This means students who performed well in Physics 1114 continue to perform well in Physics 1214. The second best predictor was the lab grade, followed by the GPA, and then the homework average. Again these results are similar to Bonham's result for a first semester Physics Course.

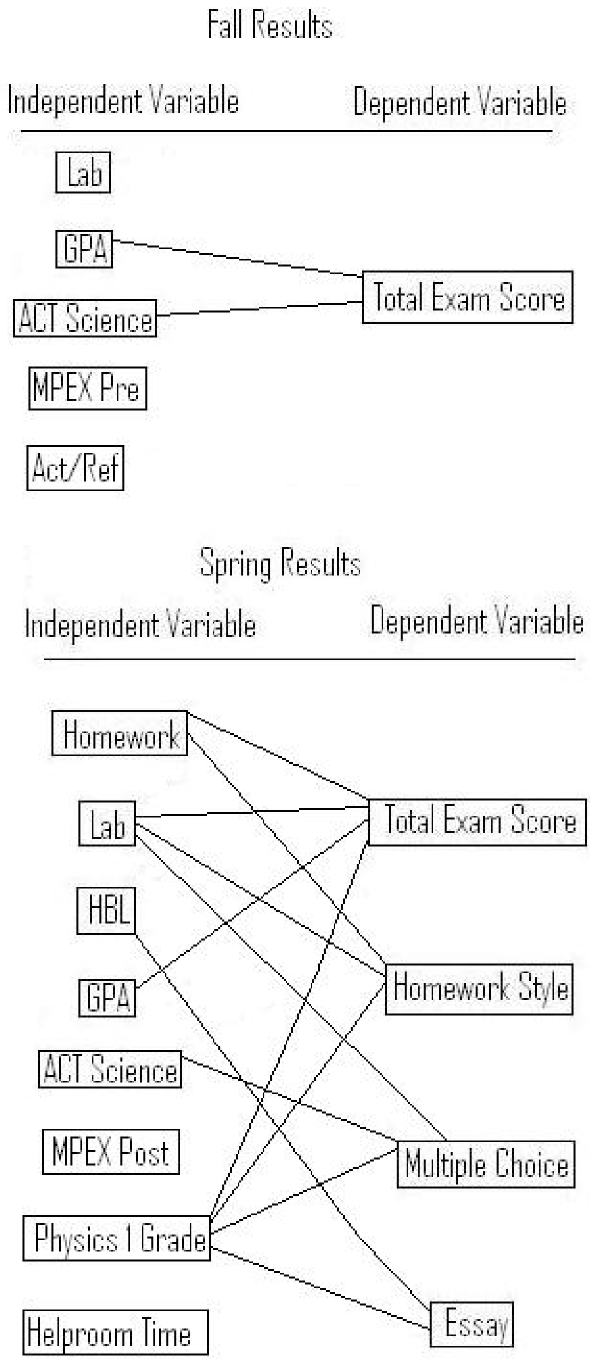

Figure 4.4: Significant Predictors of Exam performance

Student learning style poorly predicted exam performance. The active/reflective dimension was not significant in the fall, and no learning style variables tested significant in research question three for the spring semester. This would indicate that there is no relationship between exam performance and learning style. One interpretation is a professor may not need to be too concerned with the learning styles of the students. An alternate interpretation is there are not differences due to student learning styles because the method that Physics is traditionally taught incorporates many learning styles.

Student attitude in Physics was also a poor predictor of exam performance. The MPEX pre-test was a non-significant predictor in the fall, and the MPEX post-test was non-significant in the spring. This result indicates the students who perform well in courses do not necessarily think in the same manner as a physicist. There is no relationship between course performance and the way that students think about the physical world either before or after instruction. This may have occurred because student attitude is not as important a factor as ability and motivation. Exams test content knowledge not student attitude think. This may give the appearance that the faculty are not concerned with student attitude, just correct answers. This means the students worry about getting the concepts correct rather than a way of thinking.

The attitude results not being related to exam performance is somewhat consistent with the results of Perkins. [6] A difference between Perkin's study and this study is the number of variables. Perkins only compared the test results to student gain. There were not other variables. If Perkins had more variables then attitude may have not been a relationship. He also had inconsistent results. There were only significant gains in two of the four courses that he surveyed. Difference between this study and Perkins also could have been from different surveys. He used a survey that was similar to the MPEX called the CLASS. [73] Pollack [35] did incorporate more variables in his study and found no significant correlation between student attitude and student performance.

The two semesters were fairly similar with the ability/effort variables being the best predictors and the behavioral variables not significant predictors. The course components were different between the two semesters. There were more predictors in the spring semester. A possible explanation for this is the exam format was different, so perhaps the students studied differently which lead to different significant course component variables.

It is interesting to examine the various sections of the exam for the spring semester. The Physics 1114 grade predicted all three sections and the lab average predicted the homework style questions and the multiple choice section of the exam. This would indicate that there is some consistency in the sections of the exams. It is interesting to note that each section of the exam had one unique predictor variable. The homework style questions had the homework average as a predictor variable. Both the homework style section of the exam and the homework was focused on solving problems. The multiple choice section of the exam had the ACT science score as a predictor variable. Both of these exams are multiple choice exams. This means the three sections of the exam had common predictor variables and unique predictor variables where the student performs activities that are similar to that section of the exam.

Based on the results presented here, it appears that the traditional course components are not the best predictors of exam performance. An instructor would hope to be able to predict the exam performance using the course components. This would indicate a relationship exists between daily activities and exam performance. Unfortunately that is not happening consistently. The course components are not doing as good of a job of predicting the exam performance as ability or motivation. Only two course components were significant over the two semesters tested. Exam performance can be explained mostly by student ability and motivation. Students who perform well in Physics 1114 or in other courses continue getting high scores. Additionally an instructor would hope their course trains the way the student thinks about the physical world, but there is not a relationship between student attitude and course performance.

4.8 Discussion and Future Research

The results of this study has introduced several interesting new research questions. One of the more interesting results was that the physics lab was a better predictor of exam performance than the homework. One possibility for this is the conditions that the lab were administered were similar to the exam conditions. Students had to finish the labs within a time limit. The students were also limited on where they can get help. Students in the lab only had their lab partner a teaching assistant as a source for help. When students attempt homework they have other textbooks, other students, faculty, graduate students in the helproom, and the internet as means to get help. So one possible reason that the lab was the best predictor was it was administered in a way that is similar to the exam. To test this students could be forced to complete their homework in a discussion section setting, and then see if the homework predicts exam performance as well as the labs.

Another possible explanation to the why the lab was a good predictor is student motivation. It is not hard to get a good grade on the lab, but it is hard to earn a high A. The students who are willing to put the effort in this class are probably the same students who are willing to study and earn exam grades. This situation could be reproduced by giving homework questions in class. Design the questions and grading so that it is easy to earn an B, but it is hard to get a high A. If student motivation is an important predictor than this will probably show up as a predictor.

Another interesting result from this study was the ACT math score being a poor predictor of exam performance. Most physics faculty believe that math ability and performance are highly correlated. Some faculty give a math pre-test so the students can decide if they are ready to take the course. These results would indicate that this may not be necessary, but more research should focus on this question. It is a possibility that standardized test conditions may be so different from class conditions that it would not be a good predictor. Another reason that the math result may have been a poor predictor is it has been several years since most of the students took the ACT. Research should focus on more recent math achievements. Possibilities include giving the students a math pre-test or using their GPA in math courses as exam performance predictors.

An interesting direction from this study for future research would be to repeat the research on learning styles using a different learning style model. This study indicated that a Physics professor should not be concerned with student learning styles. This may have occurred because most Physics courses are designed to implement many learning style methods. This may not be true in other subject areas. This may be why the research is inconsistent with research on other subjects, so research using a different learning style model should be performed.

Other future research questions could investigate more second semester exam predictors. One possible predictor might be paper-based homework. The homework used in this study was all completed on the MasteringPhysics web system. The problems on the exam were all completed on paper, so it would be interesting to determine if paper-based homework does a better job of predicting exam performance. Another possible course component predictor could be group-work activities. These activities could be designed so it is easy to earn a B, but hard to earn an A. If the results are similar to the lab then students who are willing to put in the effort should perform well on the exam. A final possible predictor could be the science GPA of students who take a Physics course. Science GPA might be a better indicator of exam performance because students are more interested in their science courses as compared to general education courses. This might make the GPA a better predictor of exam performance.

In the spring I plan on podcasting my lectures on iTUnes U, and investigating how this change effects the results. If motivation is really the important factor behind student success then I expect that the number of times students who are motivated an watch the podcasts should be able to predict exam performance. This also might make attendance a better predictor because some students might decide that they do not need to come to class because of the podcasts.

Future research also should investigate significant predictors in the other Physics courses. These results should be generalizable because it takes similar skills to succeed in these general Physics courses. These results were similar to first semester algebra-based Physics research. My results were fairly consistent with Bonham's [38] results. We did not used the same predictor variables. In both cases ability or motivation variables were the best predictor variables. There has not been a first semester study that used as many predictors as this study did,so it would be interesting to go in more detail for a first semester Physics course. It would also be interesting to examine calculus-based Physics courses and see if similar results occur.

4.9 Project Summary

This study will be the first study that addresses the following topics:

1. All significant measurable course component predictors were identified. The best course component predictor of Physics 1214 exam performance was determined. The lab was a significant predictor in both semesters. The homework was a significant predictor in the spring. No other course components were significant predictors of exam performance. The lab may have been a good predictor because the lab has a controlled environment. Another explanation to the lab is it is a good measure of motivation. Students who are willing to work hard in the lab probably work hard in class.
2. The role of academic ability in predicting exam scores was determined. In both semesters the ACT science score and GPA were significant predictors of exam performance. The GPA is another example of student motivation being a good predictor of exam performance.
3. The relationship between student behavior variables and the exam performance was found. In the fall semester both the active/reflective dimension and the MPEX pre-test could predict exam performance. In the spring semester the MPEX post-test predicted exam performance. Student learning styles and how much a student thinks like an "expert physicist" are poor predictors of exam performance. A possible explanation for this is the professor rarely worries about teaching a thinking method while teaching class.
4. It was found there was not many performance differences on the course components due learning styles. This possibly occurred because Physics is taught in a manner that incorporates multiple learning styles. This means no student is shown preferential treatment. The subjects in the literature always were taught

where a particular learning style was unintentionally favored.

5. It was determined what other factors could be used to predict exam performance. Time spent in the helproom, class attendance, lab attendance, and exam help session attendance could not be used to predict exam performance. These variables were important measures of motivation even if they were poor predictors. There were significant performance differences between students who had perfect attendance and students who missed at least one class. Students who did not miss class outperformed students without perfect attendance. There were also performance differences between students who attended two exam review session and students who attended less sessions. Students with who attended two helps sessions scored higher on exams. Finally students who spent at least 7.5 hours in the helproom scored higher on exams than students who spent less time.

6. The student's performance in Physics 1114 could be used to predict exam performance. This also could be a measure of motivation. Students who were motivated in the past continue to stay motivated.

7. The only variable that was a consistent predictor when all of the significant predictors was combined in a research question during the two semesters was the GPA. The reason that the fall semester probably did not have many predictors was the small sample size. If the sample size was larger the results might have been more consistent with the spring results. The best predictor of Physics 2 exam performance appeared to be either the GPA or the Physics 1 grade.

8. The style of questions asked in the spring semester varied from homework-style, multiple choice or essay questions, but essentially the same predictor variables predicted the different sections of the exam. The Physics 1 grade and the lab were consistent predictors.

9. The different sections of the exam usually varied by one variable. The homework predicted homework style questions, and the ACT science score predicted the

multiple choice questions. This means that the variable that was different for the sections of the exam utilizes similar skills as that portion of the exam.

This is the only study that author is aware of that has investigated a second semester Physics course. No first semester studies have used as many predictor variables as this study. The result that ability variables are better predictors of exam performance than course components is consistent with research on first semester Physics courses.

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APPENDIX A

IRB Consent Forms

Evaluating the effectiveness of algebra-based physics course components.

Investigators: Chris Austin, B.S.
Bruce Ackerson, Ph.D.

Purpose: The goal of this research study is to evaluate the effectiveness of the course components in an algebra-based physics course. This will be done by determining which course components best predict exam performance. The relationship between the course performance and math ability, science ability, and attitude about physics will also be determined. Finally it will be determined if performance differences occur due to learning styles.

The information needed from the students include: course grades, university GPA at the beginning of the semester, and ACT math and science subscores.

Procedures: Participants will be asked to complete two surveys at the start of the semester. Each survey should not take longer than fifteen minutes. A follow-up fifteen minute survey will be given at the end of the semester. The surveys will be given in the first and last week of physics lab.

The information needed from the students include course grades, institutional GPA at the start of the semester, and ACT math and science subscores. At the end of the semester the professor will give the study researchers the course grades of all of the participants. The OSU communications office will give the GPA and ACT scores. To allow access to the data participants will need to sign the consent form.

Risks of Participation: There are no risks involved with participation.

Benefits: There are several benefits from this study. The most important benefit will be the knowledge about the course components that successfully predict exam performance. This will allow future physics professors to know the activities that increase student performance. The professors will also have advice to give to students for studying for physics exams.

Confidentiality: The data from this study will be kept confidential. The two listed researchers are the only people with access to data from this study. All records will be kept on a password protected computer that is not connected to a network. All documents with data will have different passwords. Student names will never be in a computer file with the data. Identifier tags will be used instead of student names. The key linking the student names to the identifier tags will be stored on a different computer. At the end of the semester when all of the data is collected all names will be removed from all files. The key linking the names to the identifier tags will be erased. Data will never be presented that has student names.

Compensation: There is no compensation for this study. Participation is voluntary.

Contact Informatiuon: If your have questions about this study you may contact Chris Austin at 405-744-6694 or chris.austin@okstate.edu.

If you have questions about your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu.

Participation is voluntary. Participating or not participating in this study will not affect your course grade in any way. If you decide in the future not to participate then you can end your participation at any time.
I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

____________	____________	____________	Physics 1114 / Physics 1214
Print Name	Signature of Participant	Date	Please circle one

I certify that I have personally explained this document before requesting that the participant sign it.

______________________ ____________

A.2 Consent Form Spring Semester

Evaluating the effectiveness of algebra-based physics course components.

Investigators: Chris Austin, B.S.
Bruce Ackerson, Ph.D.

Purpose: The goal of this research study is to evaluate the effectiveness of the course components in an algebra-based physics course. This will be done by determining which course components best predict exam performance. The relationship between the course performance and math ability, science ability, attitude about physics, class attendance, office hour attendance, help session attendance, and prior Physics performance will also be determined. Finally it will be determined if performance differences occur due to learning styles.

The information needed from the students include: course grades, university GPA at the beginning of the semester, ACT math and science subscores, class attendance, office hour attendance, help session attendance, and prior Physics performance.

Procedures: Participants will be asked to complete two surveys at the start of the semester. Each survey should not take longer than fifteen minutes. A follow-up fifteen minute survey will be given at the end of the semester. The surveys will be given in the first class period.

The information needed from the students include course grades, institutional GPA at the start of the semester, ACT math and science subscores, class attendance, office hour attendance, help session attendance, and prior Physics performance. The Physics 1 professor will give me the Physics 1 grades of all participants. At the end of the semester the professor will give the study researchers the course grades of all of the participants. The OSU communications office will give the GPA and ACT scores. To allow access to the data participants will need to sign the consent form.

Risks of Participation: There are no risks involved with participation.

Benefits: There are several benefits from this study. The most important benefit will be the knowledge about the course components that successfully predict exam performance. This will allow future physics professors to know the activities that increase student performance. The professors will also have advice to give to students for studying for physics exams.

Confidentiality: The data from this study will be kept confidential. The two listed researchers are the only people with access to data from this study. All records will be kept on a password protected computer that is not connected to a network. All documents with data will have different passwords. Student names will never be in a computer file with the data. Identifier tags will be used instead of student names. The key linking the student names to the identifier tags will be stored on a different computer. At the end of the semester when all of the data is collected all names will be removed from all files. The key linking the names to the identifier tags will be erased. Data will never be presented that has student names.

Compensation: There is no compensation for this study. Participation is voluntary.

Contact Informatiuon: If your have questions about this study you may contact Chris Austin at 405-744-6694 or chris.austin@okstate.edu.

If you have questions about your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu.

Participation is voluntary. Participating or not participating in this study will not affect your course grade in any way. If you decide in the future not to participate then you can end your participation at any time.

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

____________	____________	________	Physics 1114 / Physics 1214
Print Name	Signature of Participant	Date	Please circle one

I certify that I have personally explained this document before requesting that the participant sign it.

____________	________
Signature of Researcher	Date

APPENDIX B

Surveys

I have attached copies of some of the instruments that will be used in this study along with some of the answer keys for that instrument.

B.1 MPEX

Student Expectations in University Physics:
The Maryland Physics Expectations Survey

Here are 34 statements which may or may not describe your beliefs about this course. You are asked to rate each statement by circling a number between 1 and 5 where the numbers mean the following:

1: Strongly Disagree	2: Disagree	3: Neutral	4: Agree	5: Strongly Agree

Answer the questions by circling the number that best expresses your feeling. Work quickly. Don't over-elaborate the meaning of each statement. They are meant to be taken as straightforward and simple. If you don't understand a statement, leave it blank. If you understand, but have no strong opinion, circle 3. If an item combines two statements and you disagree with either one, choose 1 or 2.

1	All I need to do to understand most of the basic ideas in this course is just read the text, work most of the problems, and/or pay close attention in class.	1 2 3 4 5
2	All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems.	1 2 3 4 5
3	I go over my class notes carefully to prepare for tests in this course.	1 2 3 4 5
4	"Problem solving" in physics basically means matching problems with facts or equations and then substituting values to get a number.	1 2 3 4 5
5	Learning physics made me change some of my ideas about how the physical world works.	1 2 3 4 5
6	I spend a lot of time figuring out and understanding at least some of the derivations or proofs given either in class or in the text.	1 2 3 4 5
7	I read the text in detail and work through many of the examples given there.	1 2 3 4 5
8	In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as givens.	1 2 3 4 5
9	The best way for me to learn physics is by solving many problems rather than by carefully analyzing a few in detail.	1 2 3 4 5
10	Physical laws have little relation to what I experience in the real world.	1 2 3 4 5
11	A good understanding of physics is necessary for me to achieve my career goals. A good grade in this course is not enough.	1 2 3 4 5
12	Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation.	1 2 3 4 5
13	My grade in this course is primarily determined by how familiar I am with the material. Insight or creativity has little to do with it.	1 2 3 4 5
14	Learning physics is a matter of acquiring knowledge that is specifically located in the laws, principles, and equations given in class and/or in the textbook.	1 2 3 4 5
15	In doing a physics problem, if my calculation gives a result that differs significantly from what I expect, I'd have to trust the calculation.	1 2 3 4 5

MPEX *1*

16	The derivations or proofs of equations in class or in the text has little to do with solving problems or with the skills I need to succeed in this course.	1 2 3 4 5
17	Only very few specially qualified people are capable of really understanding physics.	1 2 3 4 5
18	To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.	1 2 3 4 5
19	The most crucial thing in solving a physics problem is finding the right equation to use.	1 2 3 4 5
20	If I don't remember a particular equation needed for a problem in an exam there's nothing much I can do (legally!) to come up with it.	1 2 3 4 5
21	If I came up with two different approaches to a problem and they gave different answers, I would not worry about it; I would just choose the answer that seemed most reasonable. (Assume the answer is not in the back of the book.)	1 2 3 4 5
22	Physics is related to the real world and it sometimes helps to think about the connection, but it is rarely essential for what I have to do in this course.	1 2 3 4 5
23	The main skill I get out of this course is learning how to solve physics problems.	1 2 3 4 5
24	The results of an exam don't give me any useful guidance to improve my understanding of the course material. All the learning associated with an exam is in the studying I do before it takes place.	1 2 3 4 5
25	Learning physics helps me understand situations in my everyday life.	1 2 3 4 5
26	When I solve most exam or homework problems, I explicitly think about the concepts that underlie the problem.	1 2 3 4 5
27	"Understanding" physics basically means being able to recall something you've read or been shown.	1 2 3 4 5
28	Spending a lot of time (half an hour or more) working on a problem is a waste of time. If I don't make progress quickly, I'd be better off asking someone who knows more than I do.	1 2 3 4 5
29	A significant problem in this course is being able to memorize all the information I need to know.	1 2 3 4 5
30	The main skill I get out of this course is to learn how to reason logically about the physical world.	1 2 3 4 5
31	I use the mistakes I make on homework and on exam problems as clues to what I need to do to understand the material better.	1 2 3 4 5
32	To be able to use an equation in a problem (particularly in a problem that I haven't seen before), I need to know more than what each term in the equation represents.	1 2 3 4 5
33	It is possible to pass this course (get a "C" or better) without understanding physics very well.	1 2 3 4 5
34	Learning physics requires that I substantially rethink, restructure, and reorganize the information that I am given in class and/or in the text.	1 2 3 4 5

Maintained by University of Maryland PERG
Comments and questions may be directed to E. F. Redish
Last modified March 2, 2001

B.2 Expert Response to MPEX

1. Disagree
2. Disagree
3. Agree
4. Disagree
5. Agree
6. Agree
7. Agree
8. Disagree
9. Disagree
10. Disagree
11. Agree
12. Disagree
13. Disagree
14. Disagree
15. Disagree
16. Disagree
17. Disagree
18. Agree
19. Disagree
20. Disagree
21. Disagree
22. Disagree
23. Disagree
24. Disagree
25. Agree
26. Agree
27. Disagree
28. Disagree
29. Disagree
30. Agree
31. Agree
32. Agree
33. Disagree
34. Agree

B.3 Index of Learning Styles

INDEX OF LEARNING STYLES*

DIRECTIONS

Enter your answers to every question on the ILS scoring sheet. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently.

1. I understand something better after I
a) try it out.
b) think it through.

2. I would rather be considered
a) realistic.
b) innovative.

3. When I think about what I did yesterday, I am most likely to get
a) a picture.
b) words.

4. I tend to
a) understand details of a subject but may be fuzzy about its overall structure.
b) understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
a) talk about it.
b) think about it.

6. If I were a teacher, I would rather teach a course
a) that deals with facts and real life situations.
b) that deals with ideas and theories.

7. I prefer to get new information in
a) pictures, diagrams, graphs, or maps.
b) written directions or verbal information.

8. Once I understand
a) all the parts, I understand the whole thing.
b) the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
a) jump in and contribute ideas.
b) sit back and listen.

10. I find it easier
  a) to learn facts.
  b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
  a) look over the pictures and charts carefully.
  b) focus on the written text.

12. When I solve math problems
  a) I usually work my way to the solutions one step at a time.
  b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
  a) I have usually gotten to know many of the students.
  b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
  a) something that teaches me new facts or tells me how to do something.
  b) something that gives me new ideas to think about.

15. I like teachers
  a) who put a lot of diagrams on the board.
  b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
  a) I think of the incidents and try to put them together to figure out the themes.
  b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
  a) start working on the solution immediately.
  b) try to fully understand the problem first.

18. I prefer the idea of
  a) certainty.
  b) theory.

19. I remember best
  a) what I see.
  b) what I hear.

20. It is more important to me that an instructor
  a) lay out the material in clear sequential steps.
  b) give me an overall picture and relate the material to other subjects.

21. I prefer to study
  a) in a study group.
  b) alone.

22. I am more likely to be considered
  a) careful about the details of my work.
  b) creative about how to do my work.

23. When I get directions to a new place, I prefer
  a) a map.
  b) written instructions.

24. I learn
  a) at a fairly regular pace. If I study hard, I'll "get it."
  b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
  a) try things out.
  b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
  a) clearly say what they mean.
  b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
  a) the picture.
  b) what the instructor said about it.

28. When considering a body of information, I am more likely to
  a) focus on details and miss the big picture.
  b) try to understand the big picture before getting into the details.

29. I more easily remember
  a) something I have done.
  b) something I have thought a lot about.

30. When I have to perform a task, I prefer to
  a) master one way of doing it.
  b) come up with new ways of doing it.

31. When someone is showing me data, I prefer
  a) charts or graphs.
  b) text summarizing the results.

32. When writing a paper, I am more likely to
  a) work on (think about or write) the beginning of the paper and progress forward.
  b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
  a) have "group brainstorming" where everyone contributes ideas.
  b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
a) sensible.
b) imaginative.

35. When I meet people at a party, I am more likely to remember
a) what they looked like.
b) what they said about themselves.

36. When I am learning a new subject, I prefer to
a) stay focused on that subject, learning as much about it as I can.
b) try to make connections between that subject and related subjects.

37. I am more likely to be considered
a) outgoing.
b) reserved.

38. I prefer courses that emphasize
a) concrete material (facts, data).
b) abstract material (concepts, theories).

39. For entertainment, I would rather
a) watch television.
b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
a) somewhat helpful to me.
b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
a) appeals to me.
b) does not appeal to me.

42. When I am doing long calculations,
a) I tend to repeat all my steps and check my work carefully.
b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
a) easily and fairly accurately.
b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
a) think of the steps in the solution process.
b) think of possible consequences or applications of the solution in a wide range of areas.

B.4 Scoring the ILS

This is the method to determine the learning style as determined by Felder. For each question place a one in the appropriate blank and then sum the number of a's and b's.

Active or Reflective Learner

Question	a(ACT)	b(REF)
1		
5		
9		
13		
17		
21		
25		
29		
33		
37		
41		
Sum		

Now subtract the smaller of the two sums from the larger of the two sums and place the letter of the larger letter next to the difference. This will determine how active or reflective a learner is.

$$Act/Ref = (larger - smaller)(letteroflargervalue) \tag{B.1}$$

If the score is between one and three then the learner is fairly well balanced. If the score is between five and seven then there is a moderate preference. The student will learn more easily using techniques that favor this style. If the score is between nine and eleven then there is a strong preference for one of the styles, and the student may encounter difficulty if this style is not used in instruction. Use the same procedure for the other learning categories.

Sensing or Intuitive Learner

Question	a(SEN)	b(INT)
2		
6		
10		
14		
18		
22		
26		
30		
34		
38		
42		
Sum		

Visual or Verbal Learner

Question	a(VIS)	b(VER)
3		
7		
11		
15		
19		
23		
27		
31		
35		
39		
43		
Sum		

Sequential or Global Learner

Question	a(Seq)	b(Glob)
4		
8		
12		
16		
20		
24		
28		
32		
36		
40		
44		
Sum		

For statistical purposes Felder suggested scoring an (a) response as a 1, and a (b) response as a 0. This means that a student's possible score on a dimension ranges between 0 and 11. So, for example, on the active/reflective dimension (a) responses represent an active preference and (b) responses represent a reflective preference. The suggested scoring method for statistical analysis becomes: a score of 0 to 1 represents a strong reflective preference, 2 or 3 represents a moderate reflective perspective, 4 or 5 a mild preference for reflective, 6 or 7 a mild preference for active, 8 or 9 a moderate preference for active, and 10 or 11 a strong preference for active. This scoring system works similarly for: sensing (a)/ intuitive (b), visual (a)/verbal (b), and sequential (a)/ global (b).

APPENDIX C

Statistics Review

A brief statistics review is given in this section for the benefit of readers unfamiliar with advanced training in statistics. This review will not demonstrate calculations, but explain techniques used in the literature review and this study. Each statistical technique answers a specific research question. The goal in any study is to match the technique and research question. The techniques reviewed are:

1. Correlation- What is the relationship between two variables?
2. Regression - Can a set of predictor variables predict the criterion variable?
3. Analysis of Variance (ANOVA) - Are the mean differences between groups significant?

Each technique will be discussed in more detail.

C.1 Correlation

The Pearson correlation coefficient [75] [76] [77] [78](r) gives the relationship between two variables. It is possible to have strong, weak, or no correlation. As an example let's consider the correlation between exam grade and homework grade (as seen below). A strong positive correlation indicated students that scored high on the exam also scored high on the homework. A strong negative correlation indicated students who scored high on the exam scored low on the homework, and students who scored high on the homework scored low on the exams. No correlation indicated there is no meaningful relationship between the two variables. The Pearson correlation coefficient is given by:

$$r = \frac{\sum(x_i - \overline{x})(y_i - \overline{y})}{S_x S_y} \tag{C.1}$$

where x_i and y_i are the individual scores, $\overline{x}$ and $\overline{y}$ are the means of the two variables, and $S_x$and S_y are the respective standard deviations. The standard deviations of x and y is calculated using equation 9.2 and 9.3 below:

$$s_x = \sqrt{\frac{\sum(x_i - \overline{x})^2}{N-1}} \tag{C.2}$$

$$s_y = \sqrt{\frac{\sum(y_i - \overline{y})^2}{N-1}} \tag{C.3}$$

The possible values for correlation range from -1 to +1. The correlation values give both the direction of the correlation and the strength. The direction of the correlation is given by the sign of the correlation coefficient. A positive correlation means that high scores for one variable correspond with high scores on another variable, and low scores on one variable correspond with low scores on another variable. A negative correlation means that high scores on one variable correspond with a low score on the other variable. Examples of positive and negative correlations are shown in figure C.1. The other information that the correlation coefficient gives is the strength of the correlation. The closer the value of the correlation coefficient is to $\mid 1 \mid$ the stronger the correlation. Examples of strong and weak correlations are given below in figure C.1.

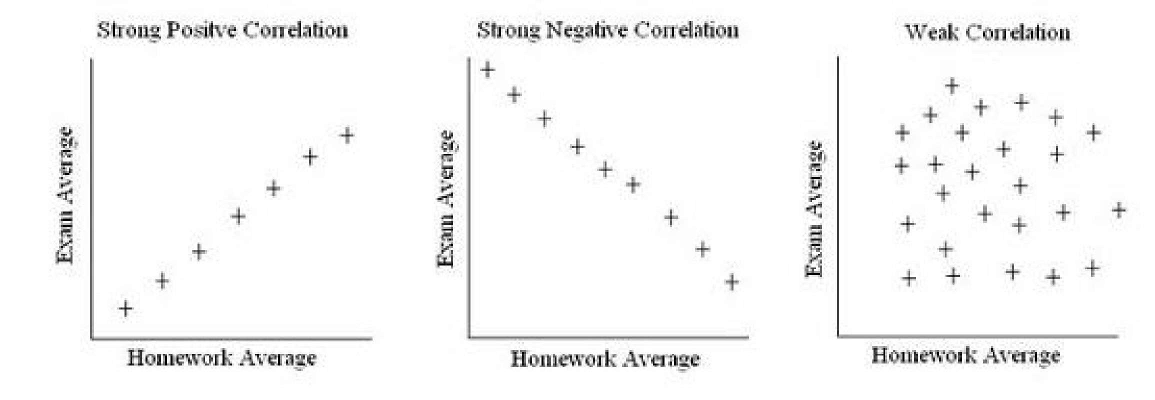

Figure C.1: Positive, Negative, and Weak Correlation

Correlation does not explain why relationships between variables occur, it only determines if a relationship between two variables exist. The Pearson correlation coefficient is rarely interpreted. The interpreted value is the coefficient of determination (r^2). The coefficient of determination represents the shared or explained variation between two variables. For example, if (r^2) for the earlier example was 0.48, then 48 percent of the variation between the homework and exams were shared. The shared variation is shown in figure 2 by area 2. The unexplained variation between two variables is found by:

$$UnexplainedVariation = 1 - r^2 \tag{C.4}$$

The unexplained variation for the example would be 0.52. This is interpreted as 52 percent of the variation in the exam score was not due to the homework, it was due to other unmeasured variables. This is shown in the figure below by area 1.

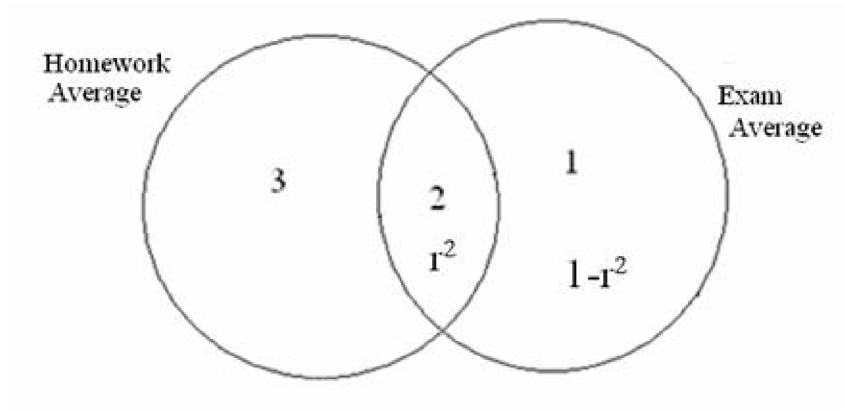

Figure C.2: Correlations among two variables

The correlation coefficient is tested for significance with a t-test. The null hypothesis tested is there is no correlation among the two variables (r = 0). The observed t-value is calculated by:

$$t = \frac{r\sqrt{N-2}}{\sqrt{1 -^{r} 2}} \tag{C.5}$$

where N is the total number the number of data values in the data set. This observed value is tested against a critical t-value at the following degrees of freedom:

$$df = N - 2 \tag{C.6}$$

The degrees of freedom represent how much the deviations are able to vary from each other. If the observed t-value is greater than the critical value than the null hypothesis of no correlation among the two sets of data is rejected.

C.2 Simple Regression

There is one predictor variable (independent variable) and one criterion variable (dependent variable) in simple regression. [75] [76] [77] [78] The goal of simple regression is to predict the criterion variable from the predictor variable. This is accomplished using a prediction equation where the predictor variable has a weight (regression coefficient) attached to it. There are two types of regression coefficients. The β-weight is the standardized regression coefficient. It has no scales (no units) which allows for comparisons among predictors within the study. This weight is more important in multiple regression because there are several predictor variables. The second weight is the b-weight or unstandardized regression coefficient. The relationship between the regression coefficients is:

$$b = \beta \frac{S_y}{S_x} \tag{C.7}$$

where S_y and $S_x$are the standard deviations of y and x. The scales are reattached to the unstandardized regression coefficient when the β-weight is multiplied by the standard deviations. The scales allow a researcher to make comparisons to unstandardized regression coefficients stated in literature.

Once the regression coefficients are found it is possible to form two prediction equations. The standardized prediction equation is given by:

$$Y = \beta x \tag{C.8}$$

The unstandardized prediction equation is found from:

$$Y = bx + a \tag{C.9}$$

where the y-intercept (a) is found from:

$$a = \overline{Y} - b\overline{x} \tag{C.10}$$

Both the prediction equation and the correlation coefficient are tested for significance using an F-test. The F-test is given by:

$$F = \frac{r^2/k}{(1 - r^2)/(N - k - 1)} \tag{C.11}$$

where r is the correlation coefficient, k is the number of predictor variables (always one for a simple regression), and N is the number of data values in the study. The F value is then tested against a critical F value at $(df_{regression}, df_{residual})$. These df are determined by

$$df_{regression} = k \tag{C.12}$$

$$df_{residual} = N - k - 1 \tag{C.13}$$

The goal is to beat the critical value which means the null hypothesis of the two variables not being related is rejected. When comparing the F value and critical value the table will give a p-value. This is the probability of making a mistake. The regression coefficients are tested for significance using a t-test. The t-value is calculated by:

$$t = \frac{b}{s_b} \tag{C.14}$$

where b is the unstandardized regression coefficient found above and S_b is the standard error of the regression coefficient. The standard error for the regression coefficient is found by:

$$S_b = \frac{\sum(x_i - \overline{x})(y_i - \overline{y})}{\sum(x_i - \overline{x})^2} \tag{C.15}$$

The t-value is then compared to a critical value at$df_{residual}$. T-values larger than two are typically significant. To test the regression coefficients using an F-test the t-value would have to be converted to an F-value using the relation:

$$F = t^2 \tag{C.16}$$

This value is then tested against a critical value at (1, $df_{residual}$). Again the goal is to beat the critical value.

C.3 Multiple Regression

Several predictor variables are used to predict the criterion variable in multiple regression. [75] [76] [77] [78] Predictions are made by forming a prediction equation where the predictor variables are weighted by regression coefficients. The regression coefficients are either standardized or unstandardized. The standardized regression coefficients (β-weights) do not have scales which allow comparisons of predictor variables in the study. The larger β-weights are better predictors of the criterion variable. If comparisons to variables in other studies are desired then the unstandardized regression coefficients (b-weights) are used. Comparisons are possible because the b-weights have scales attached to them. The regression coefficients are related by:

$$b_i = \beta_i \frac{S_y}{S_{xi}} \tag{C.17}$$

where S_y is the standard deviation of the criterion variable, and S_{xi} is the standard deviation of the predictor variable.

Prediction equations are formed using the regression coefficients. The standardized prediction equation is given by:

$$Y = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_N x_N \tag{C.18}$$

The unstandardized prediction equation is given by:

$$Y = a + b_1 x_1 + b_2 x_2 + \ldots + b_N x_N \tag{C.19}$$

The intercept is given by::

$$a = \overline{Y} - b_1 \overline{x_1} - b_2 \overline{x_2} - \ldots - -b_N \overline{x_N} \tag{C.20}$$

A benefit of running multiple regression is the coefficient of determination (R^2) is found. This value is also referred to as the squared multiple correlation coefficient. The squared multiple correlation coefficient represents the amount of variation in the criterion variable that is shared with the predictor set. The shared variation between the predictor set and the criterion variable is shown in the figure below by areas 1+2+3. The unexplained variation is given by:

$$Unexplained Variation = 1 - R^2 \tag{C.21}$$

The unexplained variation is shown by area 7. Both the shared variation and unexplained variation is interpreted in the same manner as in correlation.

Another method to determine the best predictor variable is to find the squared semi-partials. The squared semi-partials represent the unique variation that the criterion variable has with a predictor variable. This is shown by area 1 for variable 2, and area 3 for variable 1.

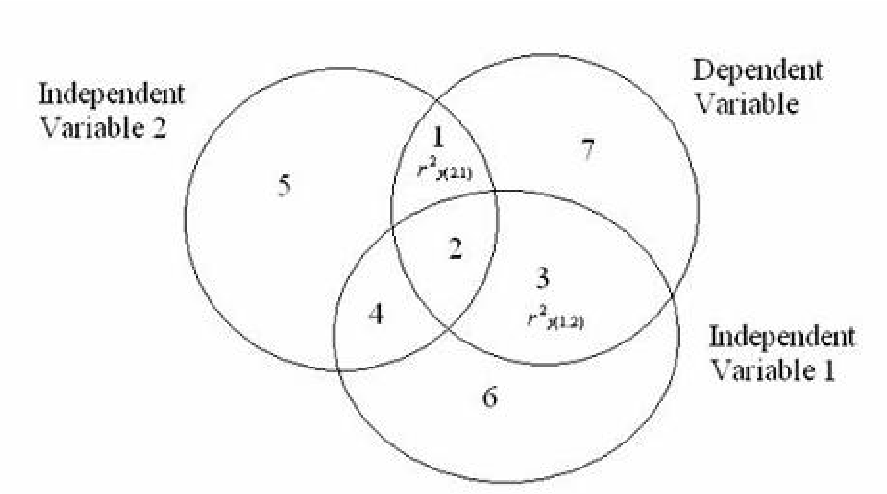

Figure C.3: Correlations among three variables

Both the prediction equation and the correlation coefficient are tested for significance using an F-test. The F-test is given by:

$$F = \frac{R^2/k}{(1 - R^2)/(N - k - 1)} \tag{C.22}$$

where R is the correlation coefficient, k is the number of predictor variables (always one for a simple regression), and N is the number of data values in the study. The F value is then tested against a critical F value at $(df_{regression}, df_{residual})$. These df are determined by

$$df_{regression} = k \tag{C.23}$$

$$df_{residual} = N - k - 1 \tag{C.24}$$

The goal is to beat the critical value which means the null hypothesis of the two variables not being related is rejected. When comparing the F value and critical value the table will give a p-value. This is the probability of making a mistake. The regression coefficients are tested for significance using a t-test. The t-value is calculated by:

$$t = \frac{b}{s_b} \tag{C.25}$$

where b is the unstandardized regression coefficient found above and S_b is the standard error of the regression coefficient. The t-value is then compared to a critical value at$df_{residual}$. T-values larger than two are typically significant. To test the regression coefficients using an F-test the t-value would have to be converted to an F-value using the relation:

$$F = t^2 \tag{C.26}$$

This value is then tested against a critical value at (1, $df_{residual}$). Again the goal is to beat the critical value.

C.4 Backward Stepwise Regression

The goal of backward stepwise regression [75] is to maximize the squared correlation coefficient by eliminating non-significant predictors. The procedure initially enters all of the variables into the regression. The worst predictor is eliminated, one predictor at a time, until only significant predictors remain. The worst predictor is determined by examining either the squared semi-partials or the standardized regression coefficients. When only significant predictors remain the squared semi-partials are used to determine which variable has the most shared variation with the dependant variable. The prediction equation and the squared multiple correlation coefficient can also be found. Let's consider an example with five predictor variables (X_1, X_2,

X_3, X_4, and X_5). Initially all five variables are entered into the regression. After the regression X_1, X_2, and X_3 were significant, and X_4 and X_5 were non-significant. The worst predictor, determined by the lowest standardized regression coefficients, between X_4 and X_5 is eliminated. For the purpose of this example let's assume X_4 was a worse predictor than X_5, so X_4 is eliminated from future analysis. The regression is now run again. After the regression X_1, X_2, and X_3 were significant, X_5 was non-significant. X_5 would now be eliminated and the regression is run again. At this time let's assume the remaining three variables are significant. At this time the squared semi-partials are used to determine which variable has the most shared variation with the dependant variable. The prediction equation and the squared multiple correlation coefficient can also be found.

C.5 Analysis of Variance

Analysis of variance [79] (ANOVA) determines if mean differences between groups are significant. The differences are tested for significance using an F-test. An F-test is a ratio of the effect of the treatment divided by the error. This F-value is then compared to a critical F-value. The mean differences between groups are significant if the calculated F-value is larger than the critical value. ANOVA only answers if the means are different. To obtain estimates of the strength of effect ω^2 needs to be determined. Small effects occur when $0.01 \leq \omega^2 < 0.06$. A medium effect occurs when $0.06 \leq \omega^2 < 0.15$. A large effect occurs if $\omega^2 > 0.15$. If the assumptions of ANOVA are failed then a possibility is to use Mann-Whitney U, the non-parametric counterpart to ANOVA. [80] It tests if there are significant differences between two variables by comparing the sum of the ranks. Each score is ranked with 1 going to the smallest variable, 2 to the next smallest, until all of the scores are ranked. The ranks are then summed and compared for differences.

C.6 Regression Assumptions

In order to use regression techniques assumptions have to be tested. If these assumptions are failed then it is not appropriate to use that statistic. For regression the assumptions are:

(1) The first regression assumption is that the independent variables are fixed. This means that someone else can use the same scales that we use in our study. This assumption is not hard to meet.

(2) The next assumption is the independent variables are measured without error. Again this assumption is not hard to meet. Reliability data on the surveys could be presented to show that we meet this assumption.

(3) The correct mathematical model is used in the analysis. This basically says that there are no missing variables. A literature review of appropriate variables could solve this assumption

(4) The regression of Y on X is linear. To test this assumption the predicted values vs. actual values would be plotted. When this is plotted if the assumption is met then there should be a nice linear flow to the data.

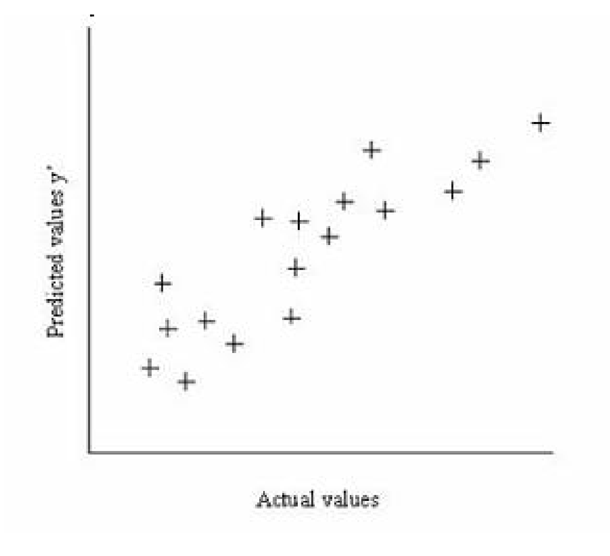

Figure C.4: Linear assumption for regression.

(5) The next assumption deals with errors. This is the same three assumptions used in a simple ANOVA (independence, normality, and homogeneity of variance). The first assumption would be independence. This says that the scores in the data set are unrelated. The second assumption is normality. This says that scores are symmetric around the mean. The last assumption is homogeneity of variance. This says that the scores are spread around the mean the same. To test for the error assumption, plot the predicted values vs. the residuals (y-y'). If this assumption is met then there should be a nice spherical pattern (figure 5).

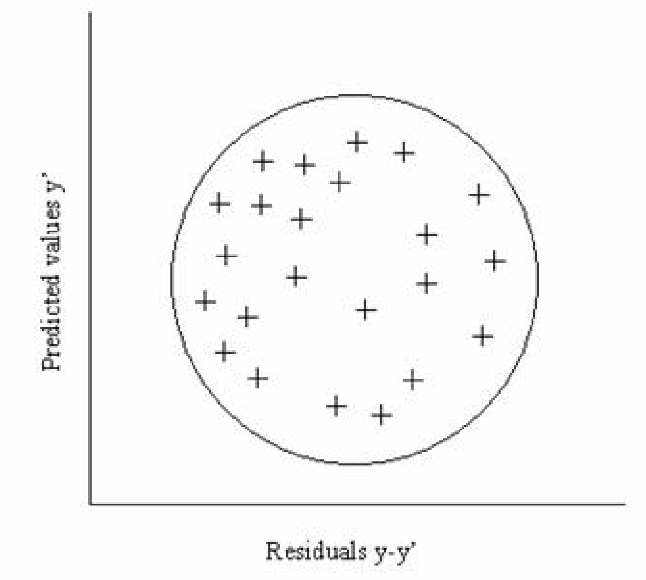

Figure C.5: Error for regression.

APPENDIX D

Test of Regression Assumptions One Through Three

The first three regression assumptions are not hard to meet. There is nothing special about my scales. Anyone could use the same set of scales. The surveys have been shown to be reliable, so the error assumption is not a problem. From the literature review there does not seem to be any missing variables. That leaves the last two assumptions.

APPENDIX E

Test of Regression Assumption Four and Five for Research Question One-Fall 2007 Data

Step 1-All variables are included in the regression. This includes homework average, lab average, PRS score, and pre-class quizzes.

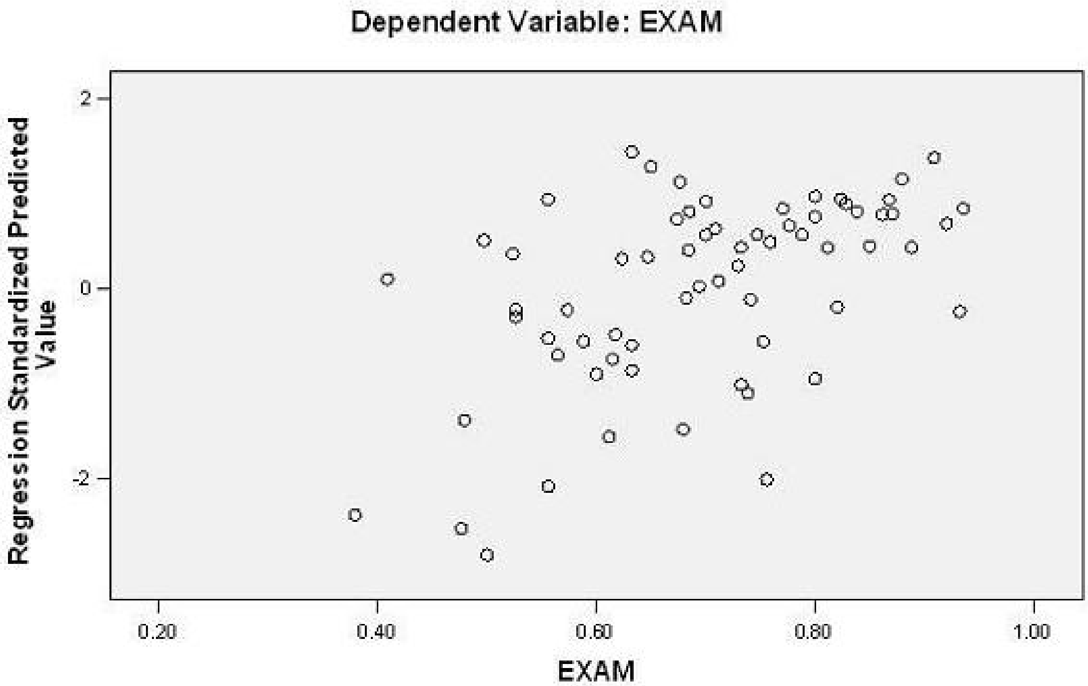

Figure E.1: Step 1-All variables entered.

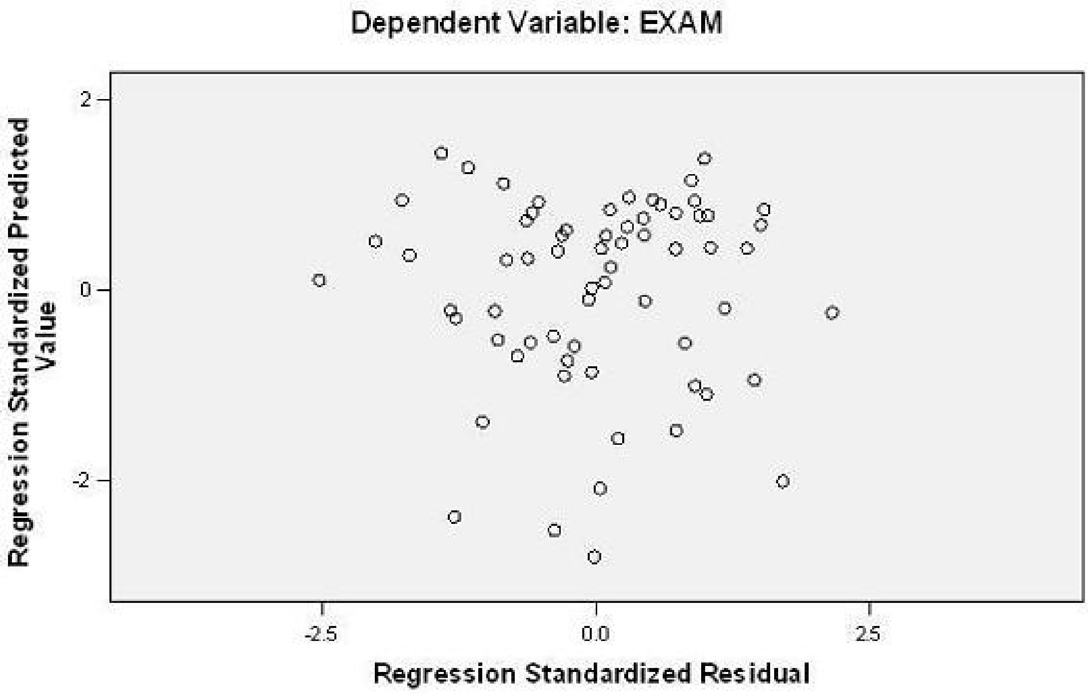

Figure E.2: Step 1-All variables entered.

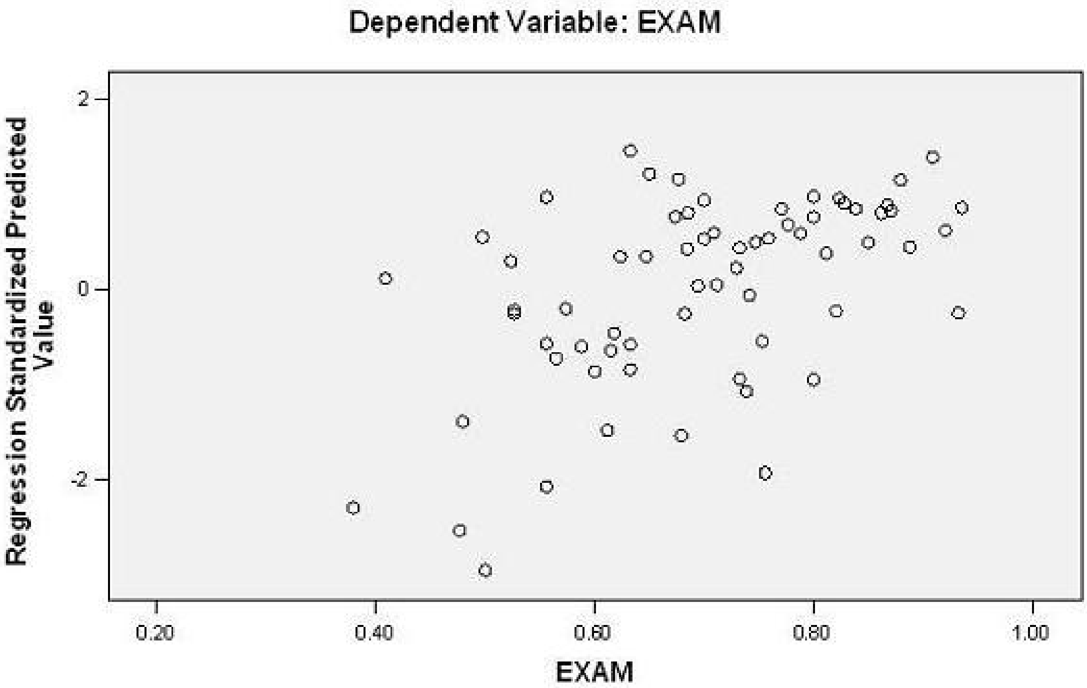

Figure E.3: Step 2-The clicker score was removed.

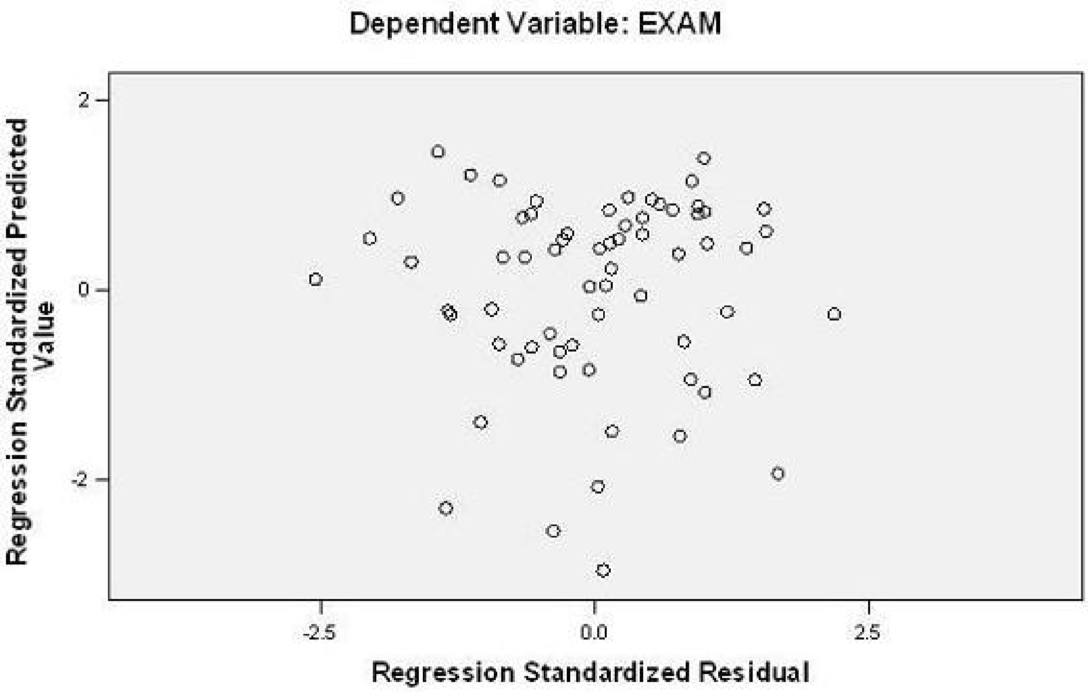

Figure E.4: Step 2-The clicker score was removed.

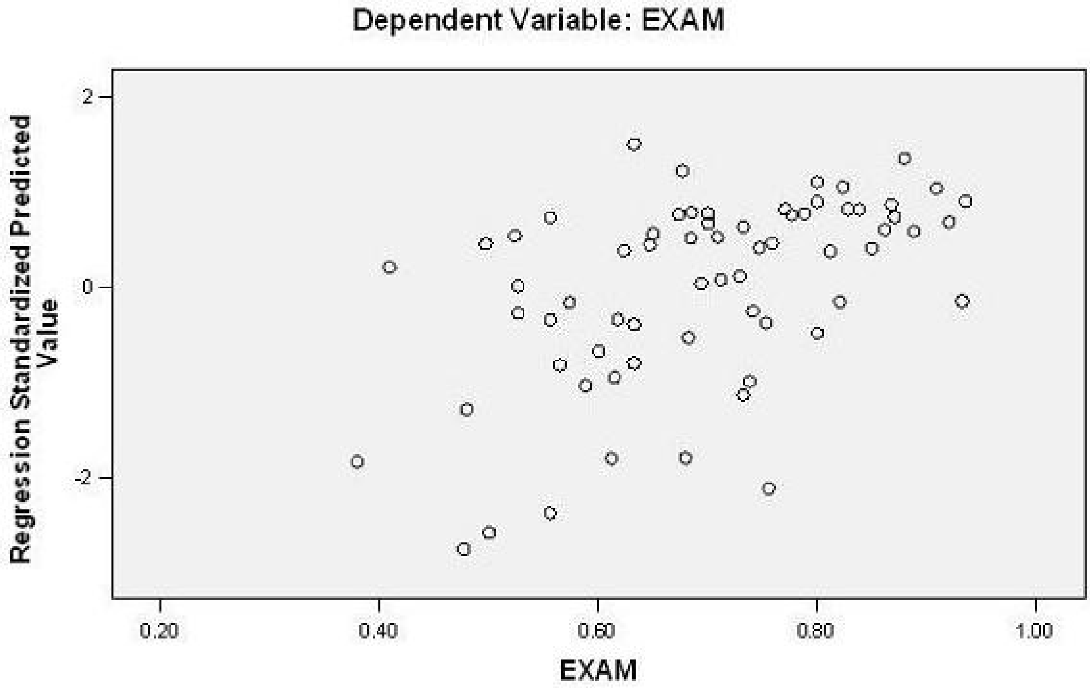

Figure E.5: Step 3-The pre-class quizzes were removed.

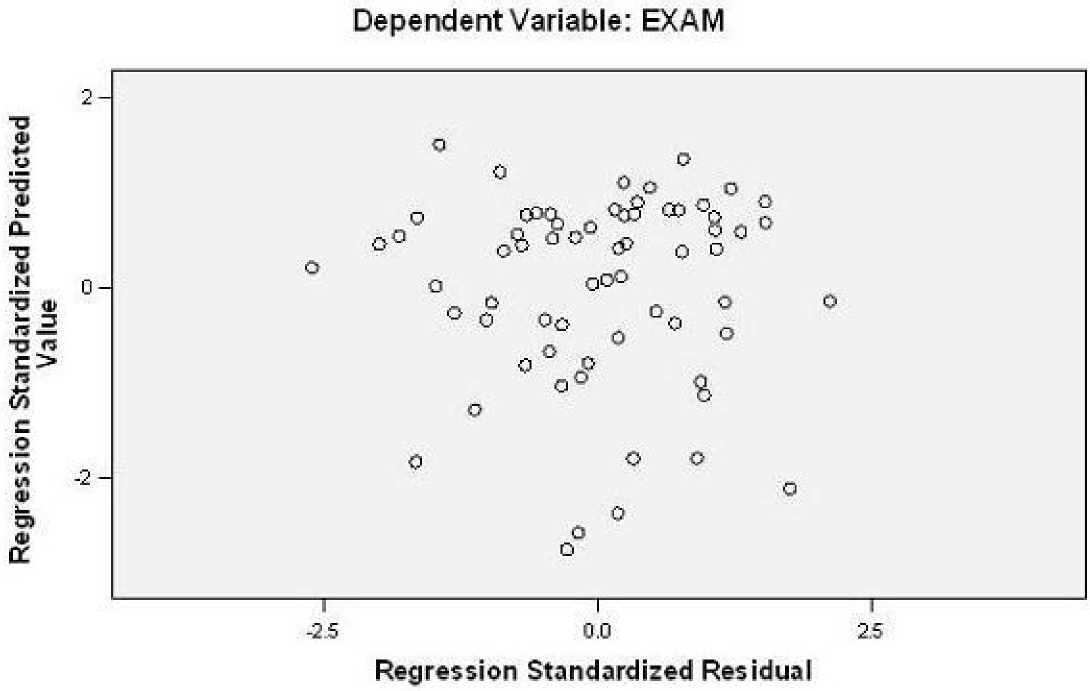

Figure E.6: Step 3-The pre-class quizzes were removed.

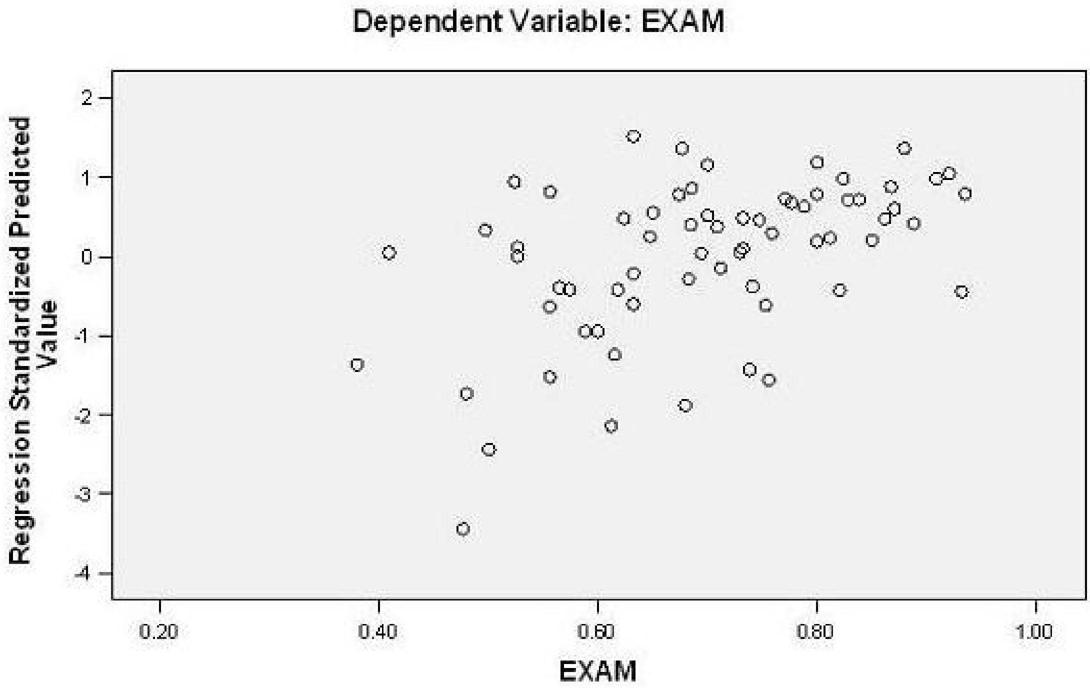

Figure E.7: Step 4-The homework average was removed.

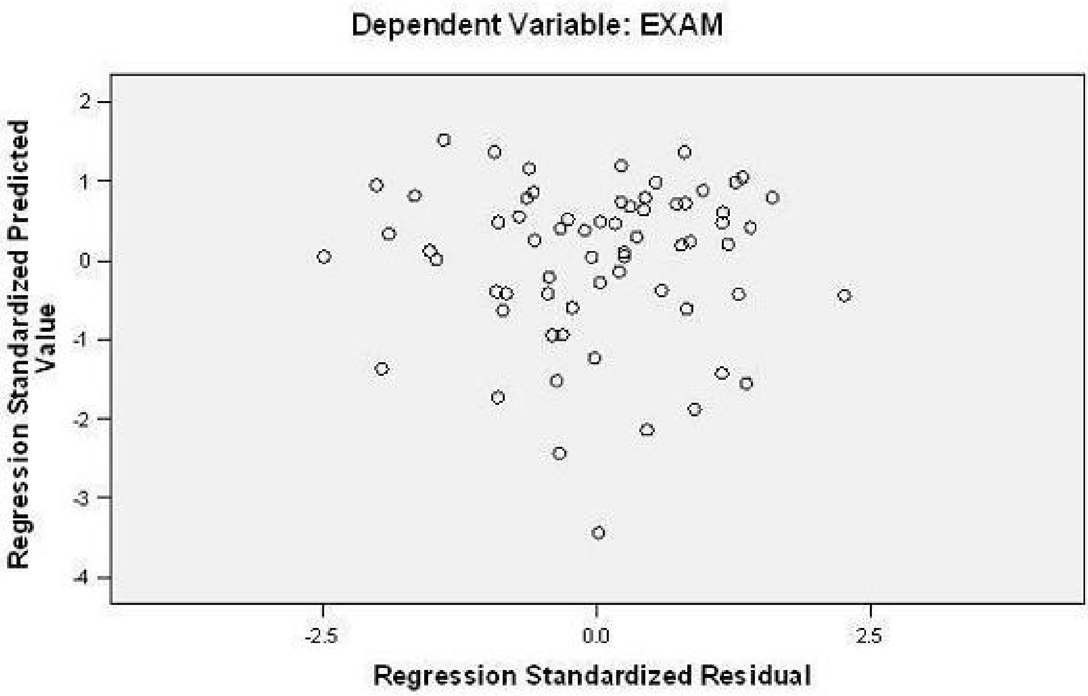

Figure E.8: Step 4-The homework average was removed.

E.1 Test of Regression Assumption Four and Five for Research Question One-Spring 2008 Data

Step 1-All variables are included in the regression. This includes homework average, lab average, PRS score, and HBL average.

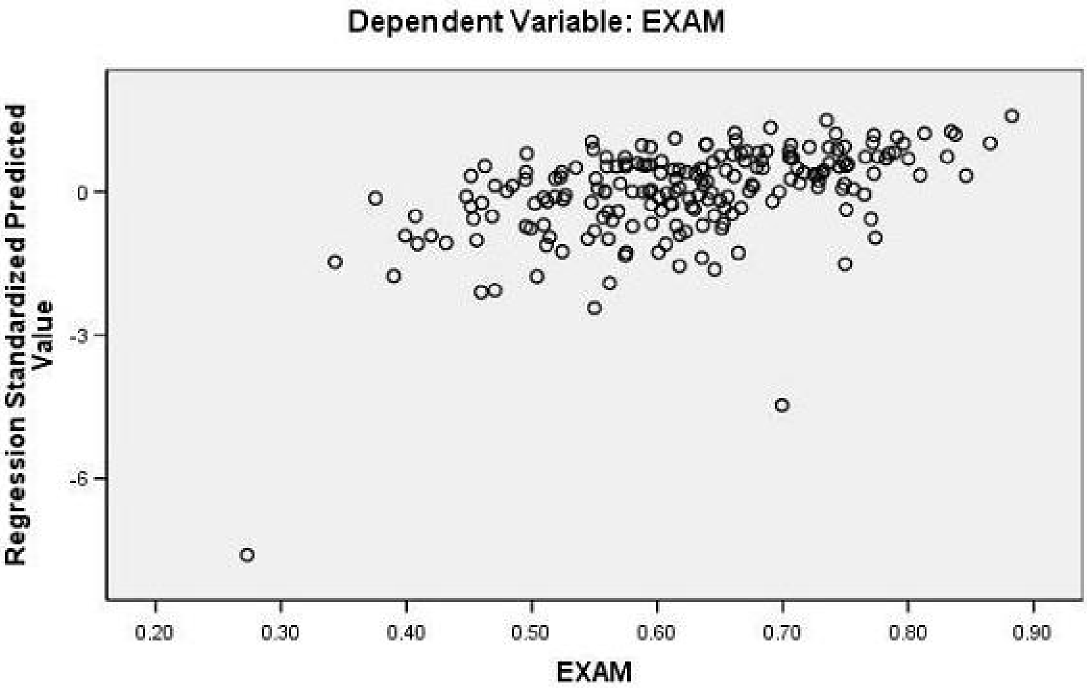

Figure E.9: Step 1-All variables entered.

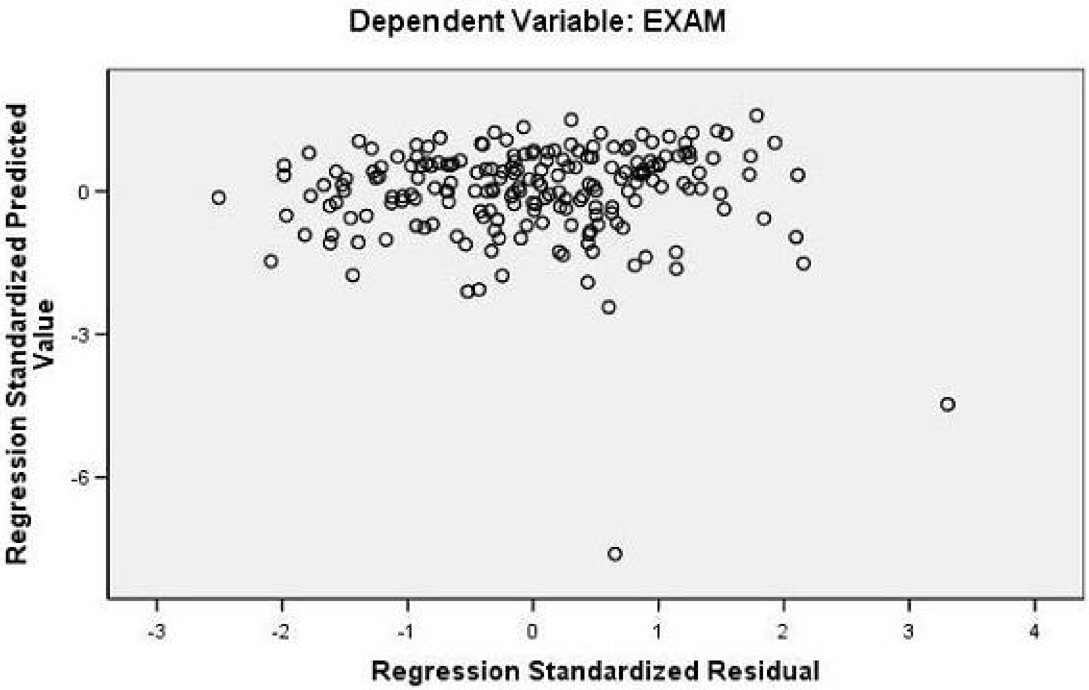

Figure E.10: Step 1-All variables entered.

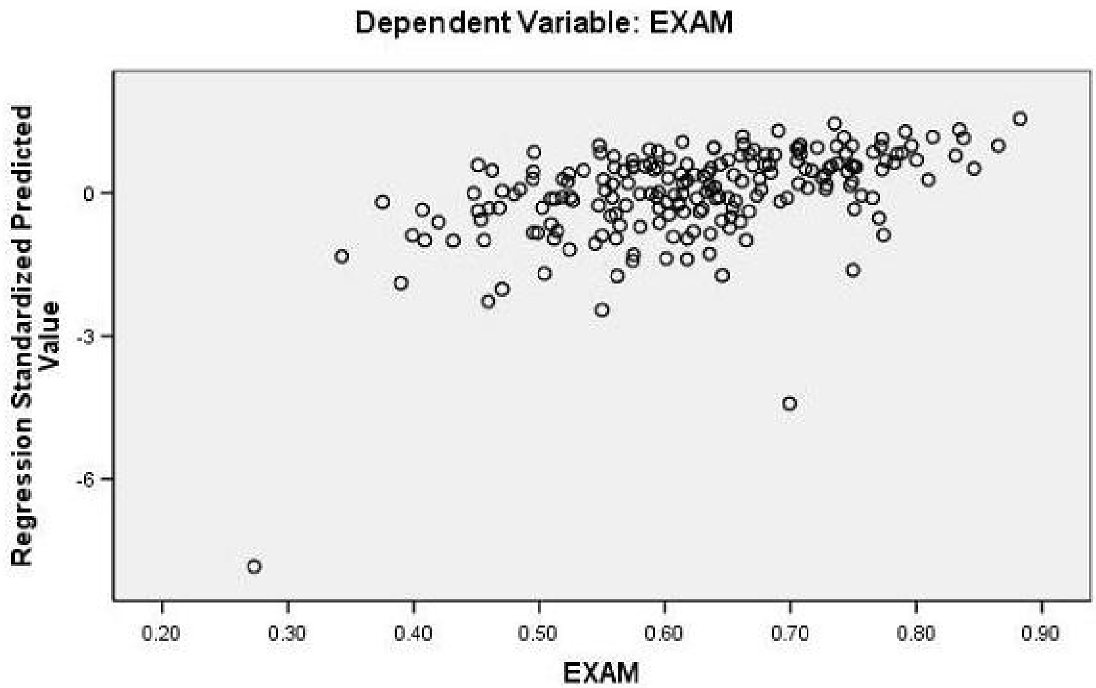

Figure E.11: Step 2-The clicker score was removed.

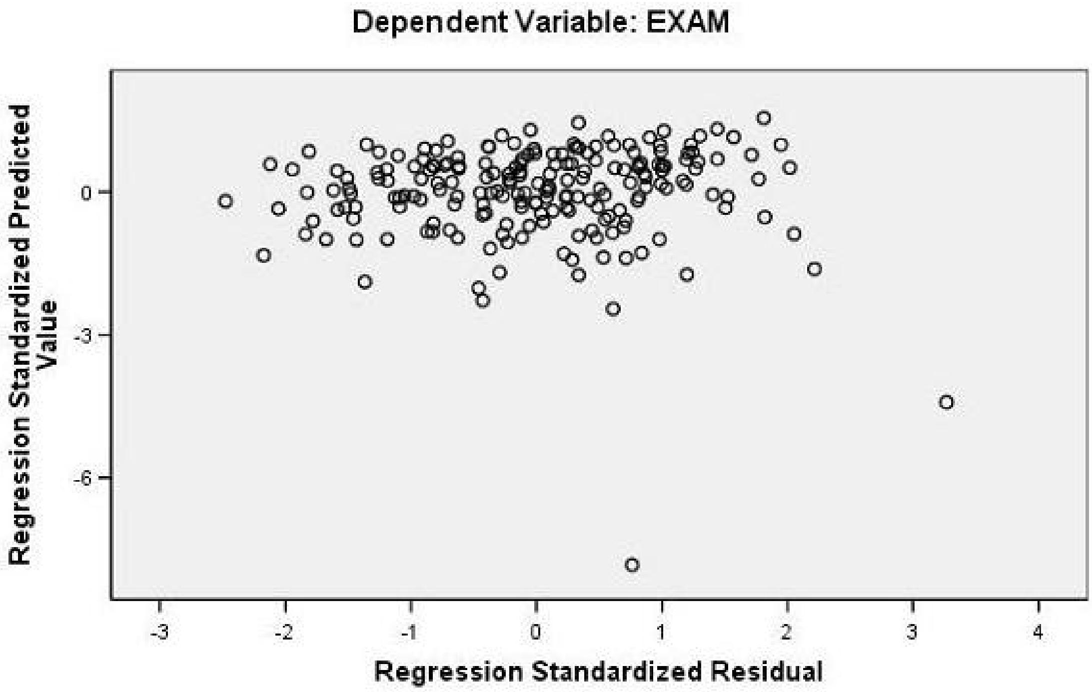

Figure E.12: Step 2-The clicker score was removed.

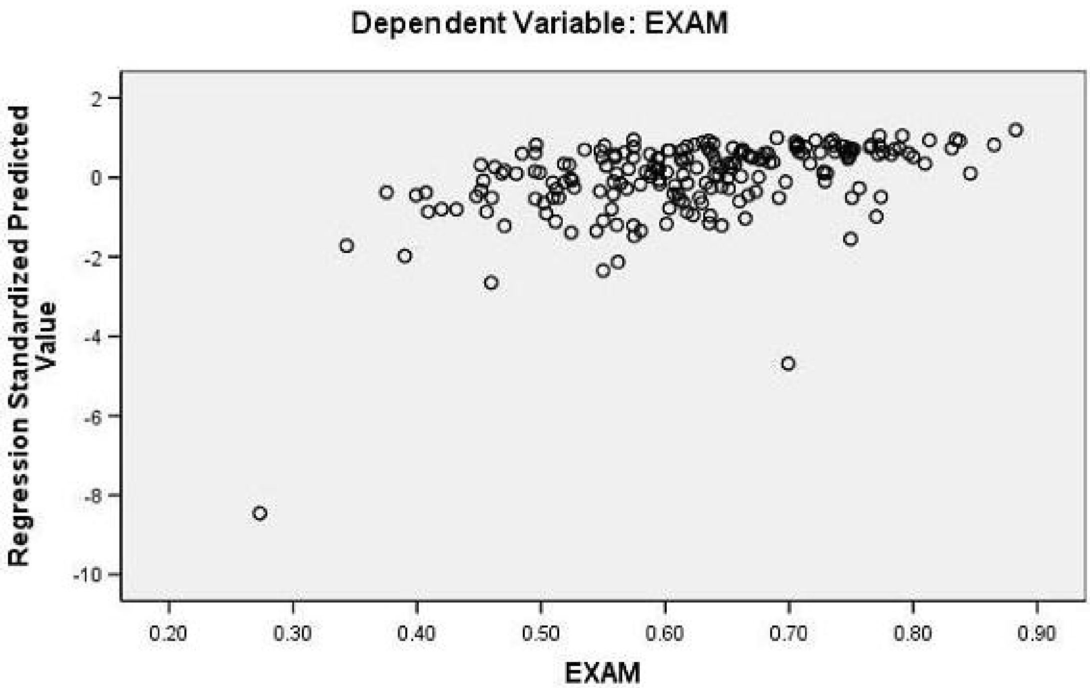

Figure E.13: Step 3-The HBL score was removed.

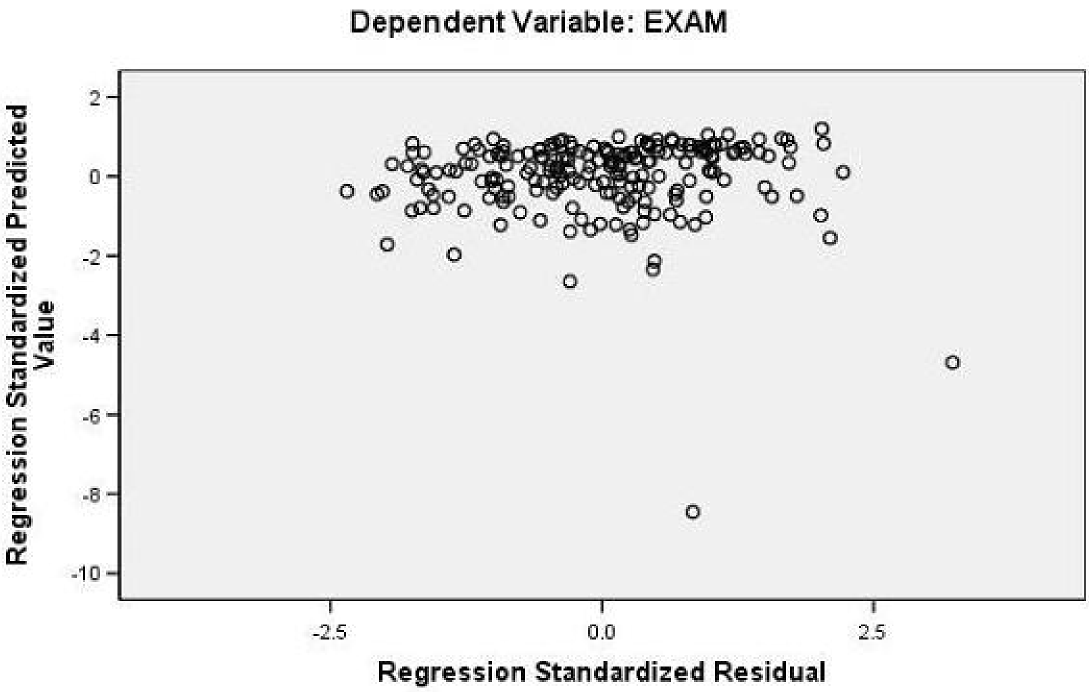

Figure E.14: Step 3-The HBL score was removed.

E.1.1 Analysis

The predicted score versus actual score seems to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The predicted score versus residual seems to have a circular pattern. Due to this assumption five is satisfied.

APPENDIX F

Test of Regression Assumption Four and Five for Research Question Two-Fall 2007 Data

Step 1-All variables are included in the regression. This includes ACT math score, ACT science score, and university GPA.

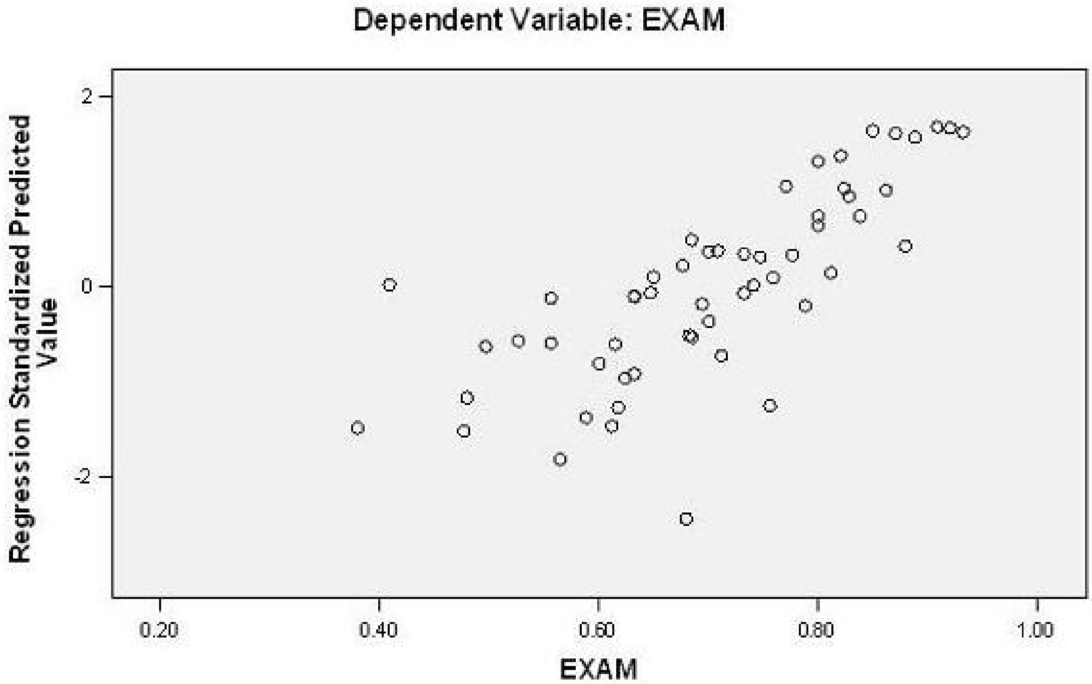

Figure F.1: Step 1-All variables entered.

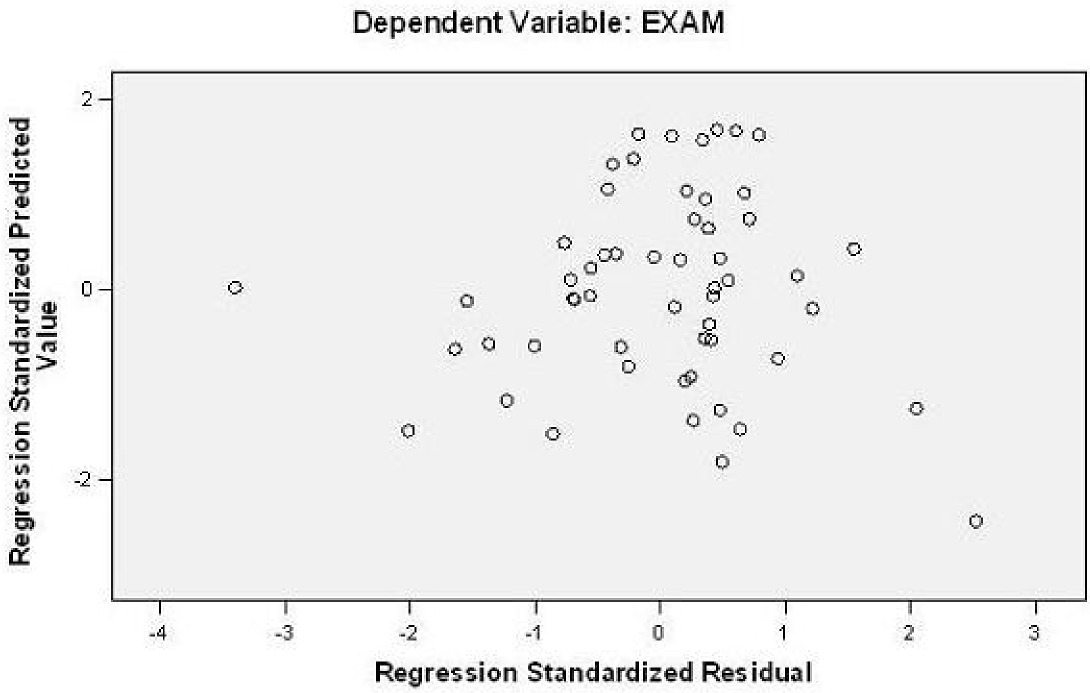

Figure F.2: Step 1-All variables entered.

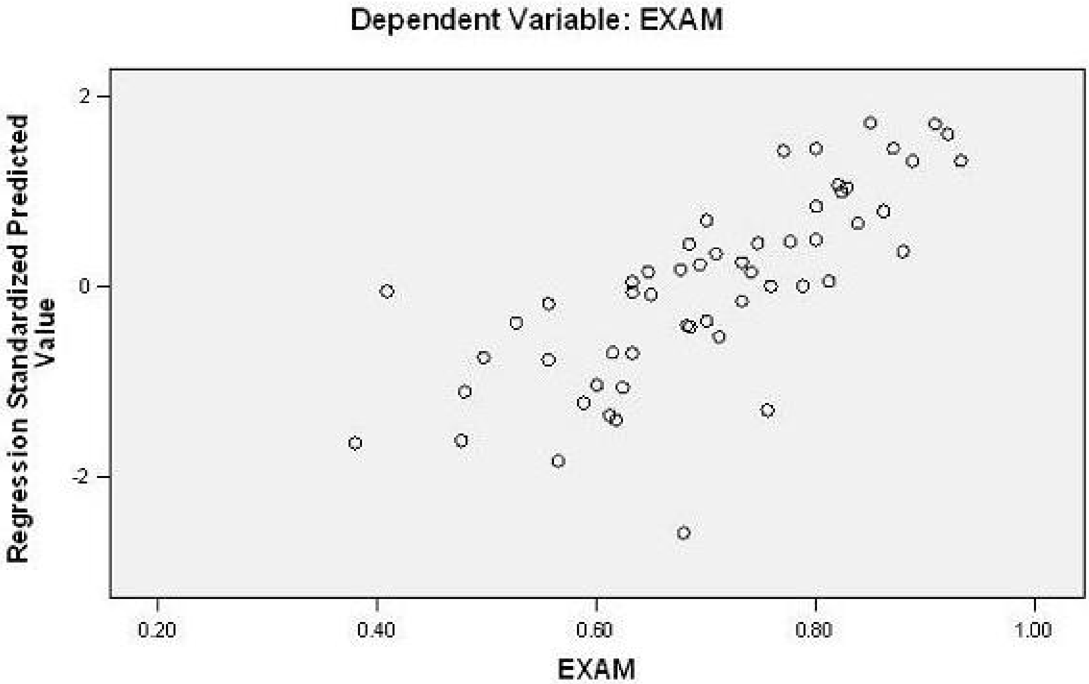

Figure F.3: Step 2-The ACT math was removed.

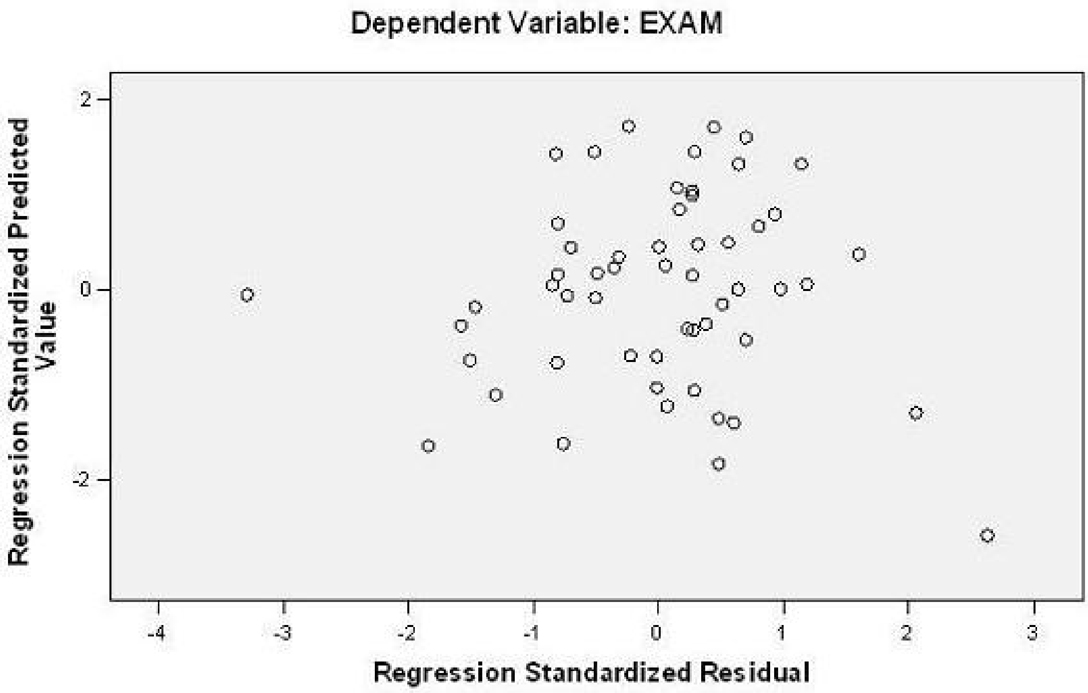

Figure F.4: Step 2-The ACT math was removed.

F.1 Test of Regression Assumption Four and Five for Research Question Two-Spring 2008 Data

Step 1-All variables are included in the regression. This includes ACT math score, ACT science score, and university GPA.

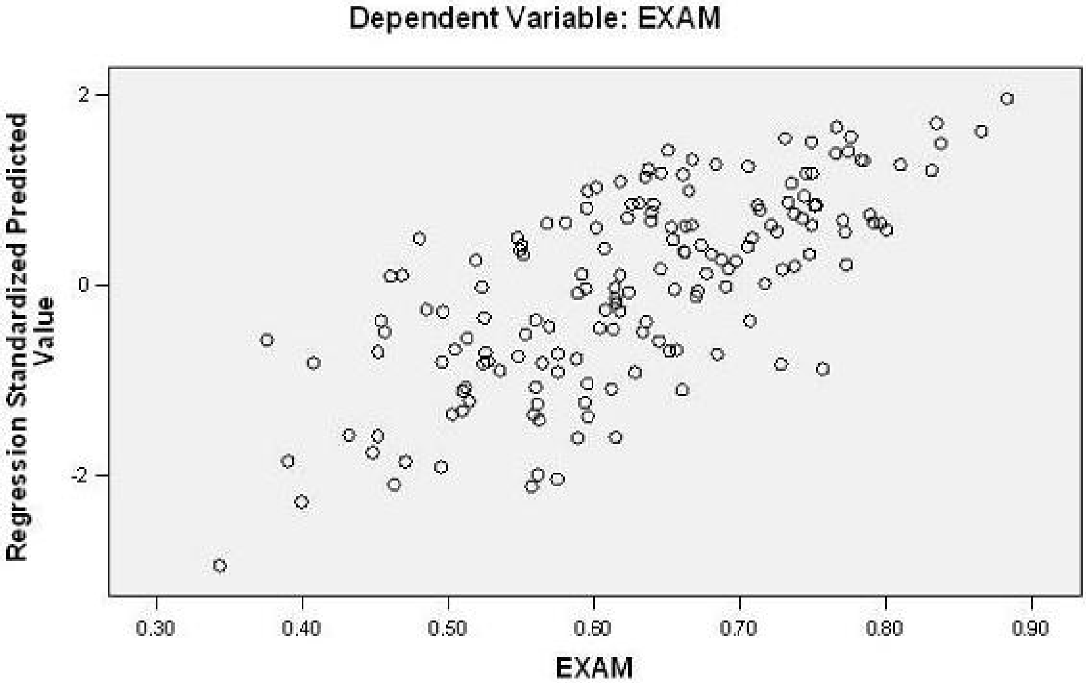

Figure F.5: Step 1-All variables entered.

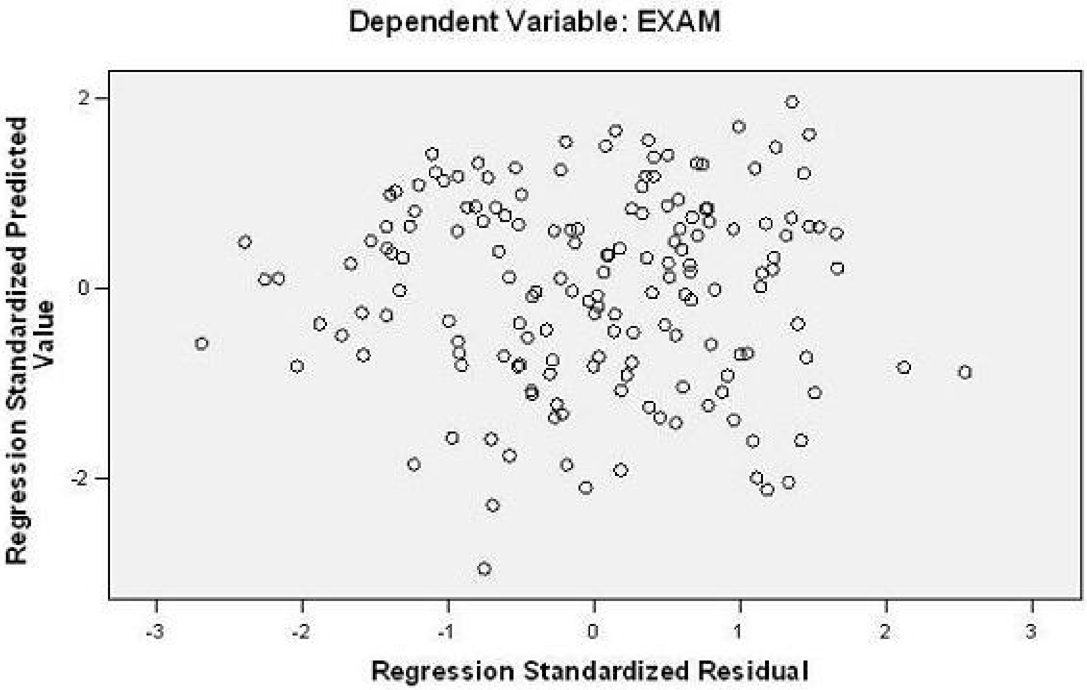

Figure F.6: Step 1-All variables entered.

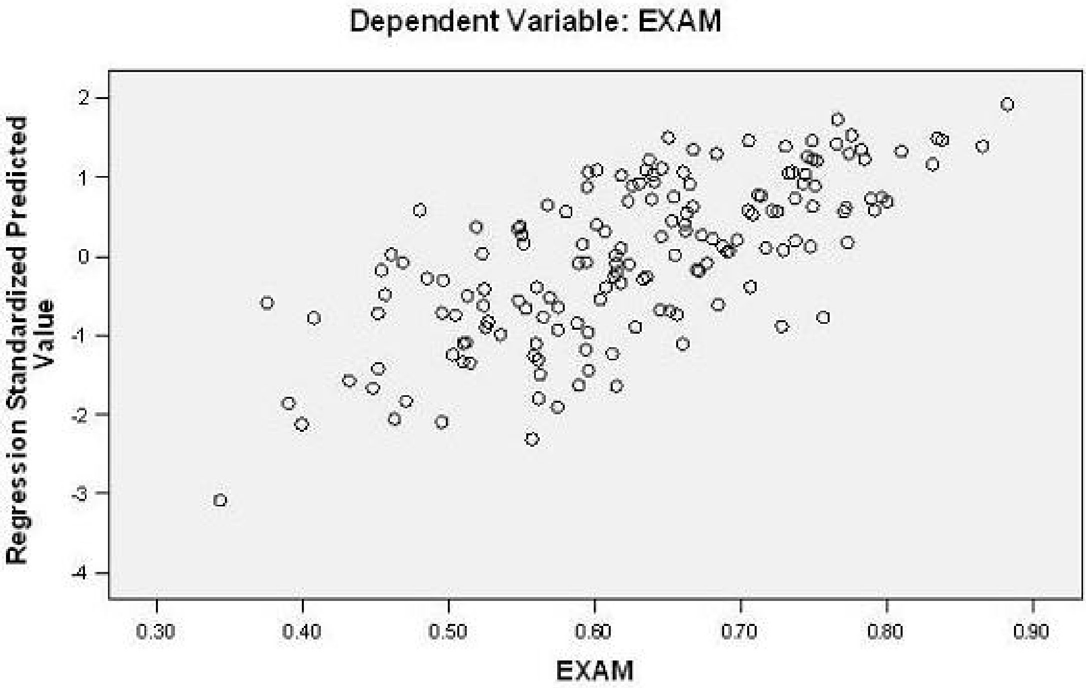

Figure F.7: Step 2-The ACT math was removed.

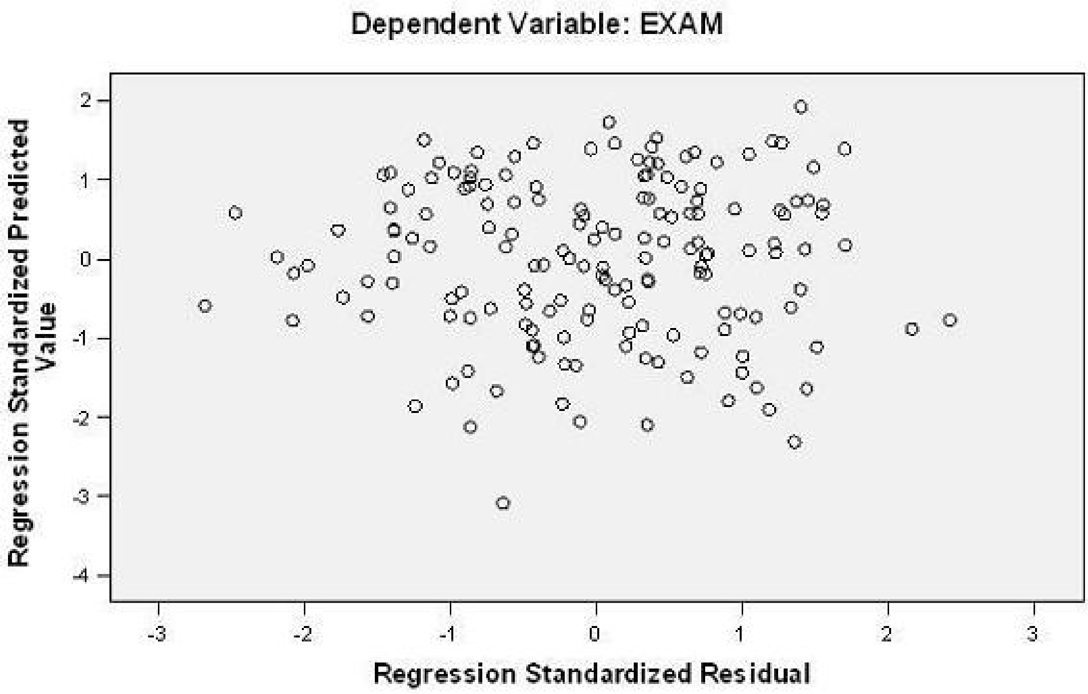

Figure F.8: Step 2-The ACT math was removed.

F.1.1 Analysis

These graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The predicted score versus residual seems to have a circular pattern. Due to this assumption five is satisfied.

APPENDIX G

Test of Regression Assumption Four and Five for Research Question Three-Fall 2007 Data

Step 1-All variables are included in the regression. This includes MPEX pre-test score, MPEX post-test score, and the score for each of the four dimensions of the Index of Learning Styles.

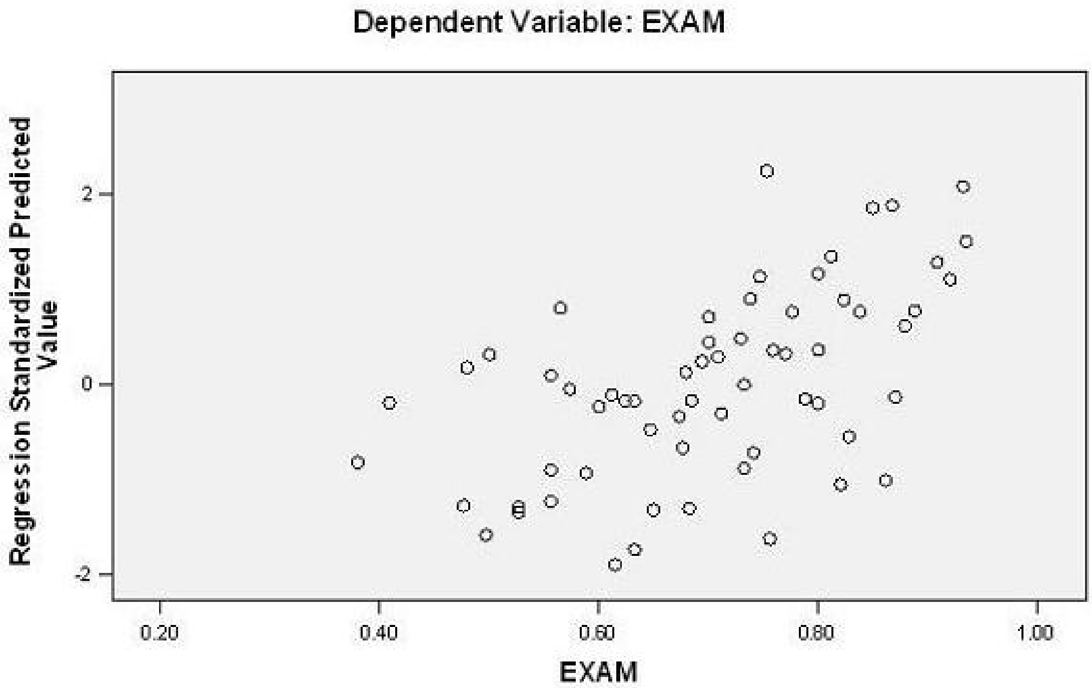

Figure G.1: Step 1-All variables entered.

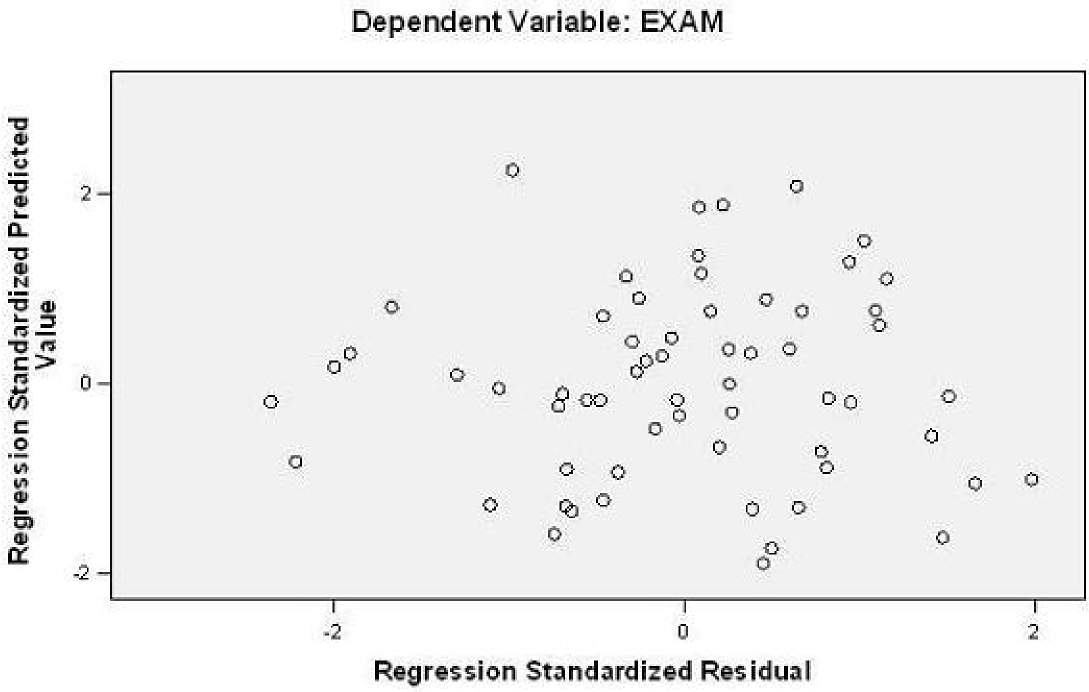

Figure G.2: Step 1-All variables entered.

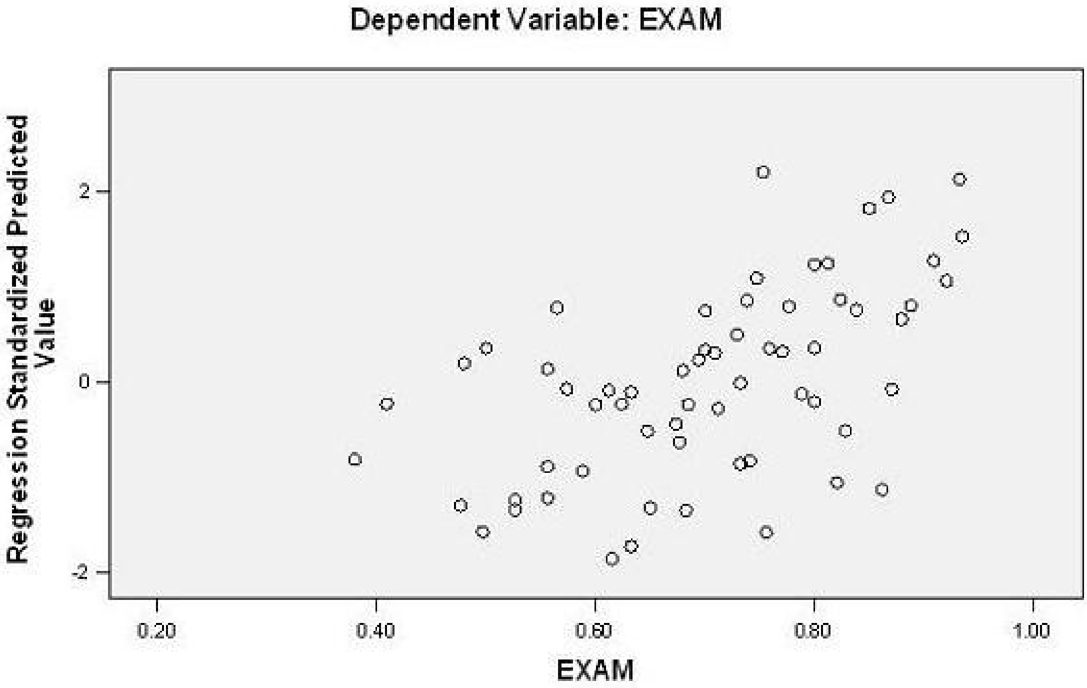

Figure G.3: Step 2-The visual score was removed.

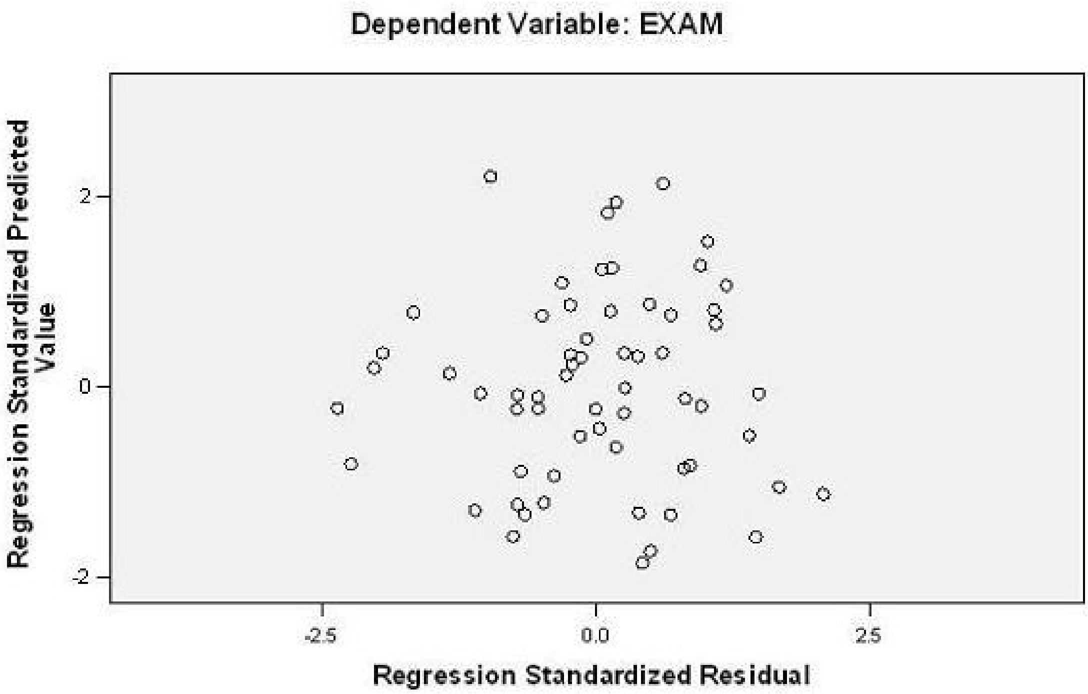

Figure G.4: Step 2-The visual score was removed.

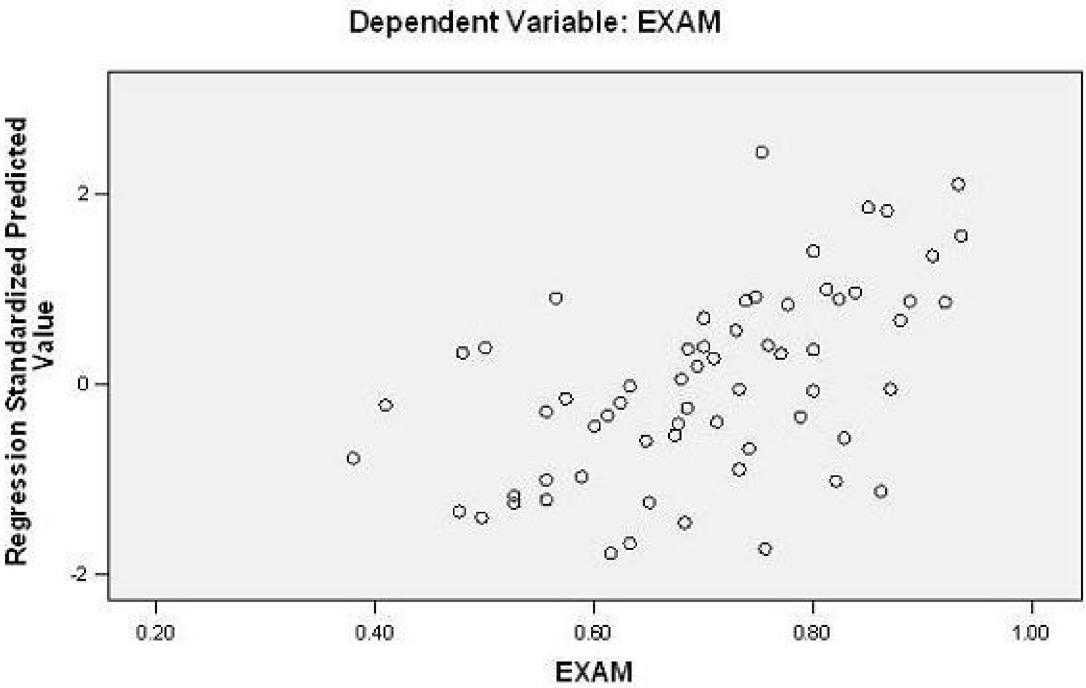

Figure G.5: Step 3-The MPEX post-test score was removed.

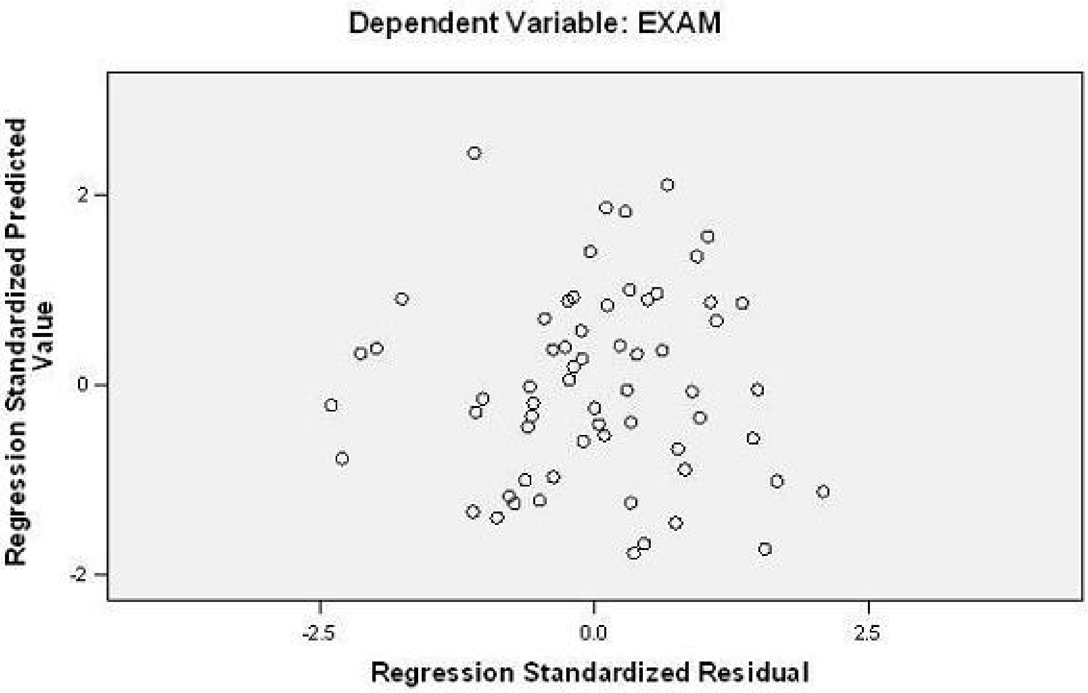

Figure G.6: Step 3-The MPEX post-test score was removed.

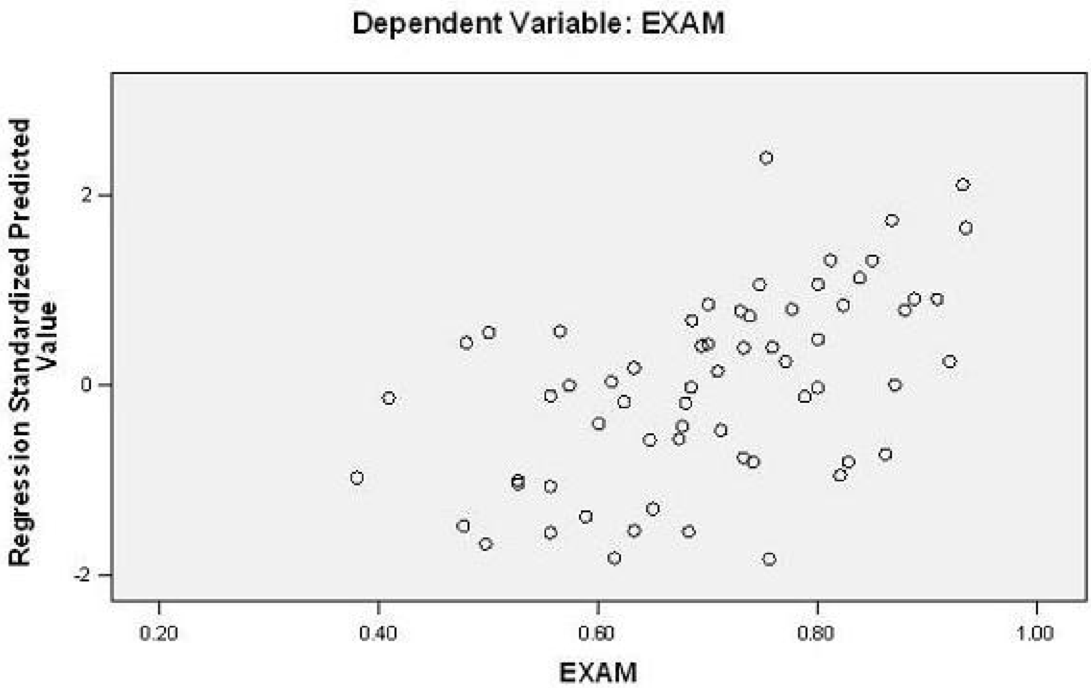

Figure G.7: Step 4-The sensing score was removed.

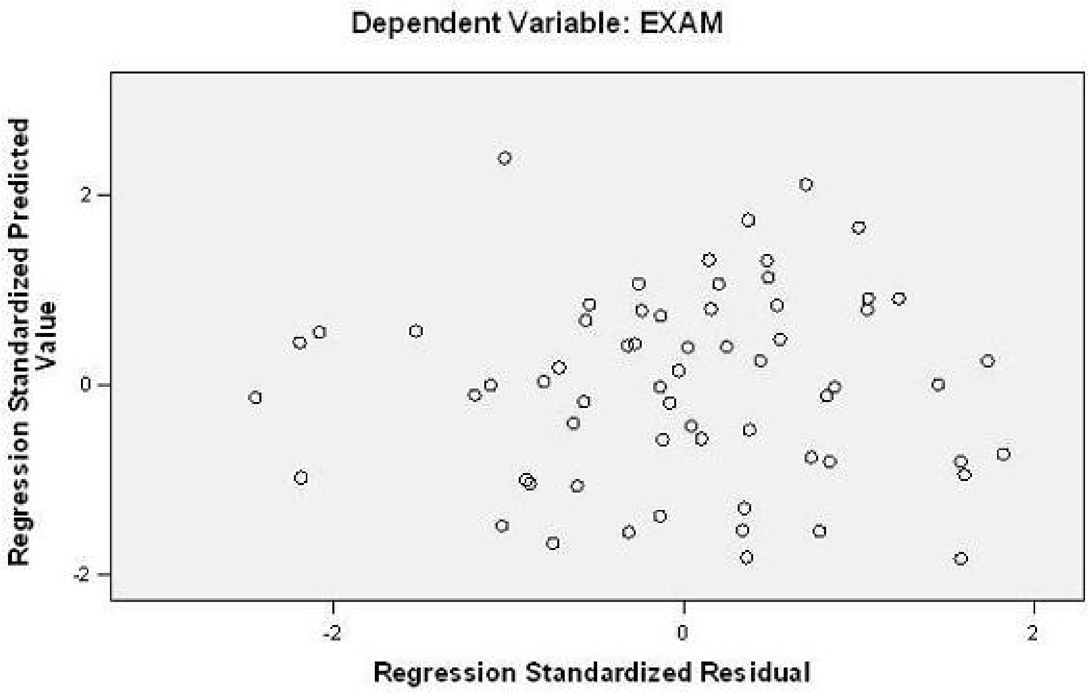

Figure G.8: Step 4-The sensing score was removed.

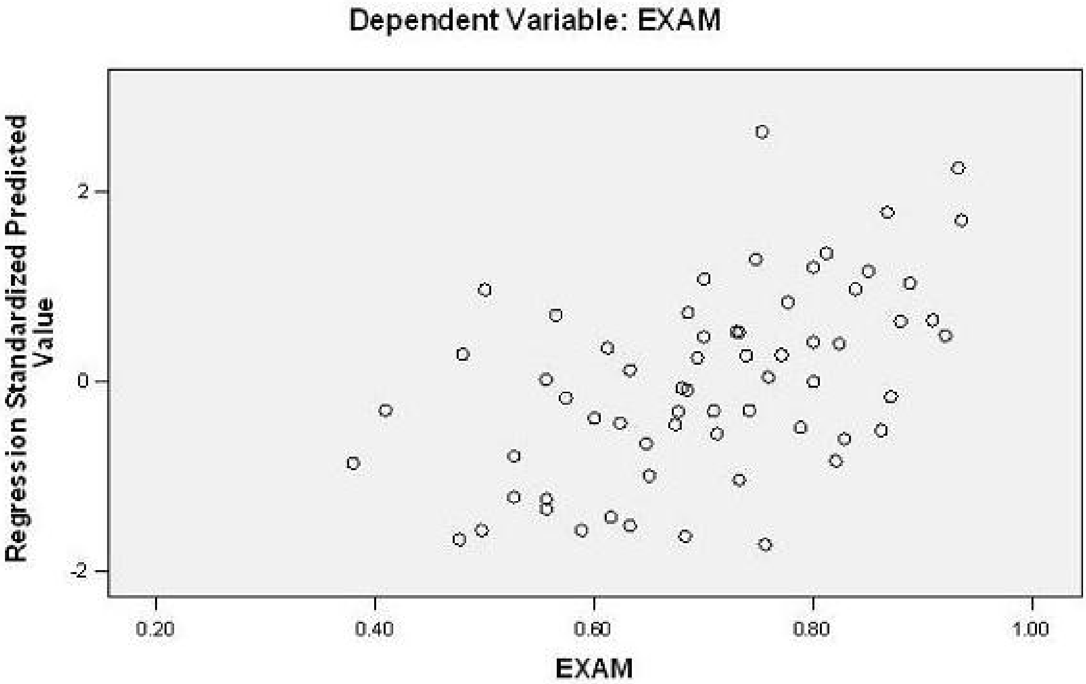

Figure G.9: Step 5-The sequential score was removed.

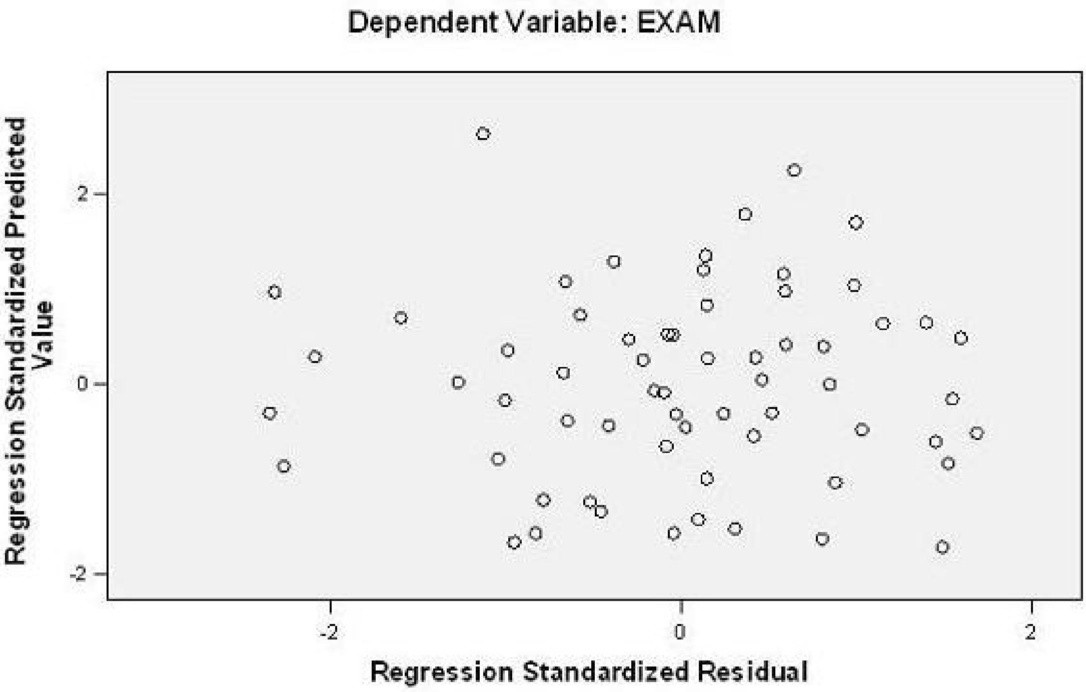

Figure G.10: Step 5-The sequential score was removed.

G.1 Test of Regression Assumption Four and Five for Research Question Three-Spring 2008 Data

Step 1-All variables are included in the regression. This includes MPEX pre-test score, MPEX post-test score, and the score for each of the four dimensions of the Index of Learning Styles.

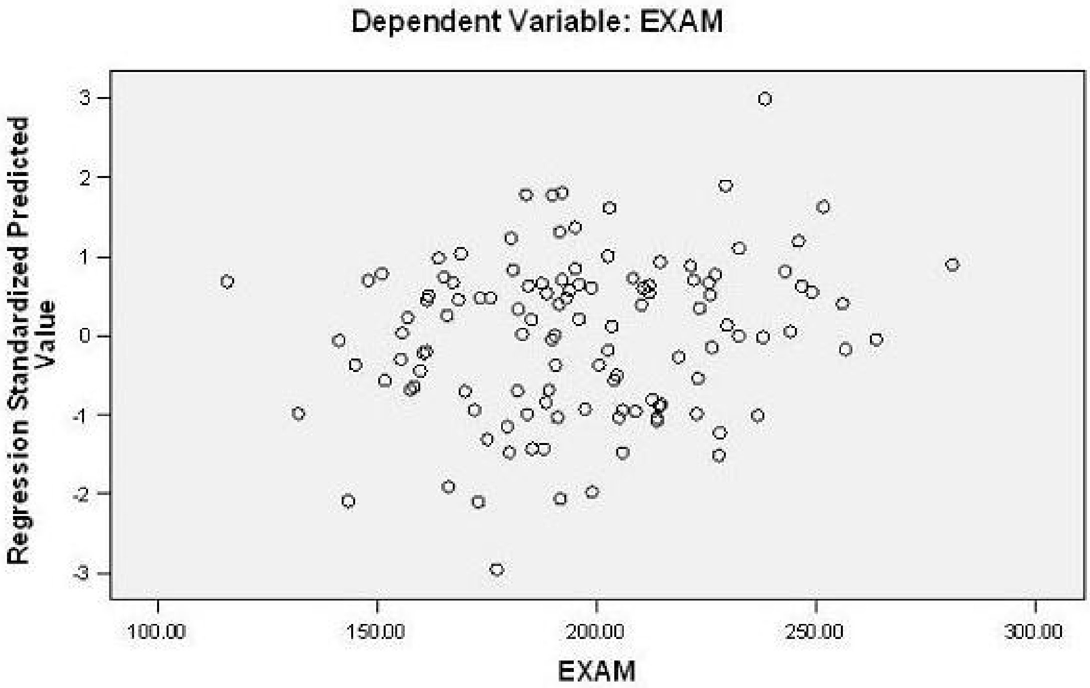

Figure G.11: Step 1-All variables entered.

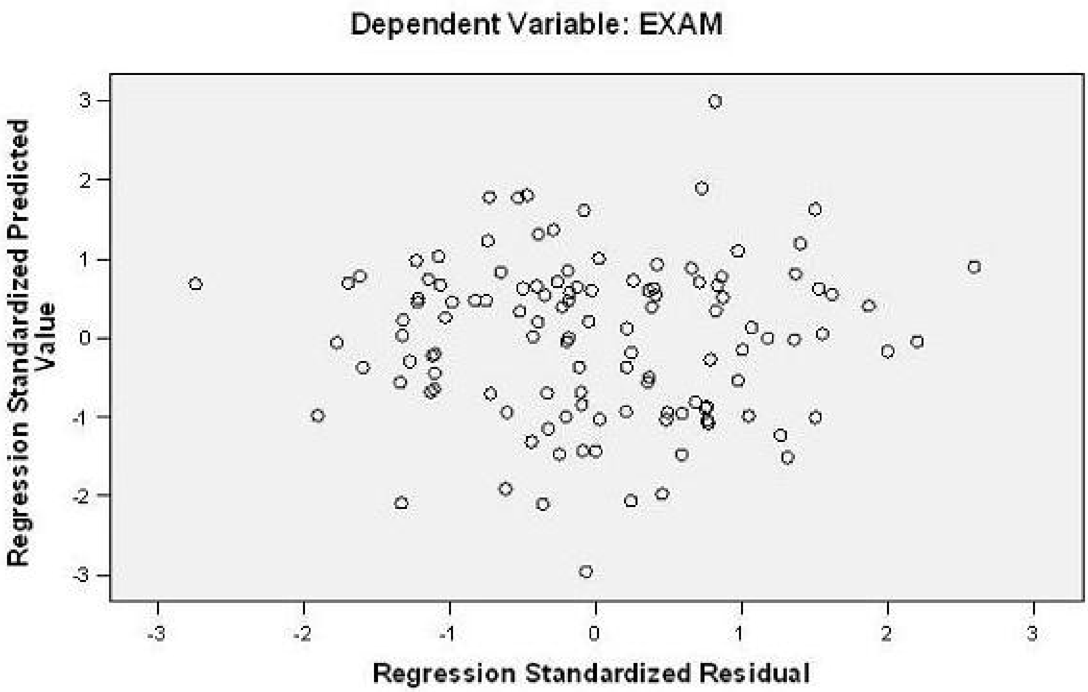

Figure G.12: Step 1-All variables entered.

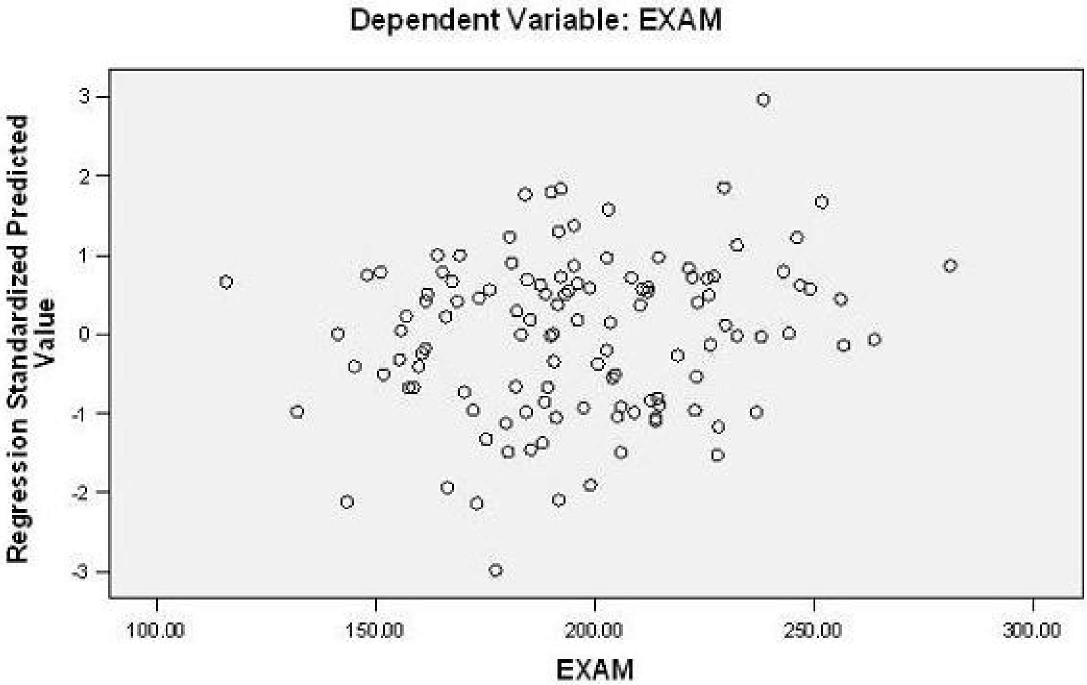

Figure G.13: Step 2-The visual score was removed.

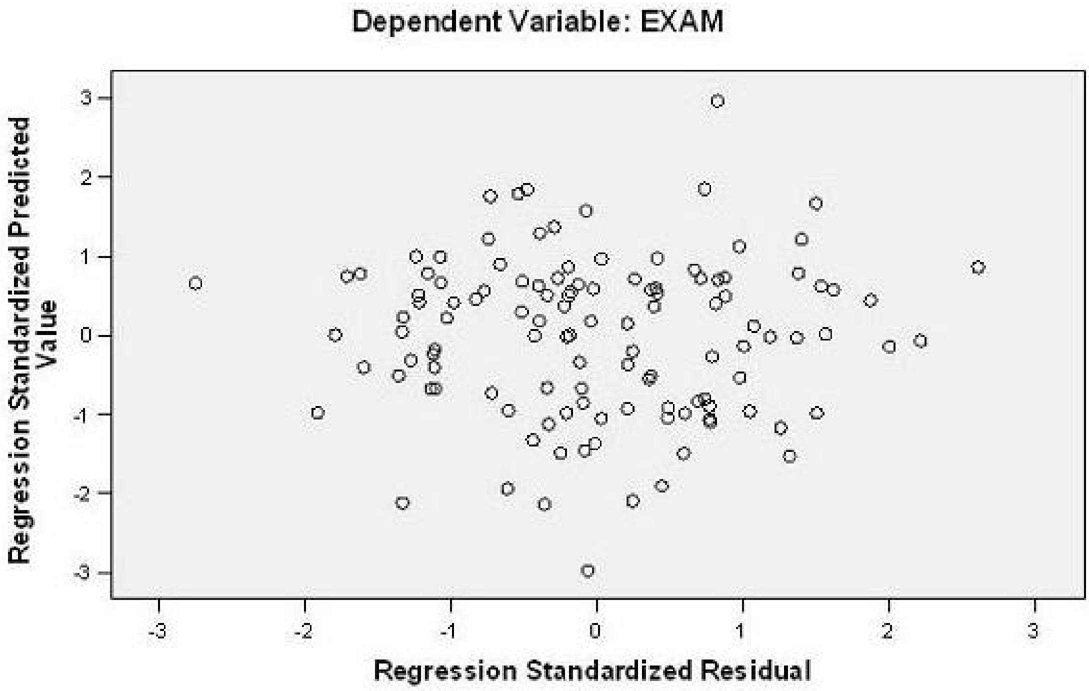

Figure G.14: Step 2-The visual score was removed.

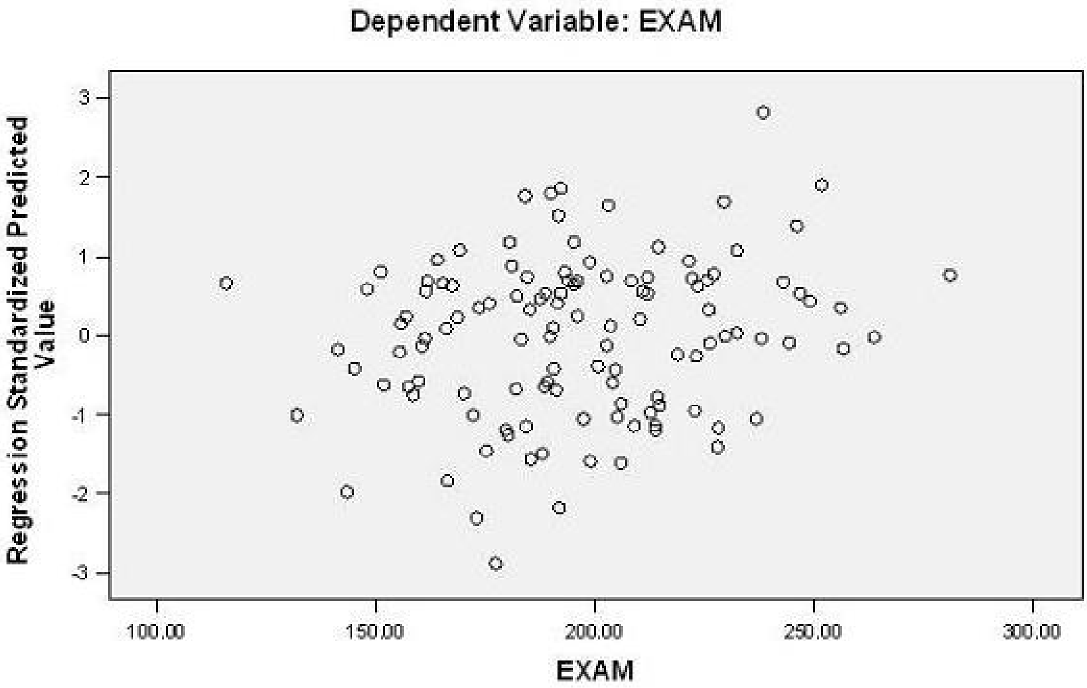

Figure G.15: Step 3-The sequential score was removed.

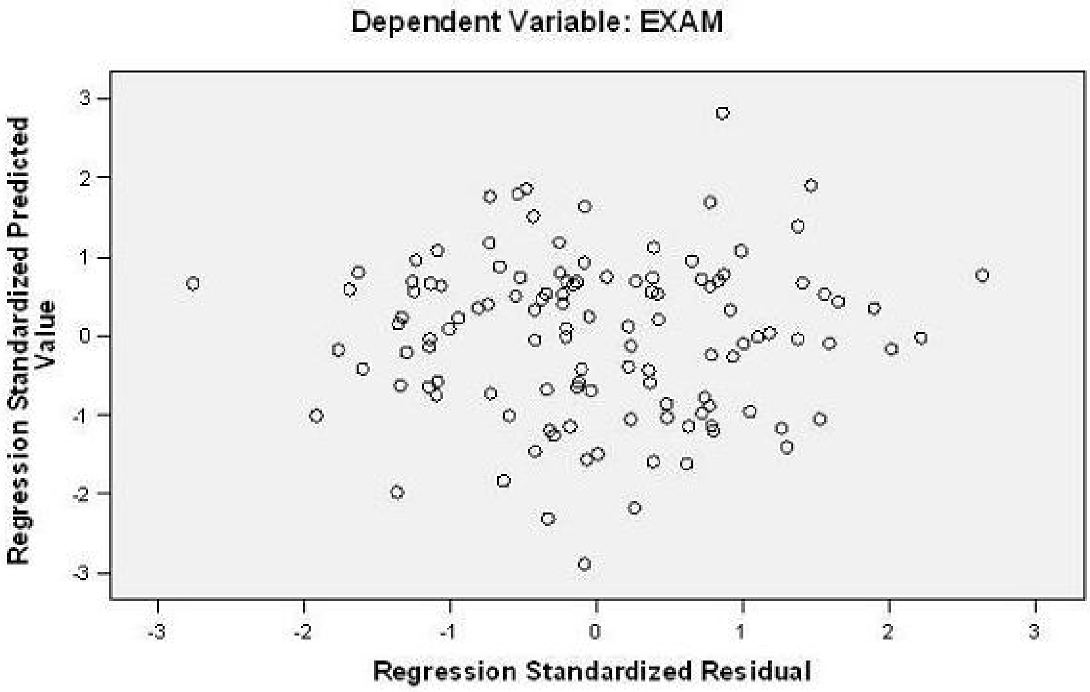

Figure G.16: Step 3-The sequential score was removed.

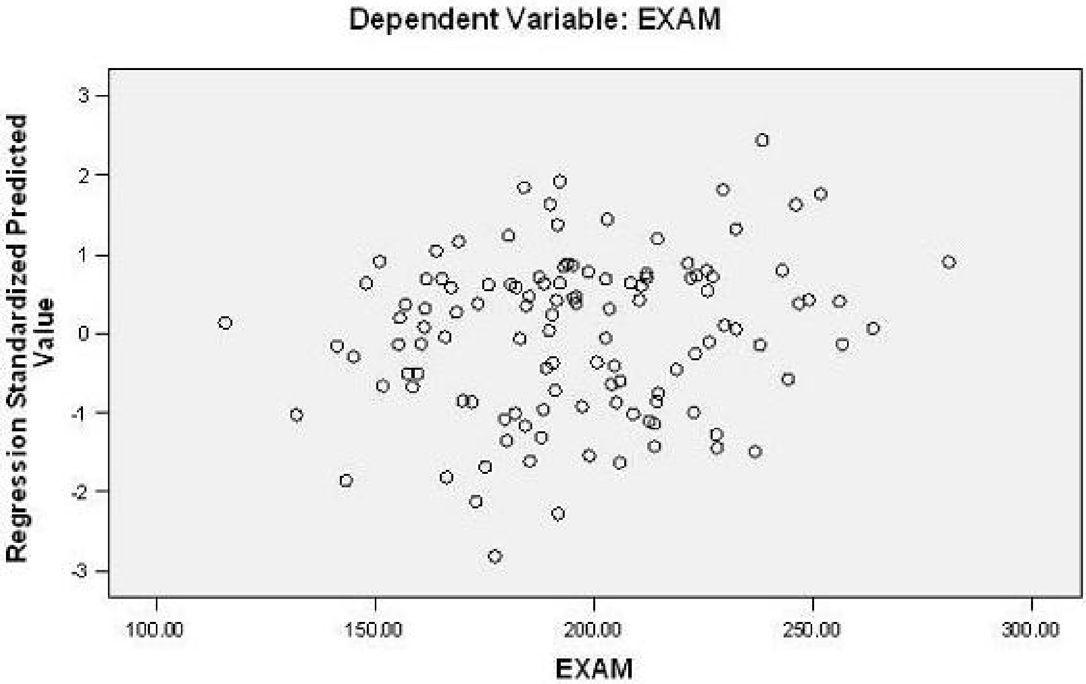

Figure G.17: Step 4-The sensing score was removed.

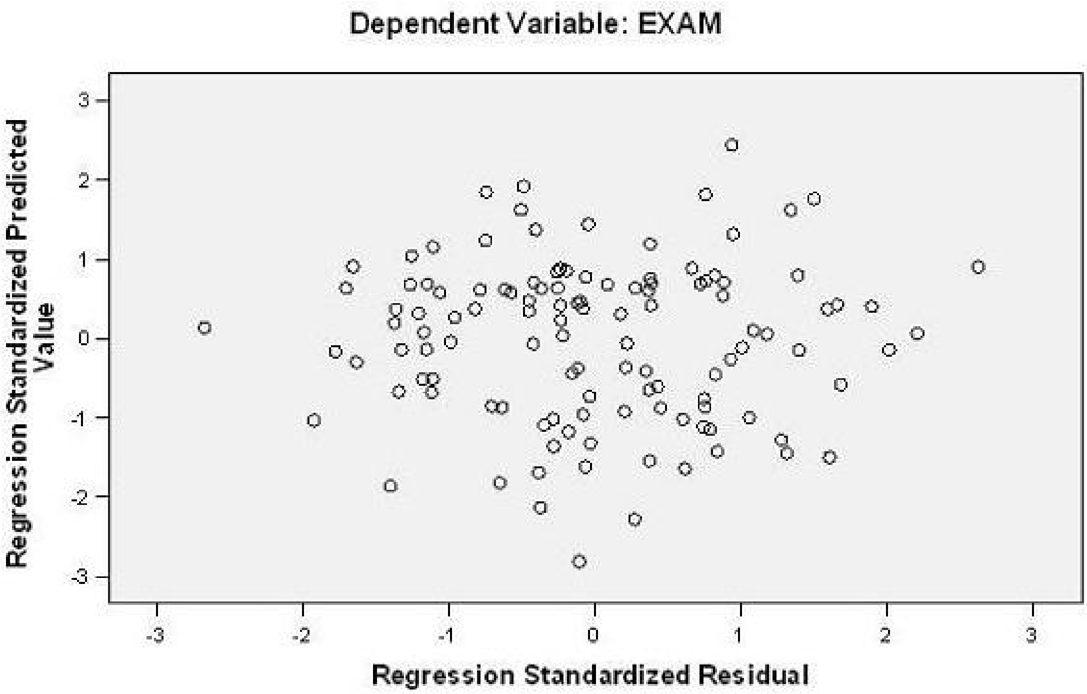

Figure G.18: Step 4-The sensing score was removed.

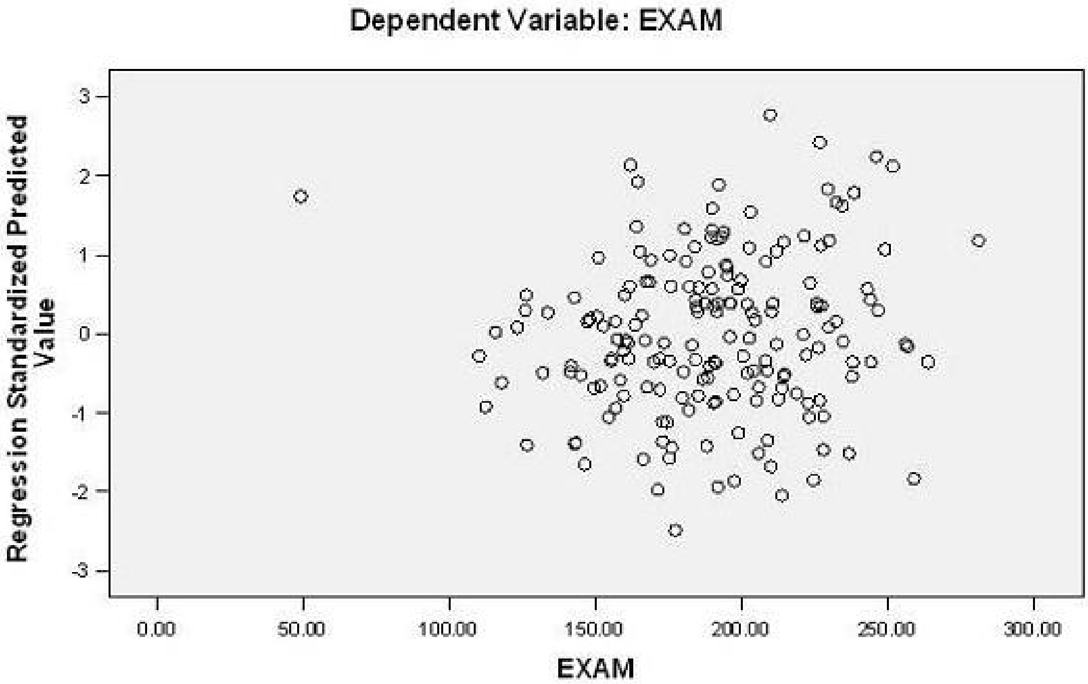

Figure G.19: Step 5-The MPEX pre-test score was removed.

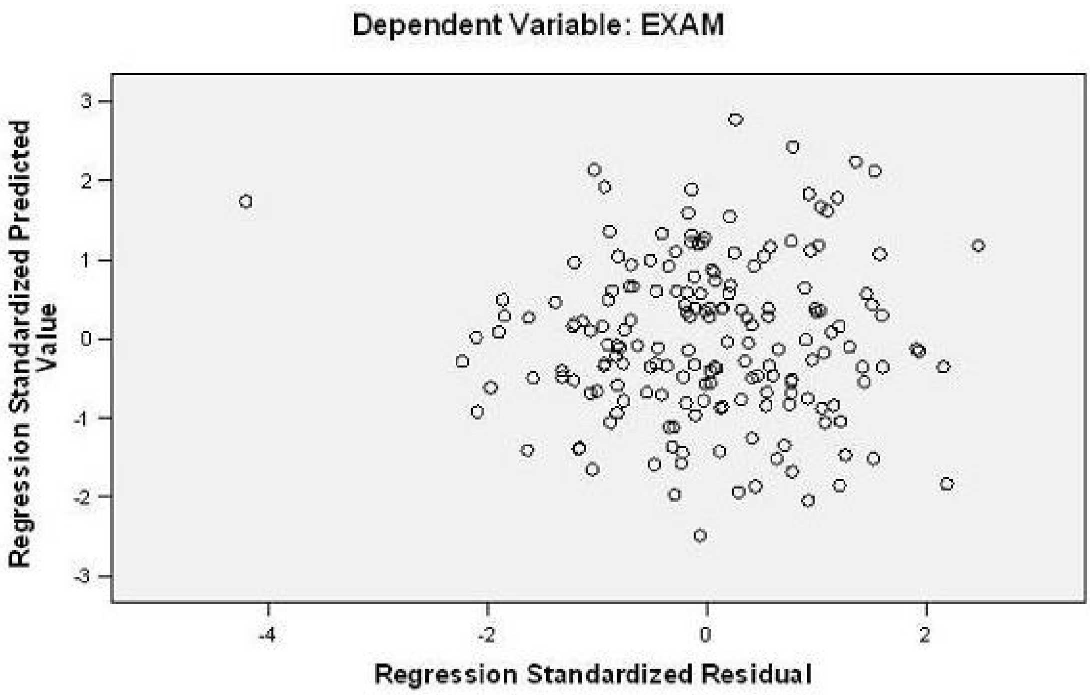

Figure G.20: Step 5-The MPEX pre-test score was removed.

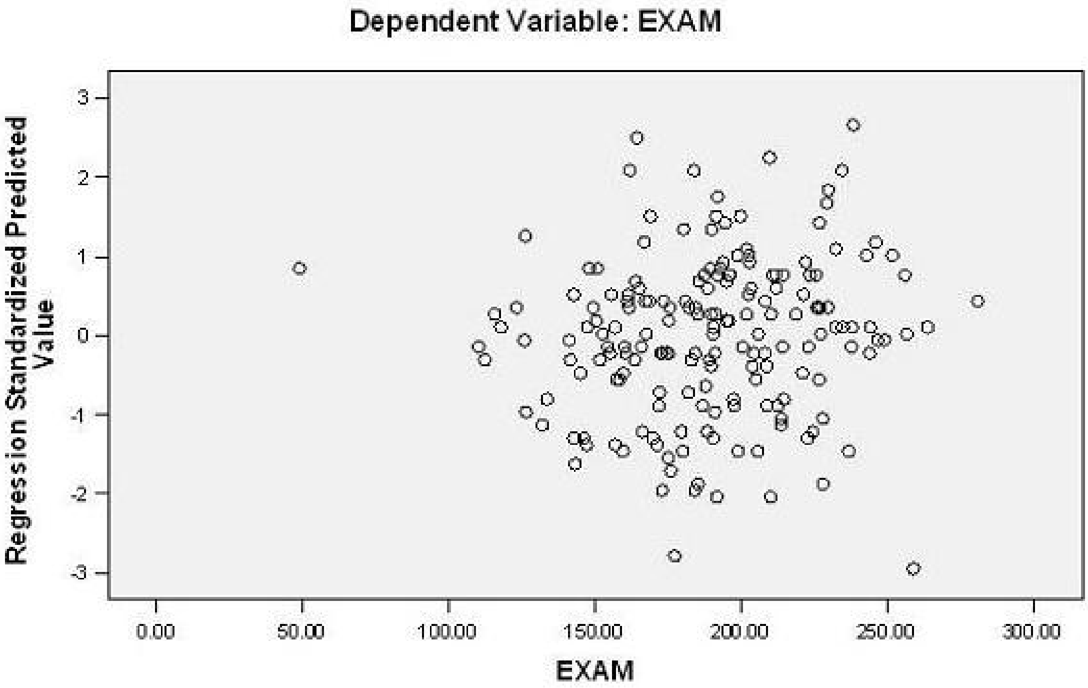

Figure G.21: Step 6-The active score was removed.

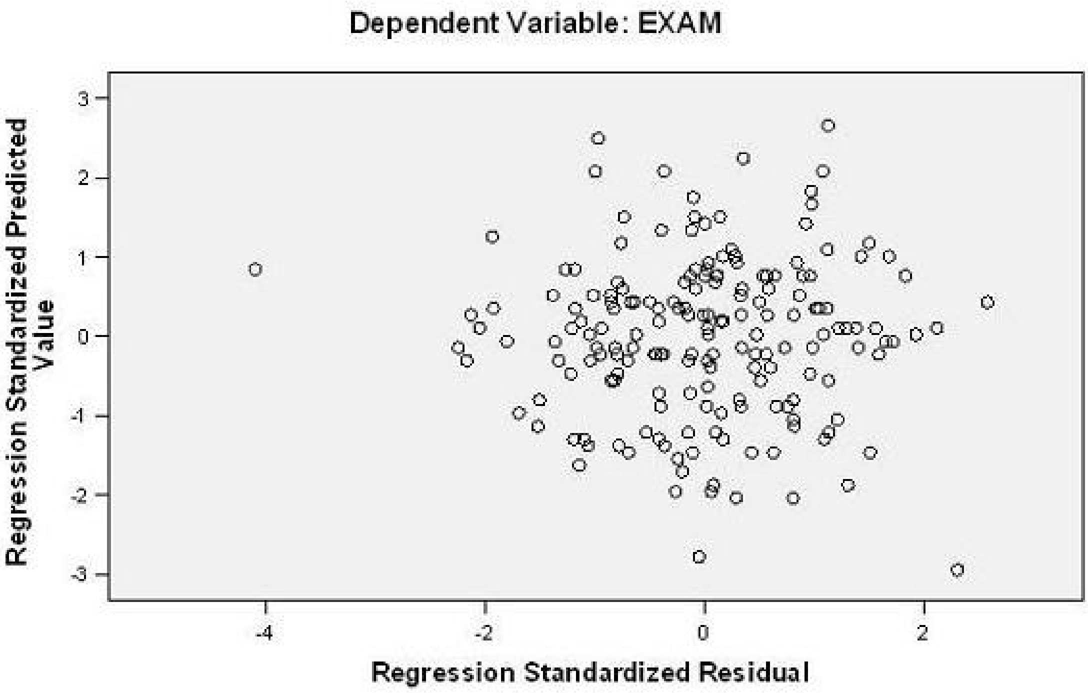

Figure G.22: Step 6-The active score was removed.

G.1.1 Analysis

The fall graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The spring graphs however do not seem to have a linear flow, and probably should not be analyzed. The predicted score versus residual seems to have a circular pattern. Due to this assumption five is satisfied.

APPENDIX H

Test of Regression Assumption Four and Five for Research Question Four-Spring 2008 Data

Step 1-All variables are included in the regression. This includes lab attendance, help session attendance, time spent in the helproom, and Physics 1 grade.

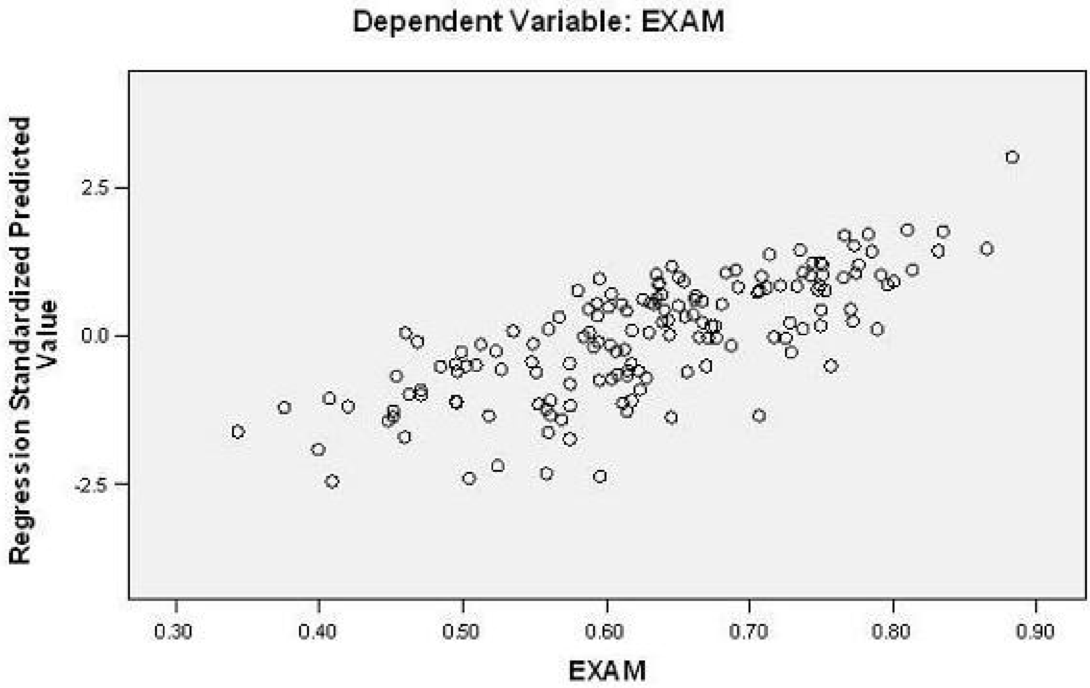

Figure H.1: Step 1-All variables entered.

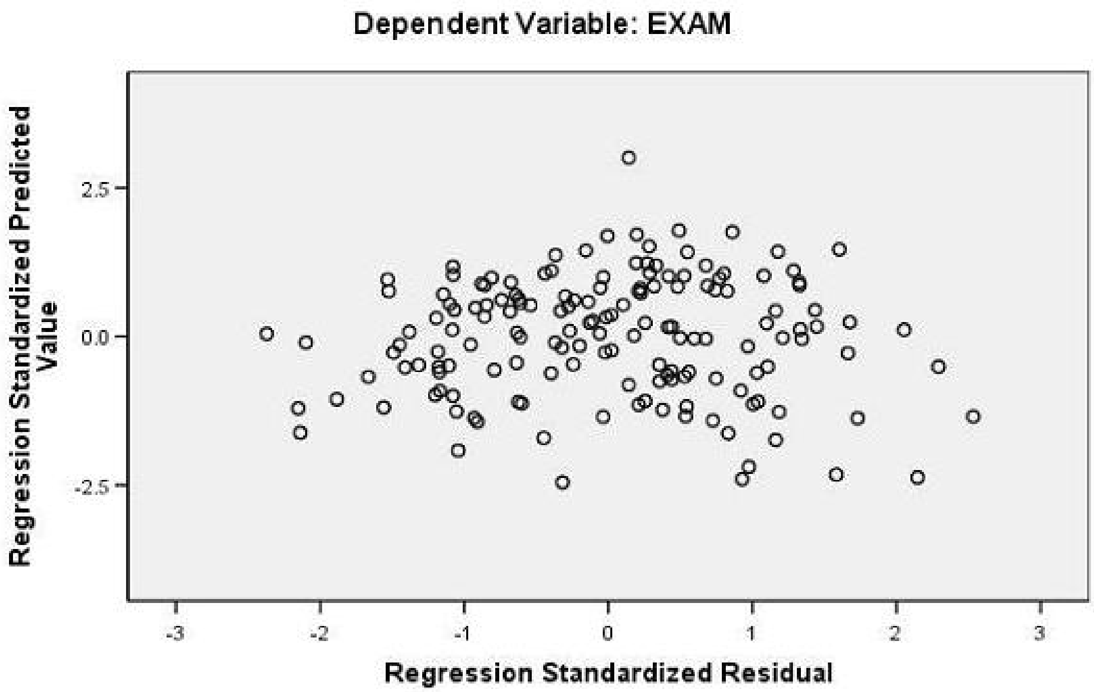

Figure H.2: Step 1-All variables entered.

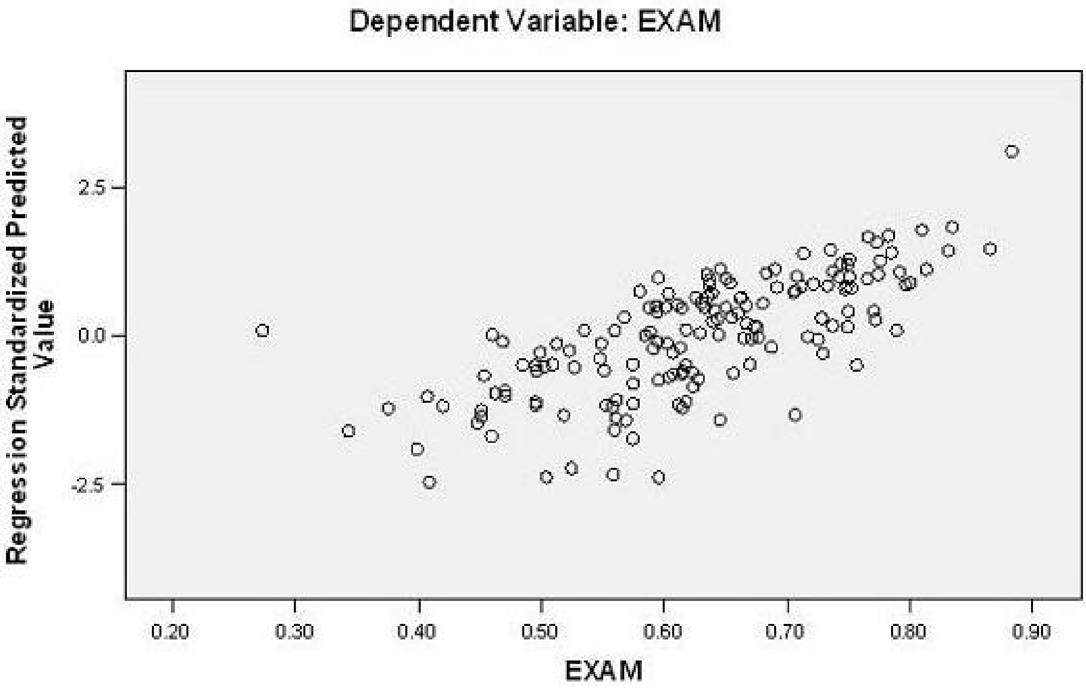

Figure H.3: Step 2-The lab attendance was removed.

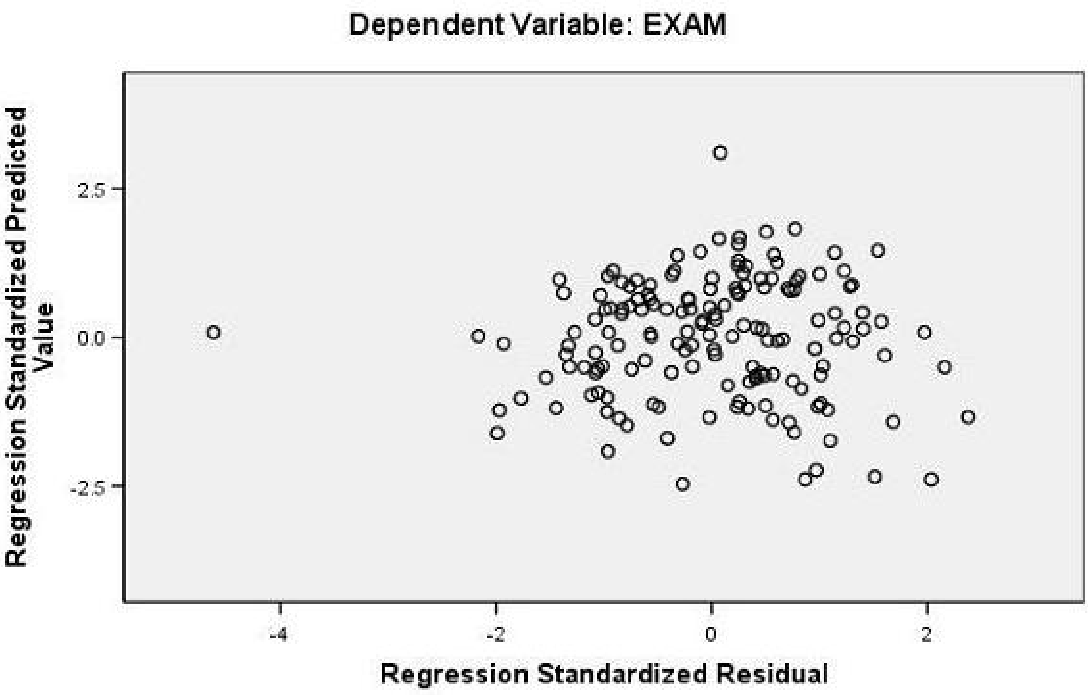

Figure H.4: Step 2-The lab attendance was removed.

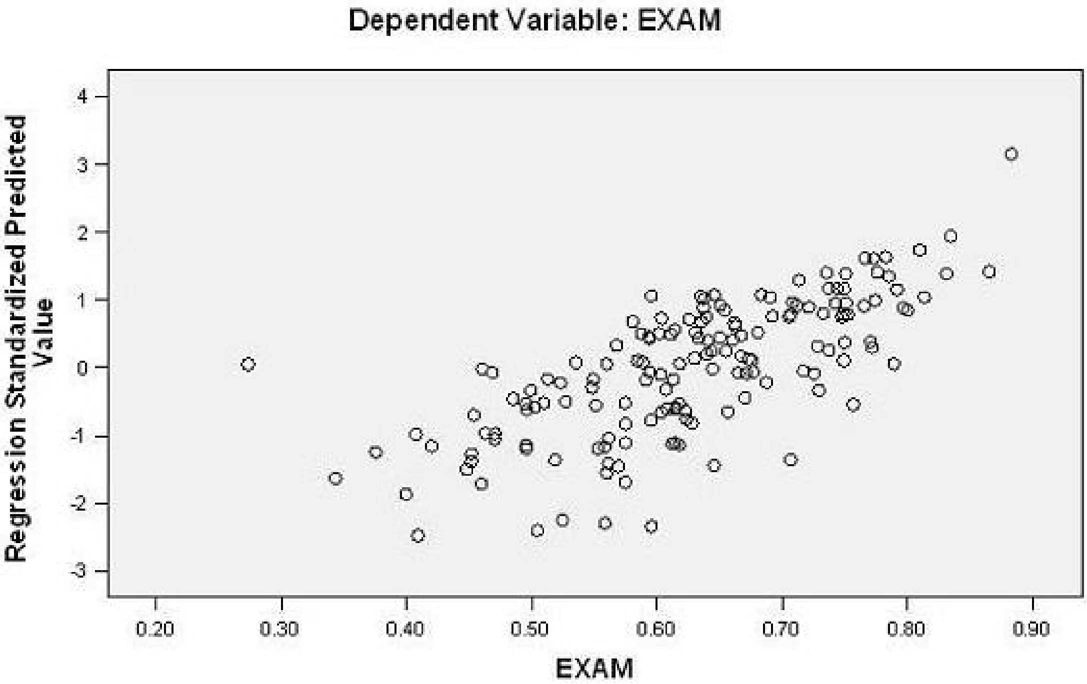

Figure H.5: Step 3-The help session attendance was removed.

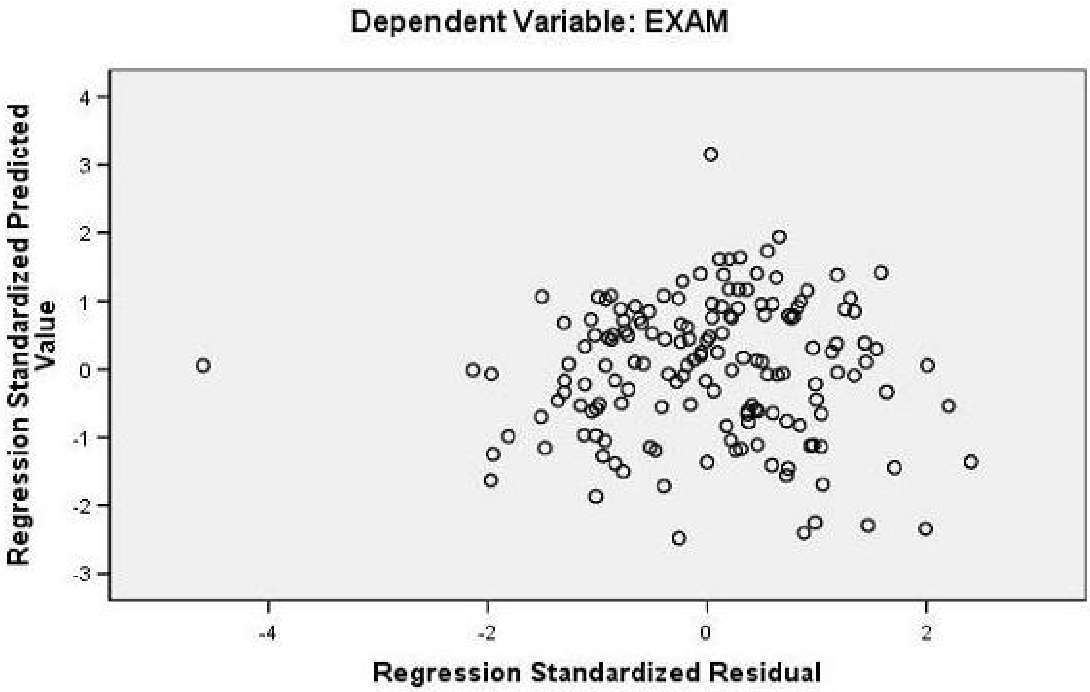

Figure H.6: Step 3-The help session attendance was removed.

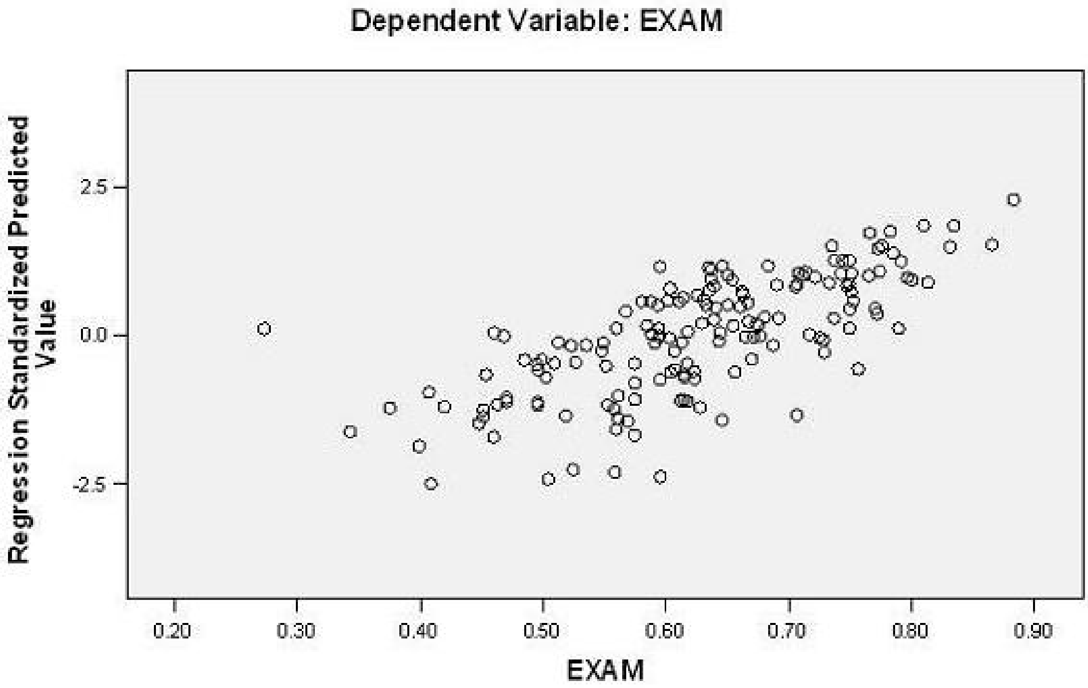

Figure H.7: Step 4-The time spent in the helproom was removed.

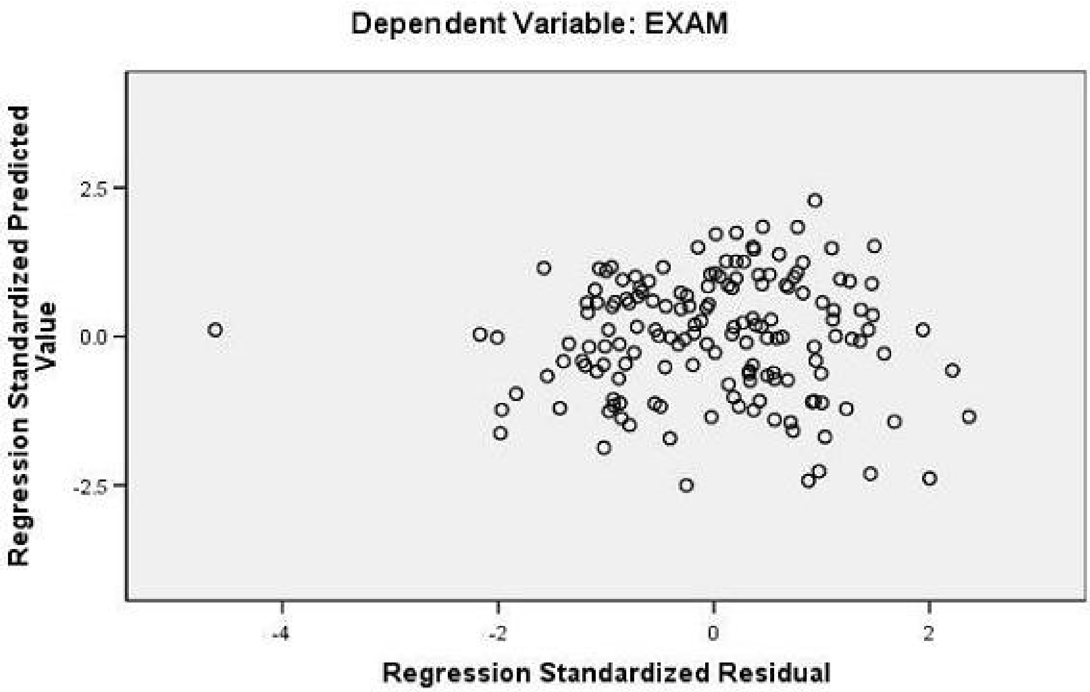

Figure H.8: Step 4-The time spent in the helproom was removed.

H.0.2 Analysis

The spring graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The fall graphs however do not seem to have a linear flow, and probably should not be analyzed. The predicted score versus residual seems to have a circular pattern. Due to this assumption five is satisfied.

APPENDIX I

Test of Regression Assumption Four and Five for Research Question Five-Fall 2007 Data

Step 1-All variables are included in the regression. This includes MPEX pre-test, active score, lab score, ACT science score, and GPA.

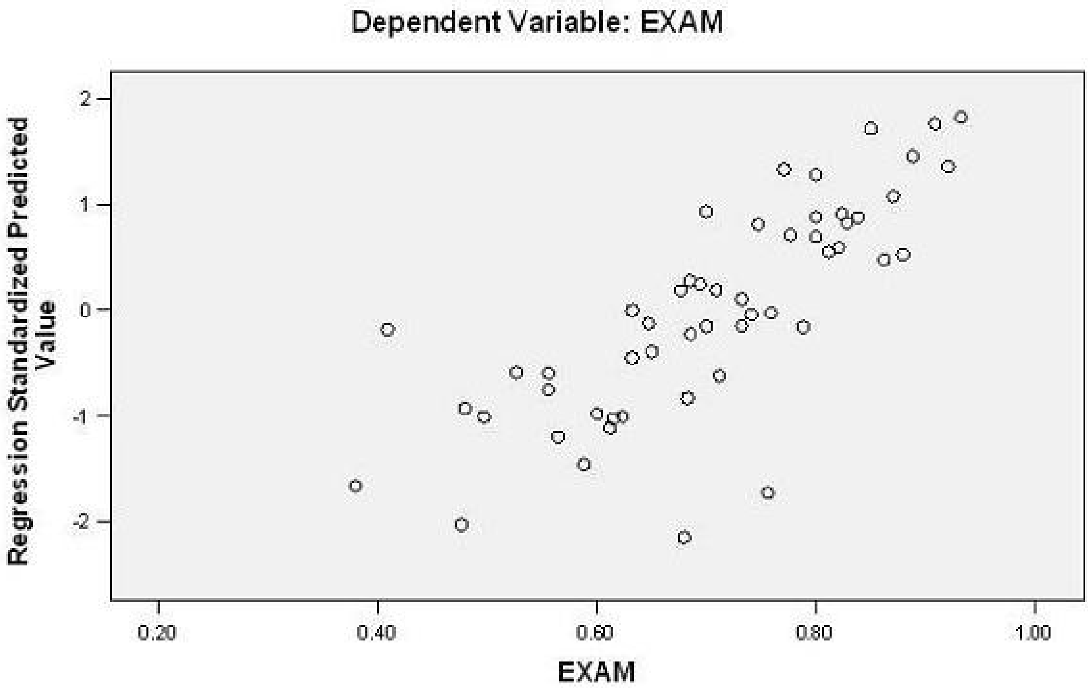

Figure I.1: Step 1-All variables entered.

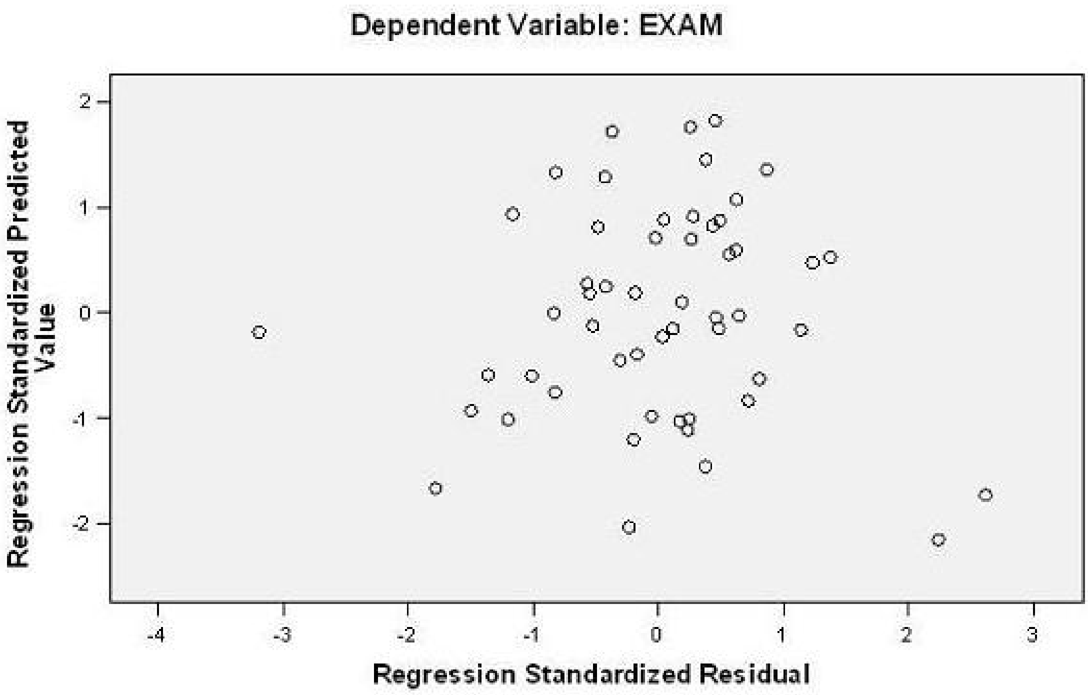

Figure I.2: Step 1-All variables entered.

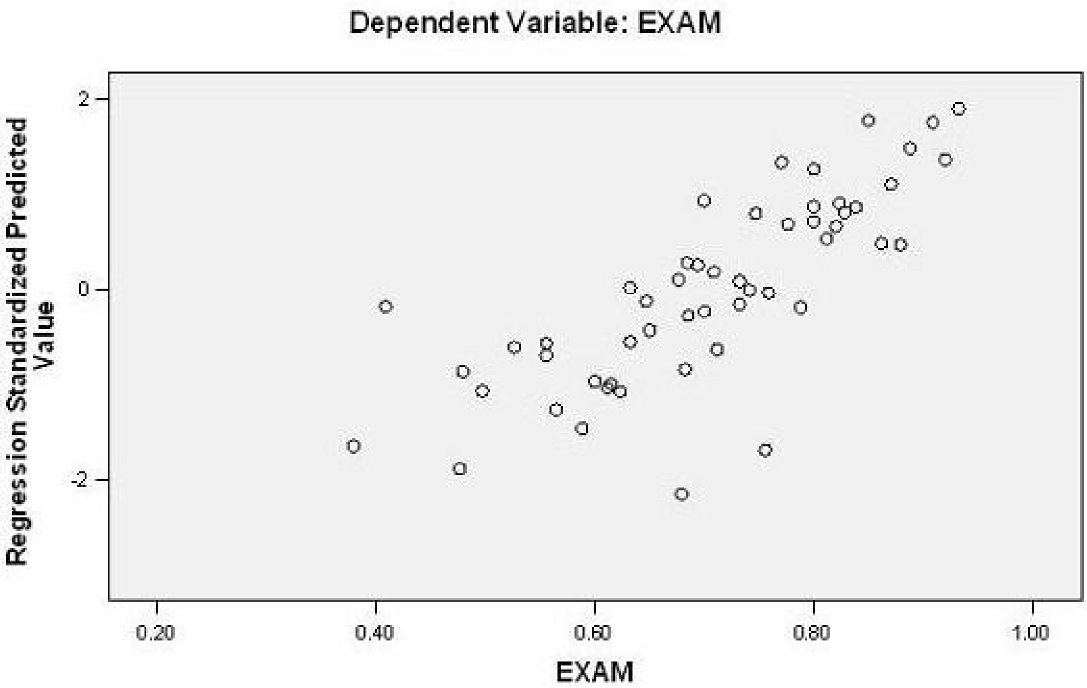

Figure I.3: Step 2-The lab score was removed.

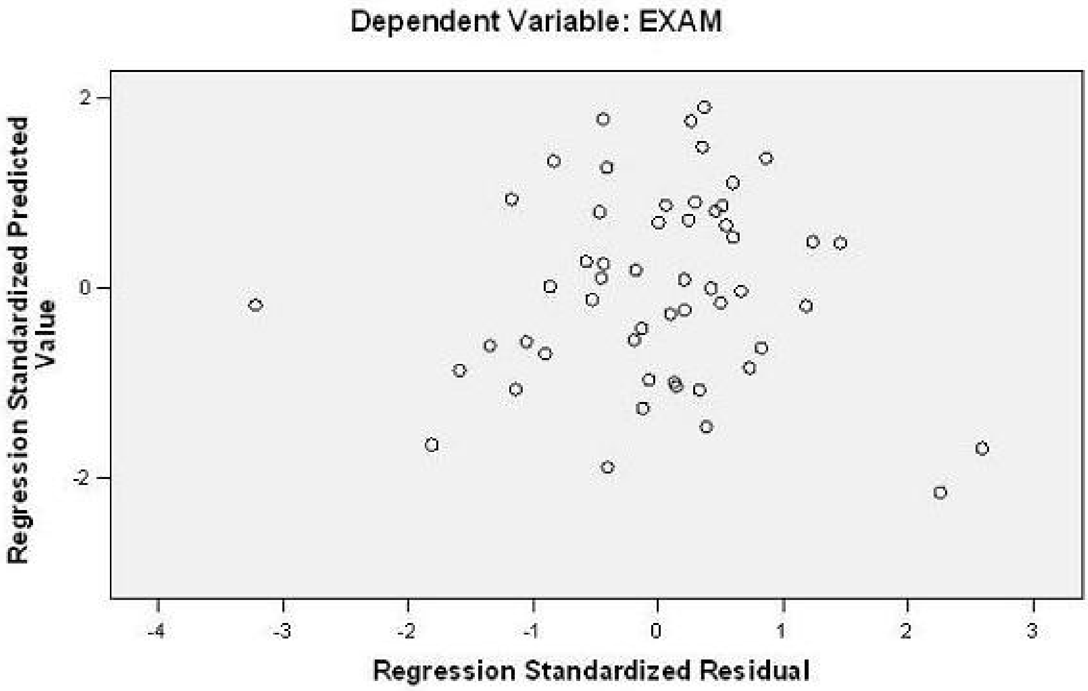

Figure I.4: Step 2-The lab score was removed.

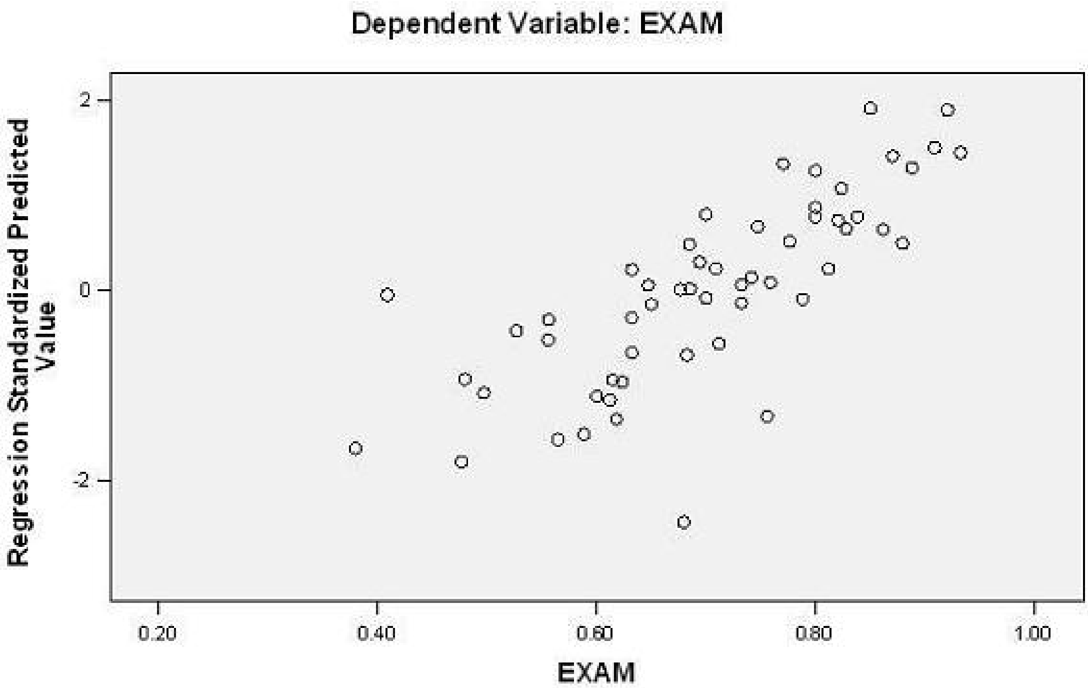

Figure I.5: Step 3-The MPEX pre-test was removed.

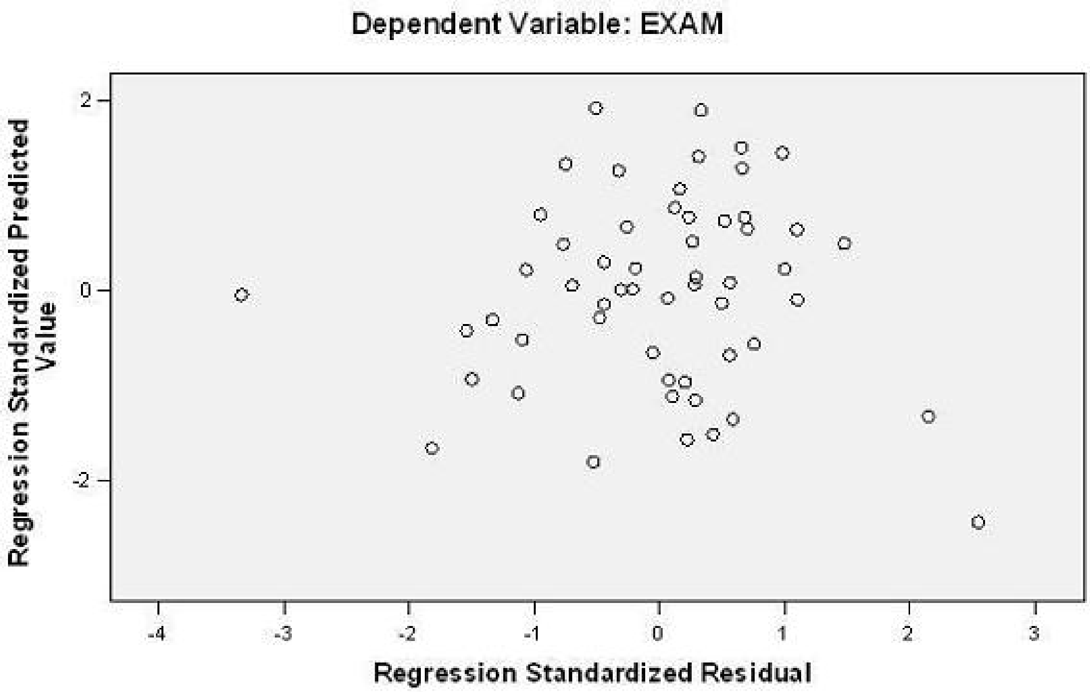

Figure I.6: Step 3-The MPEX pre-test was removed.

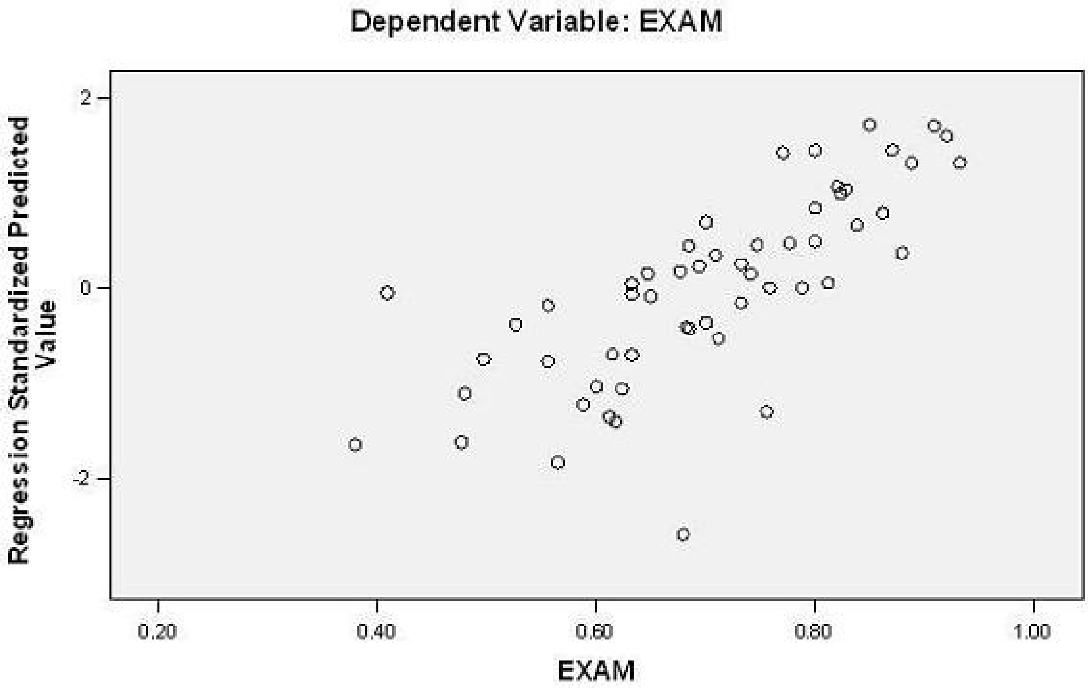

Figure I.7: Step 4-The active score was removed.

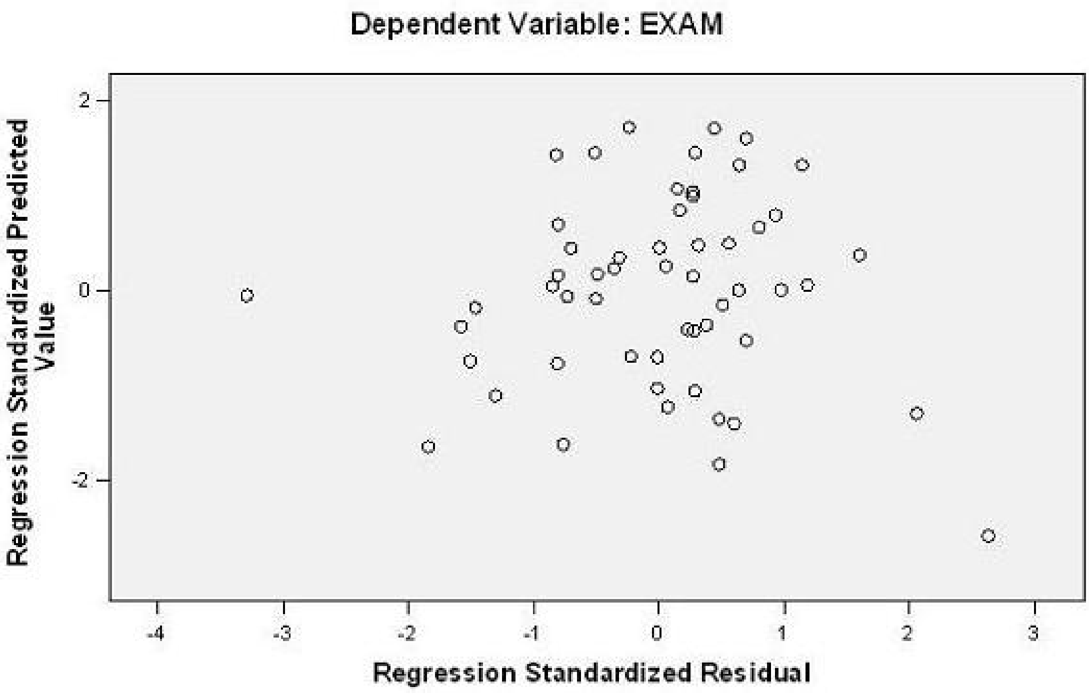

Figure I.8: Step 4-The active score was removed.

I.1 Test of Regression Assumption Four and Five for Research Question Five-Spring 2008 Data

Step 1-All variables are included in the regression. This includes Physics 1 grade, time spent in the helproom, lab score, homework score, ACT science score, and GPA.

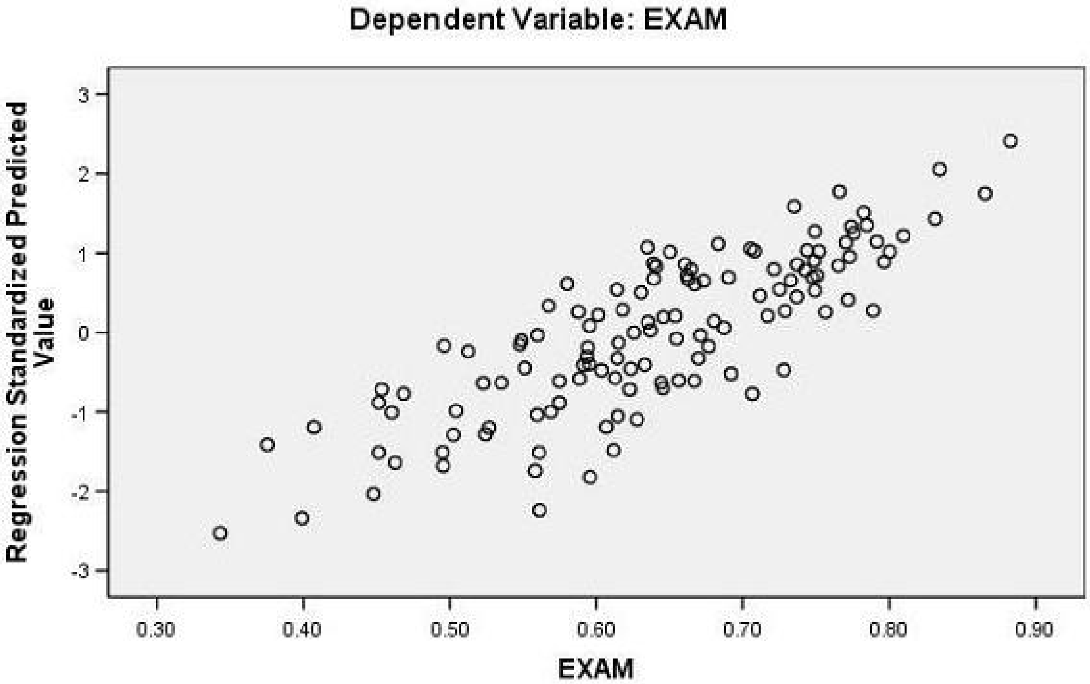

Figure I.9: Step 1-All variables entered.

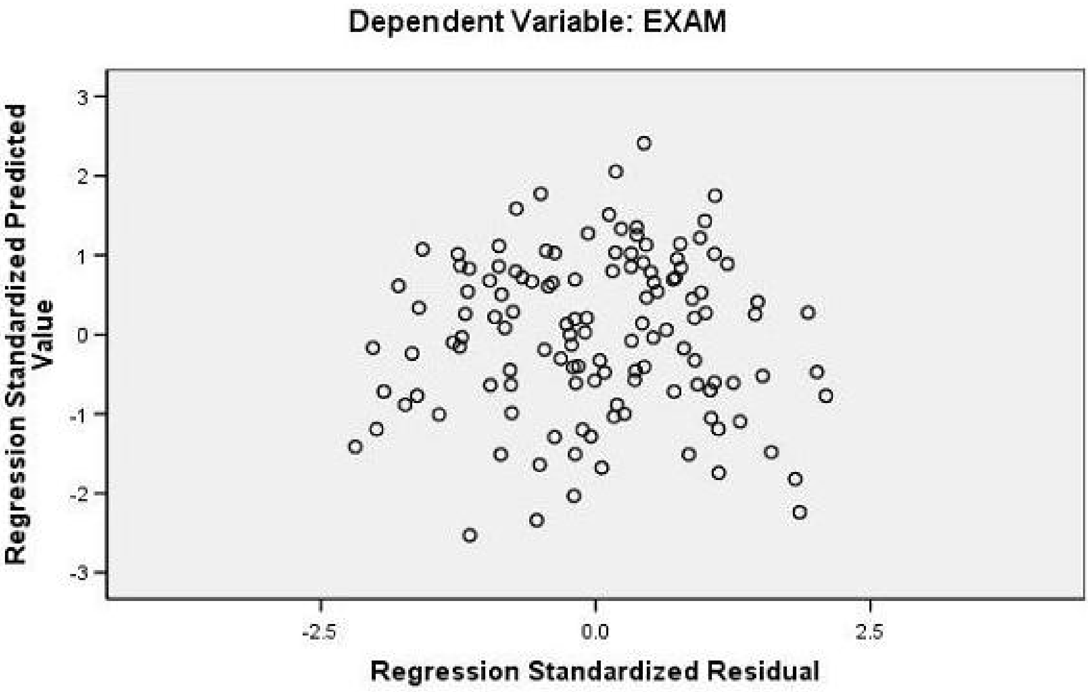

Figure I.10: Step 1-All variables entered.

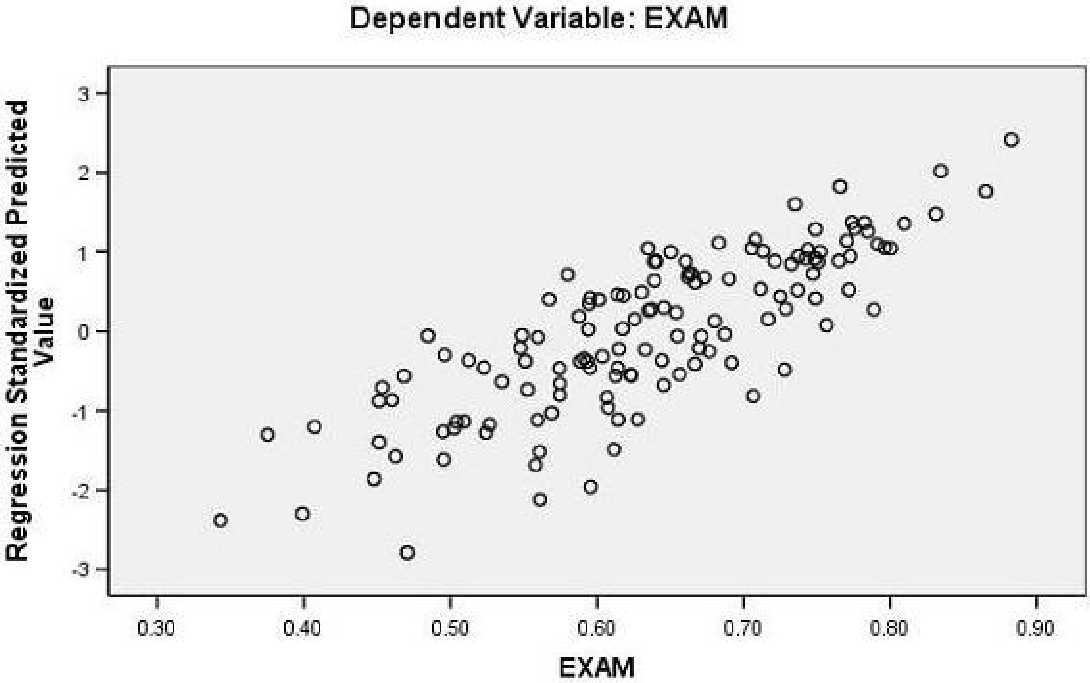

Figure I.11: Step 2-The MPEX Post was removed.

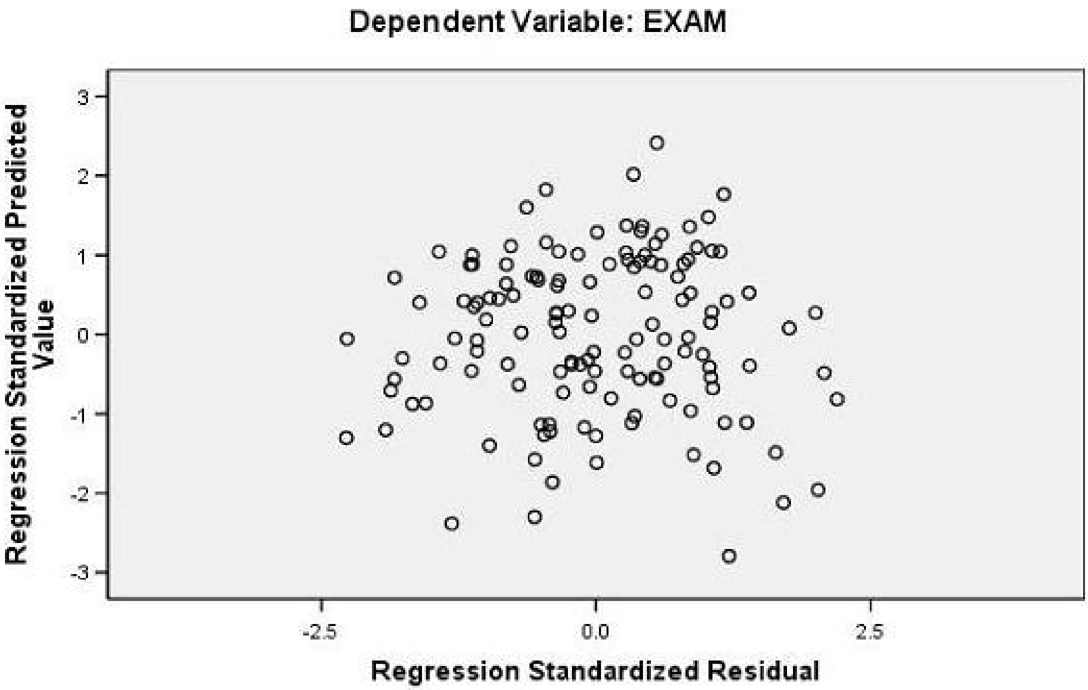

Figure I.12: Step 2-The MPEX Post was removed.

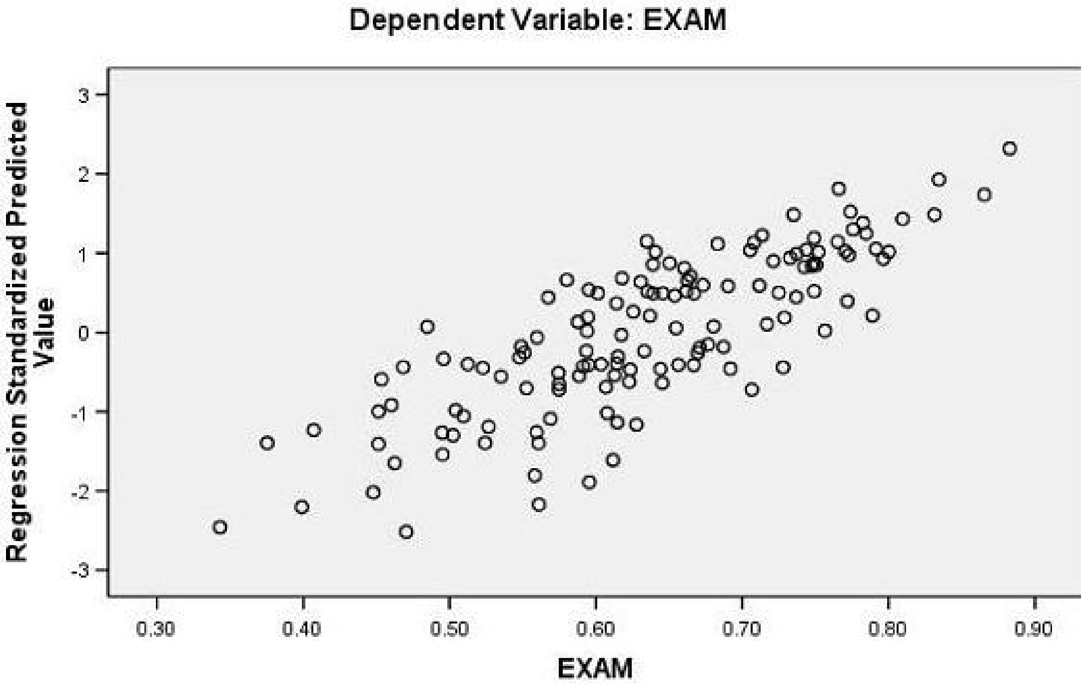

Figure I.13: Step 3-The HBL score was removed.

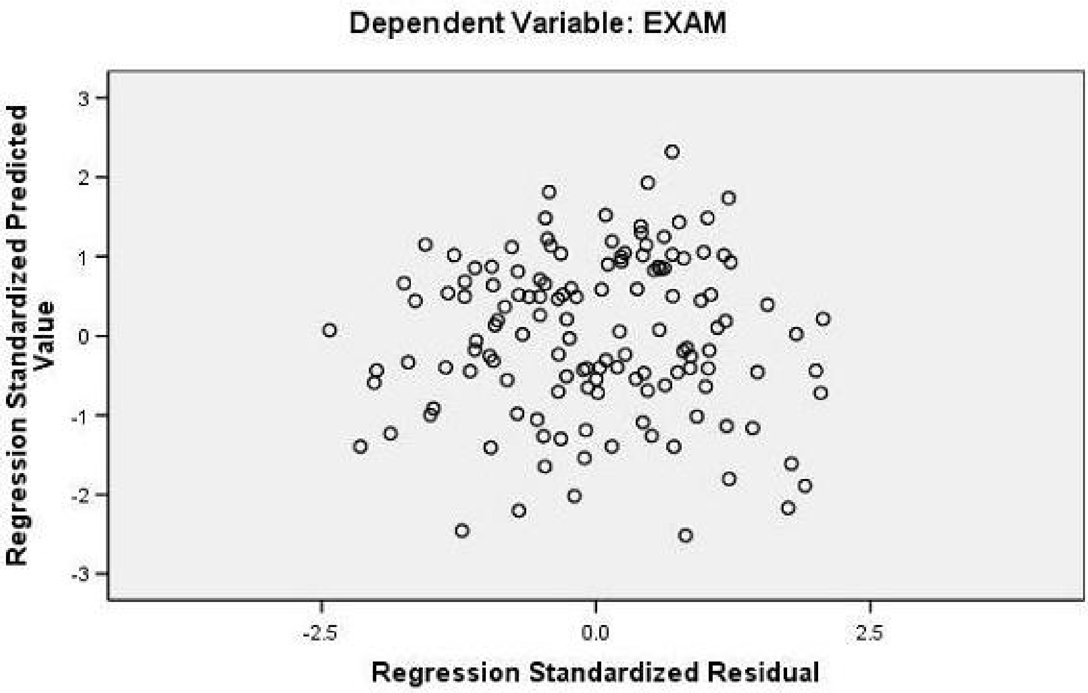

Figure I.14: Step 3-The HBL score was removed.

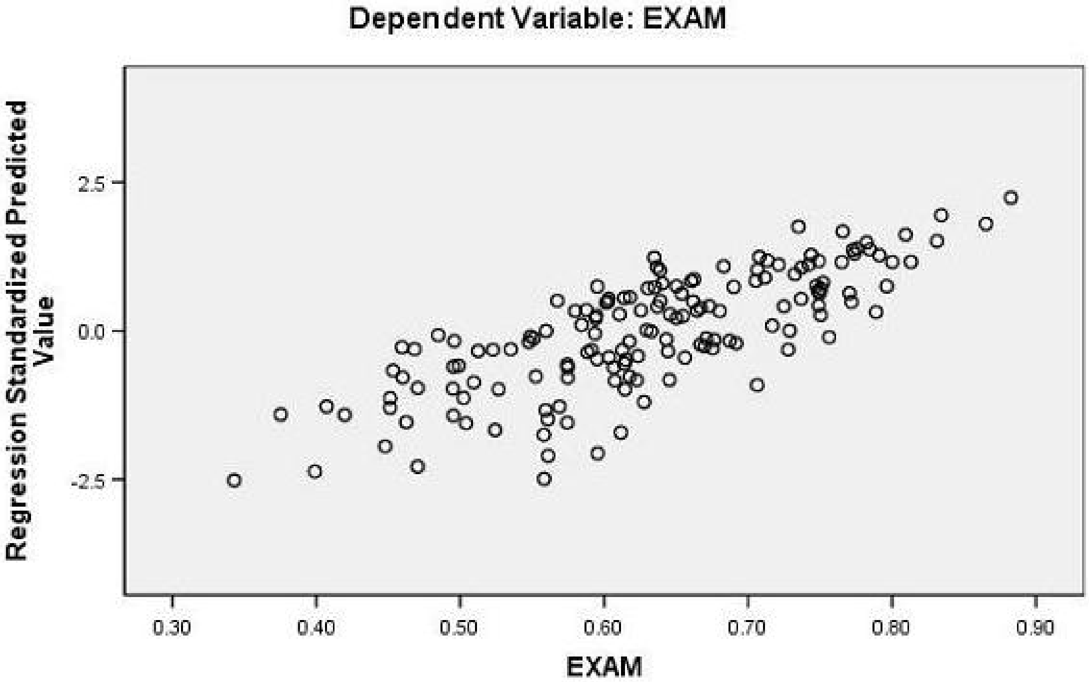

Figure I.15: Step 4-The ACT Science was removed.

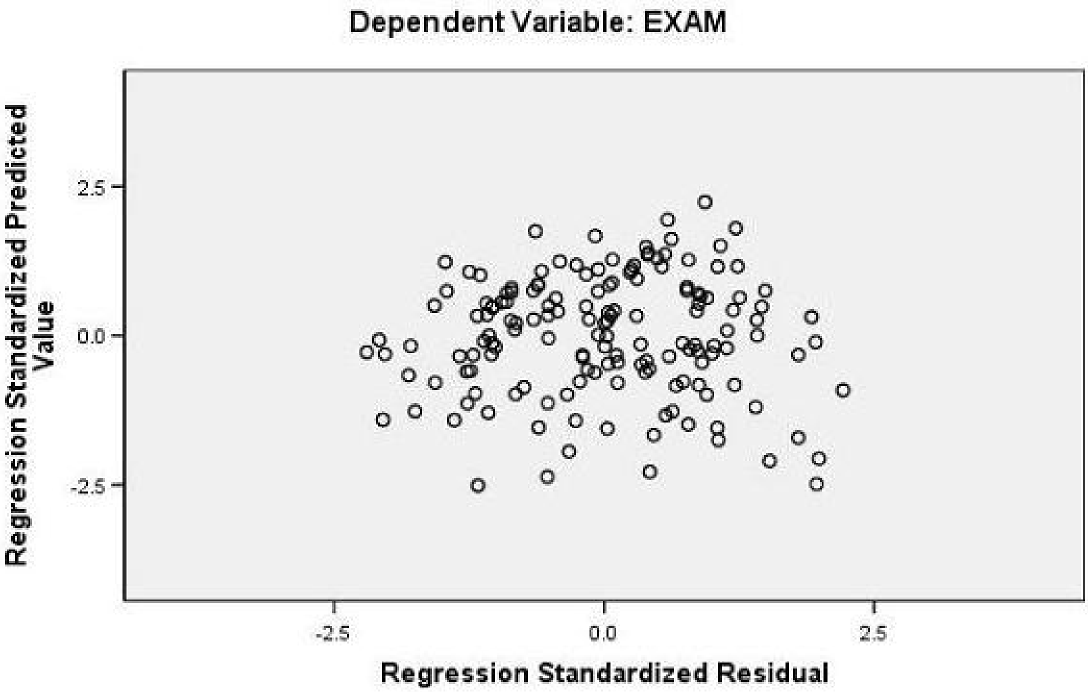

Figure I.16: Step 4-The ACT Science was removed.

I.1.1 Analysis

The graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The predicted score versus residual seems to have a circular pattern. Due to this assumption five is satisfied.

APPENDIX J

Test of Assumptions for homework style problems

J.1 Test of Regression Assumption Four and Five for Research Question One-Homework-Style Problems

Step 1-All variables are included in the regression. This includes homework average, lab average, PRS score, and HBL average.

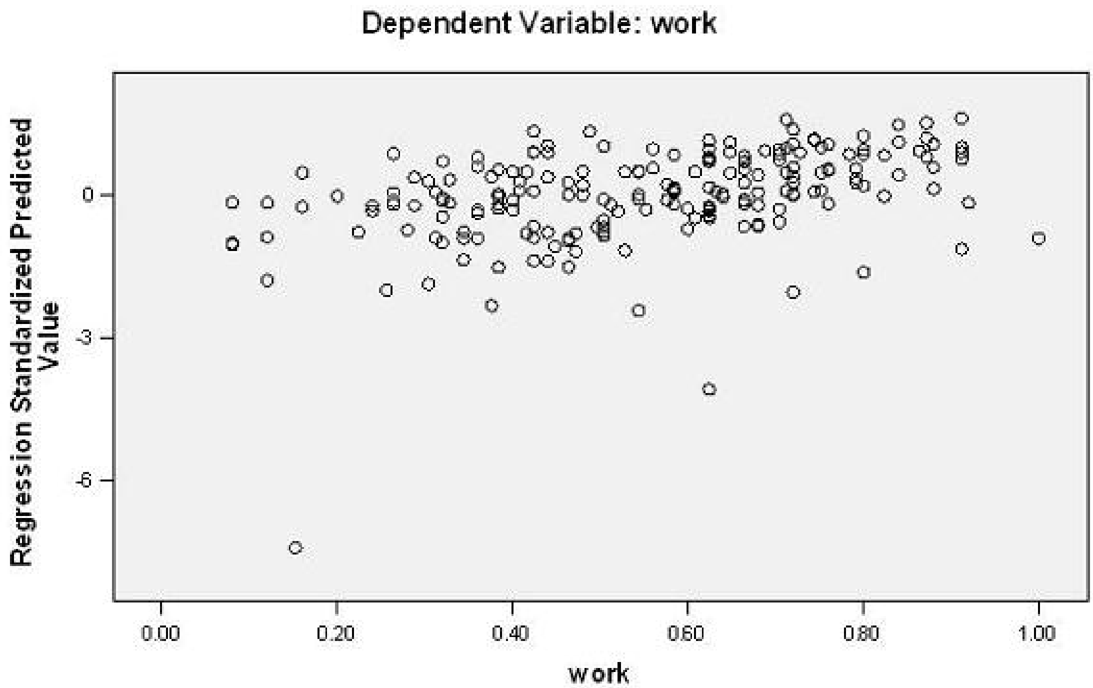

Figure J.1: Step 1-All variables entered.

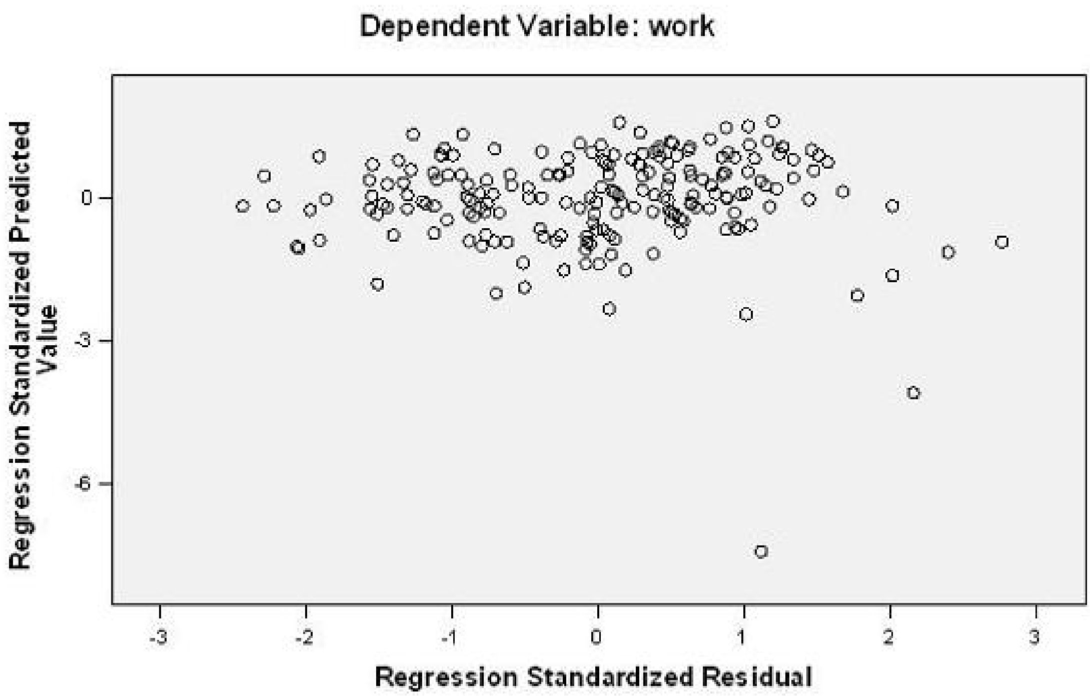

Figure J.2: Step 1-All variables entered.

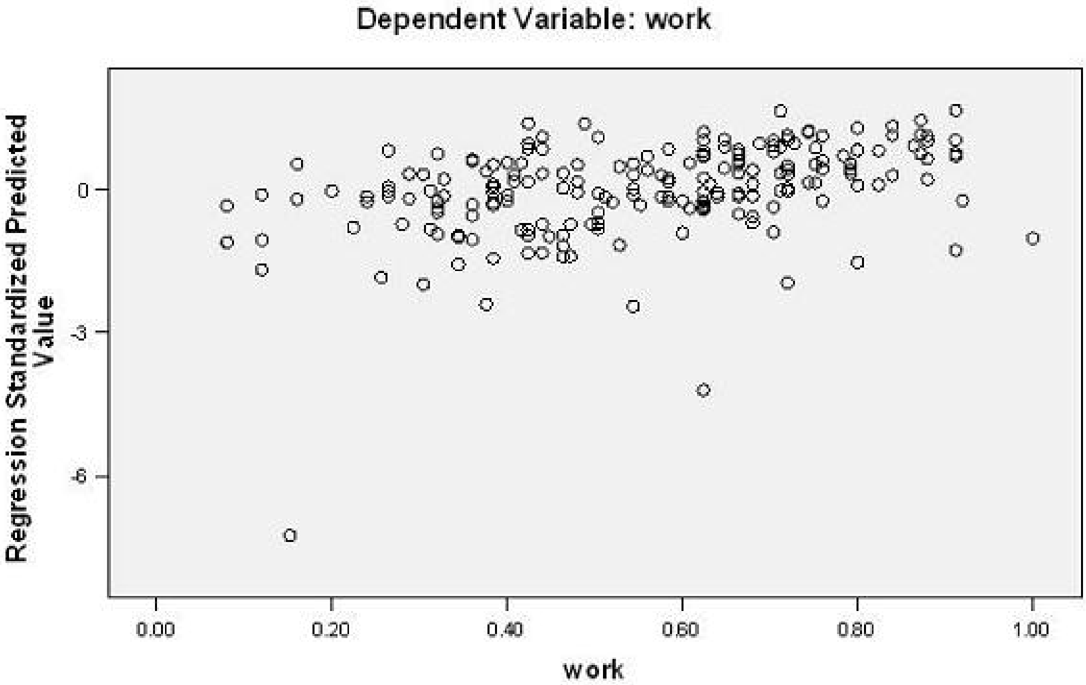

Figure J.3: Step 2-The clicker score was removed.

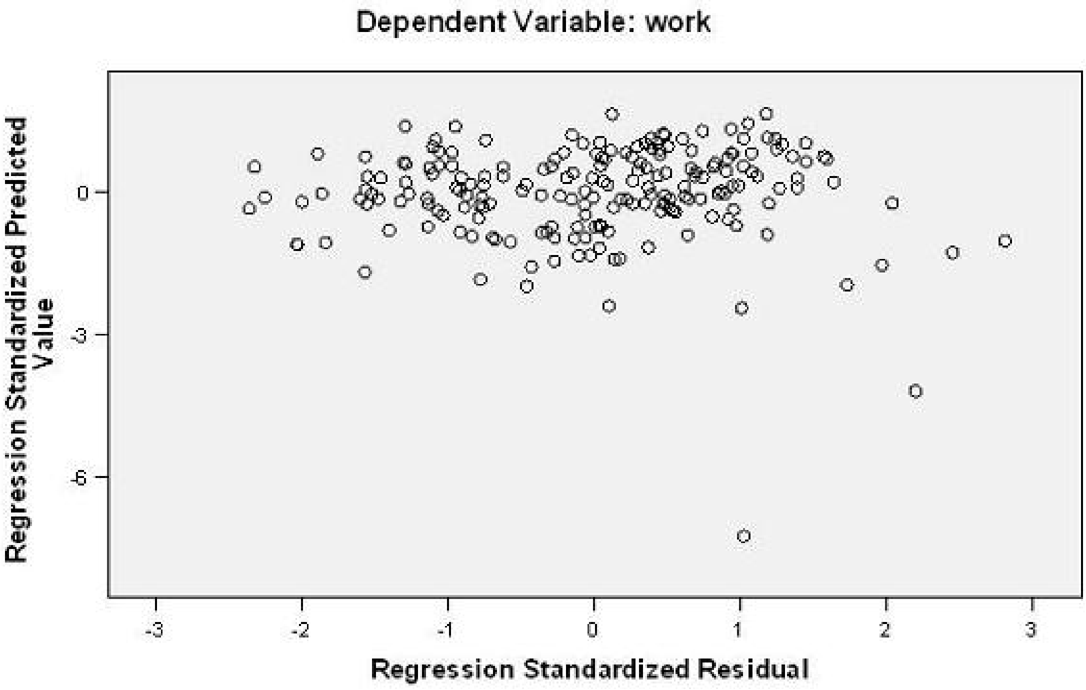

Figure J.4: Step 2-The clicker score was removed.

J.2 Test of Regression Assumption Four and Five for Research Question two-Homework-Style Problems

Step 1-All variables are included in the regression. This includes ACT science score, ACT math score, and GPA.

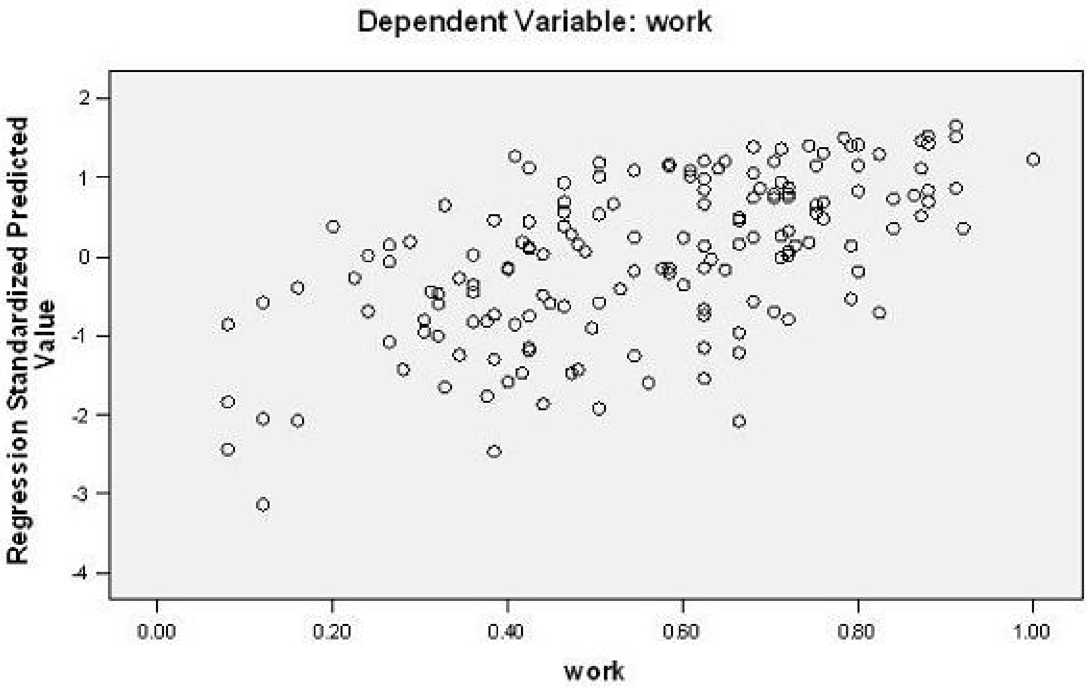

Figure J.5: Step 1-All variables entered.

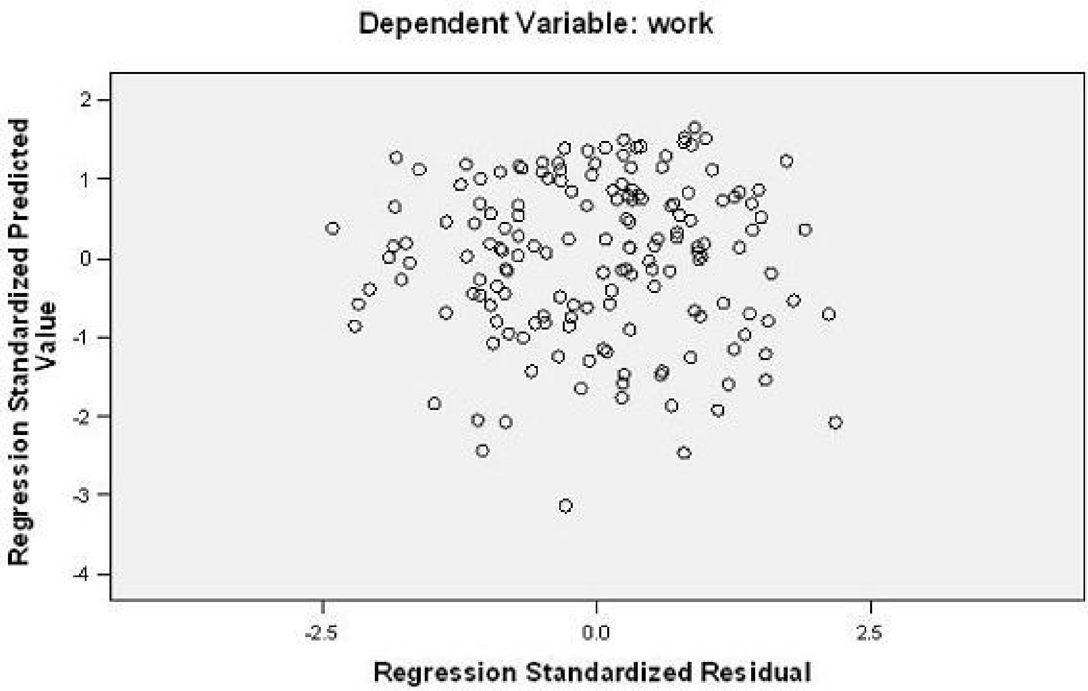

Figure J.6: Step 1-All variables entered.

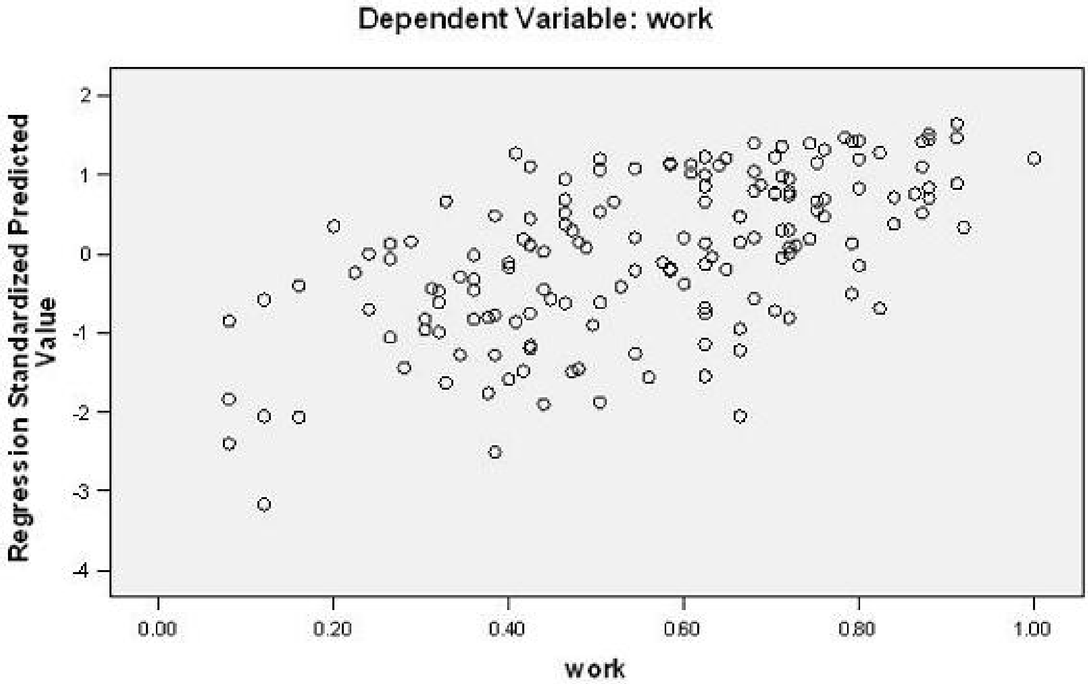

Figure J.7: Step 2-The ACT math score was removed.

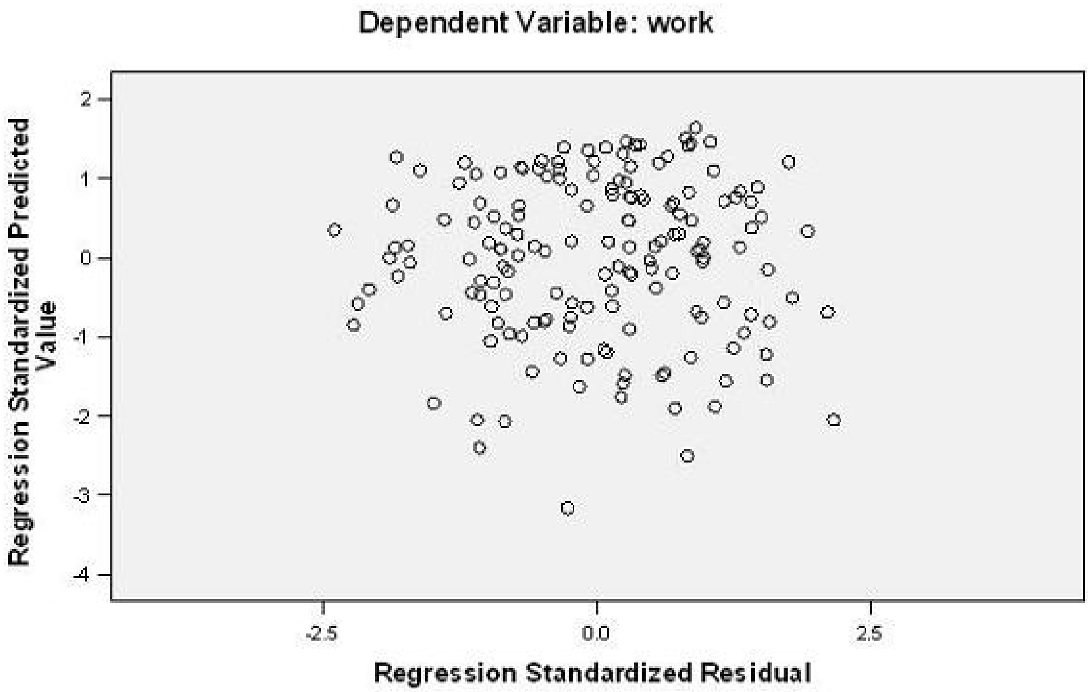

Figure J.8: Step 2-The ACT math score was removed.

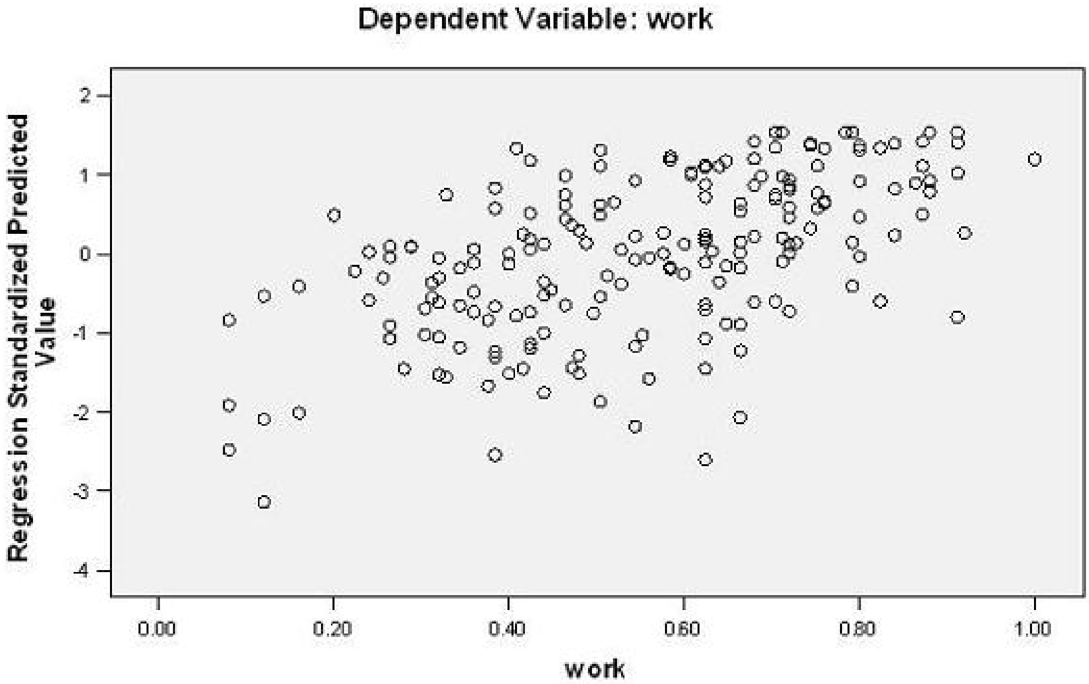

Figure J.9: Step 3-The ACT science score was removed.

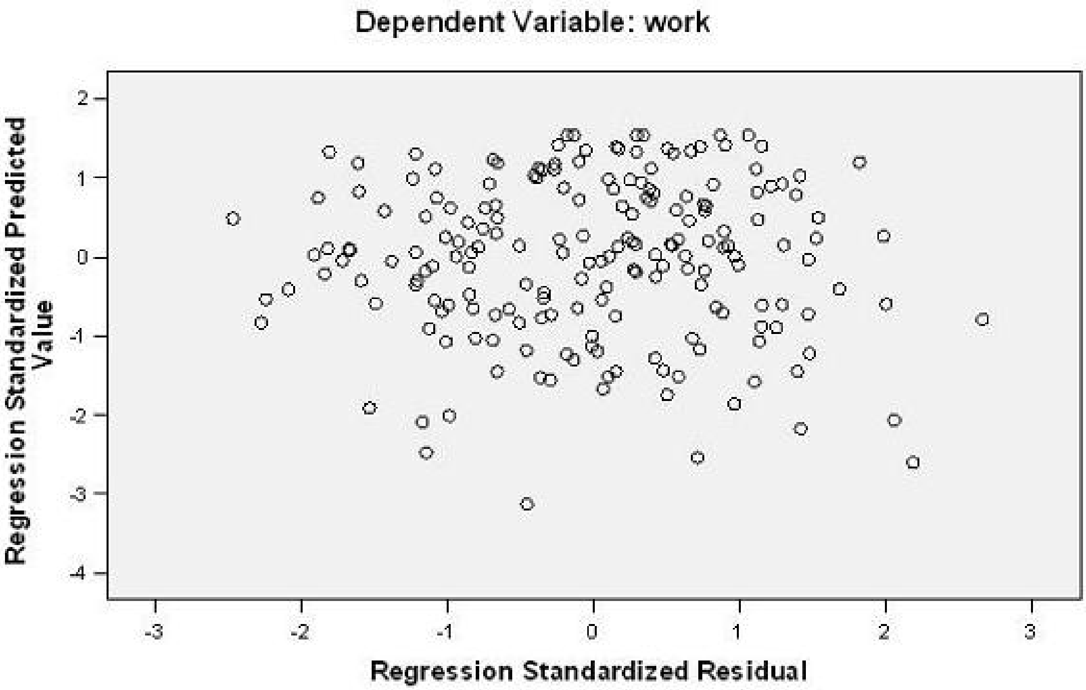

Figure J.10: Step 3-The ACT science score was removed.

J.3 Test of Regression Assumption Four and Five for Research Question three-Homework-Style Problems

Step 1-All variables are included in the regression. This includes the MPEX pre-test, MPEX post-test, and the four learning style dimensions.

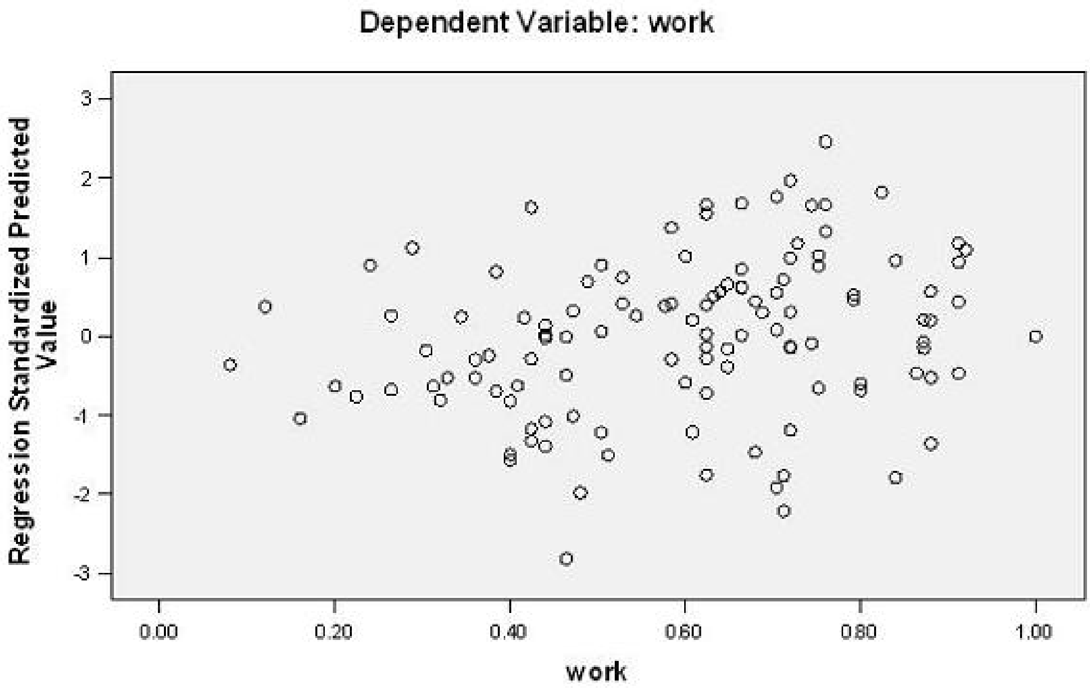

Figure J.11: Step 1-All variables entered.

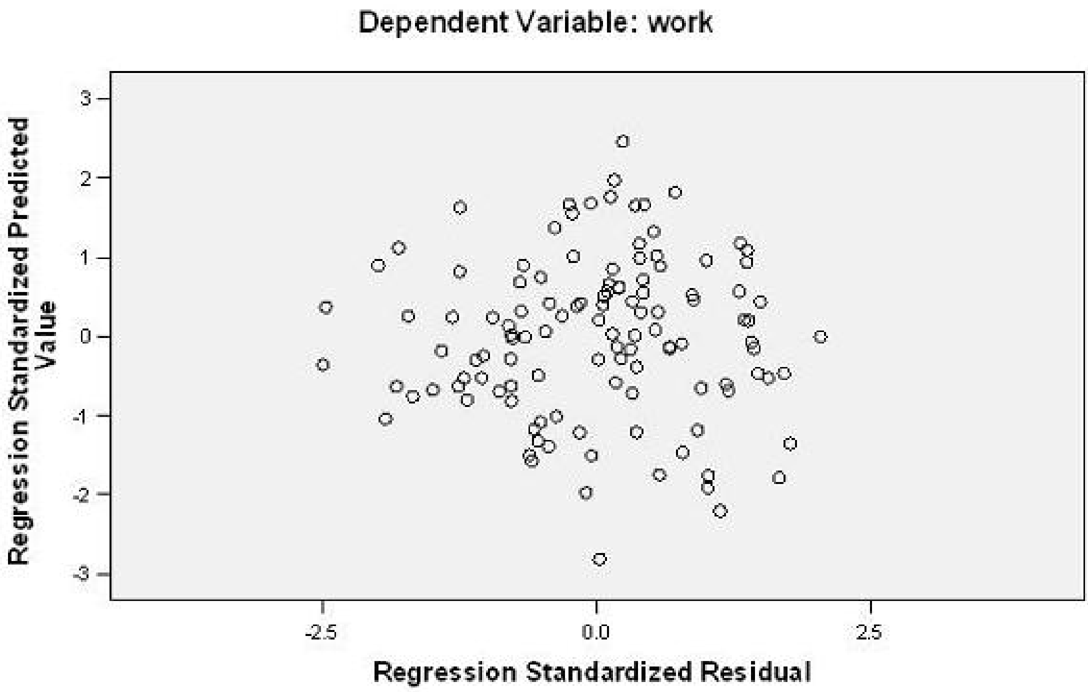

Figure J.12: Step 1-All variables entered.

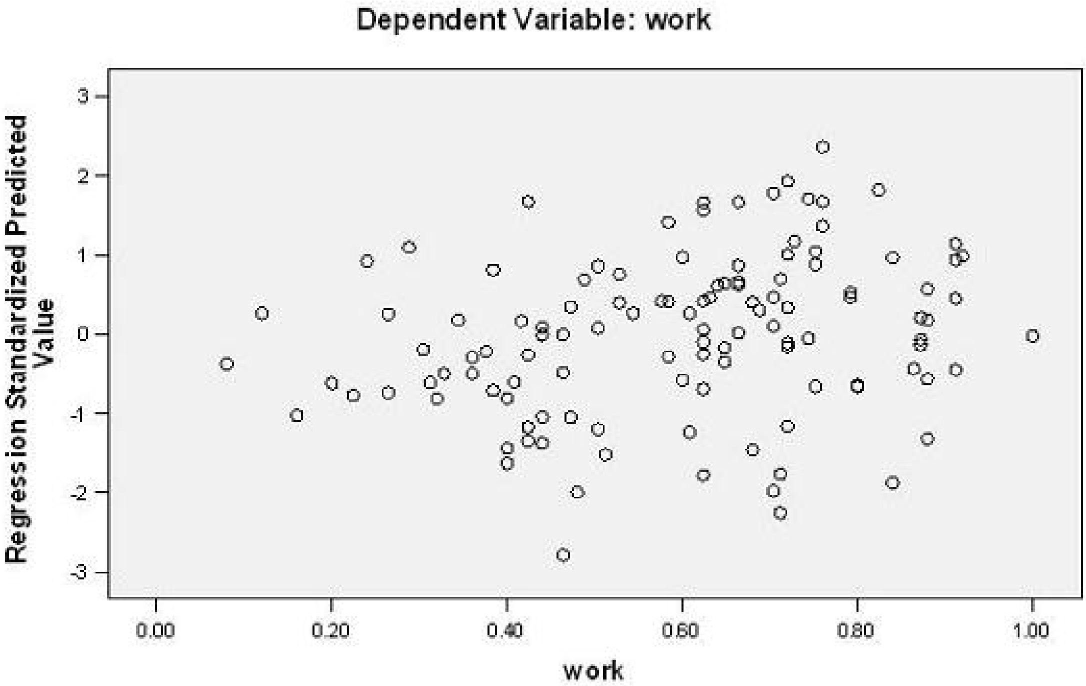

Figure J.13: Step 2-The sensing/intuitive dimension was removed.

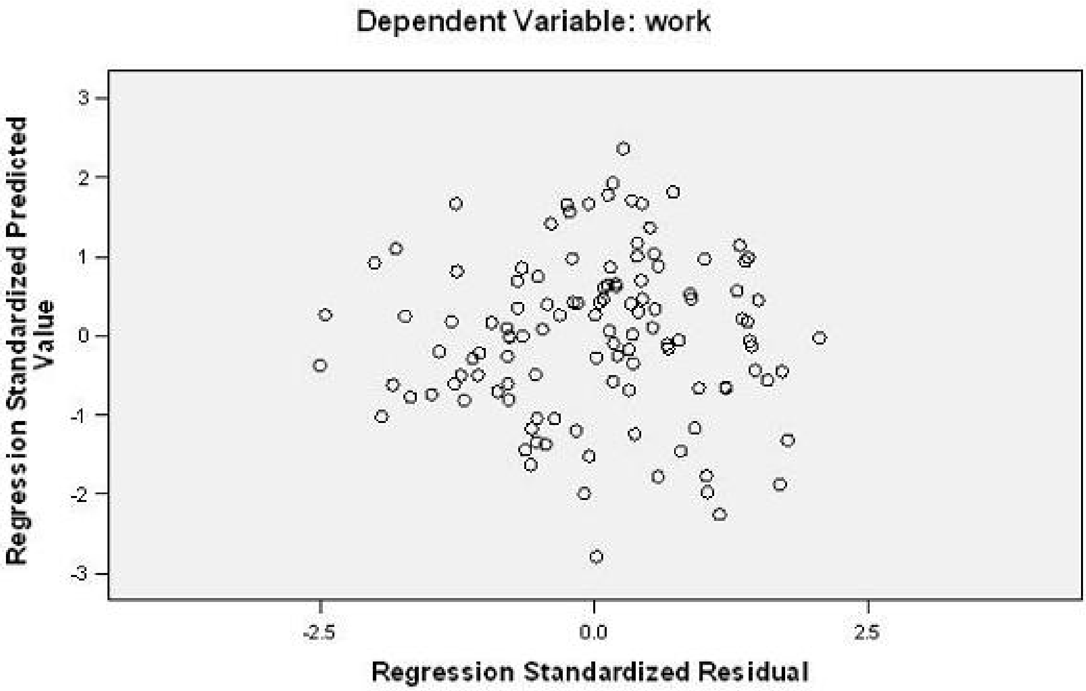

Figure J.14: Step 2-The sensing/intuitive dimension was removed.

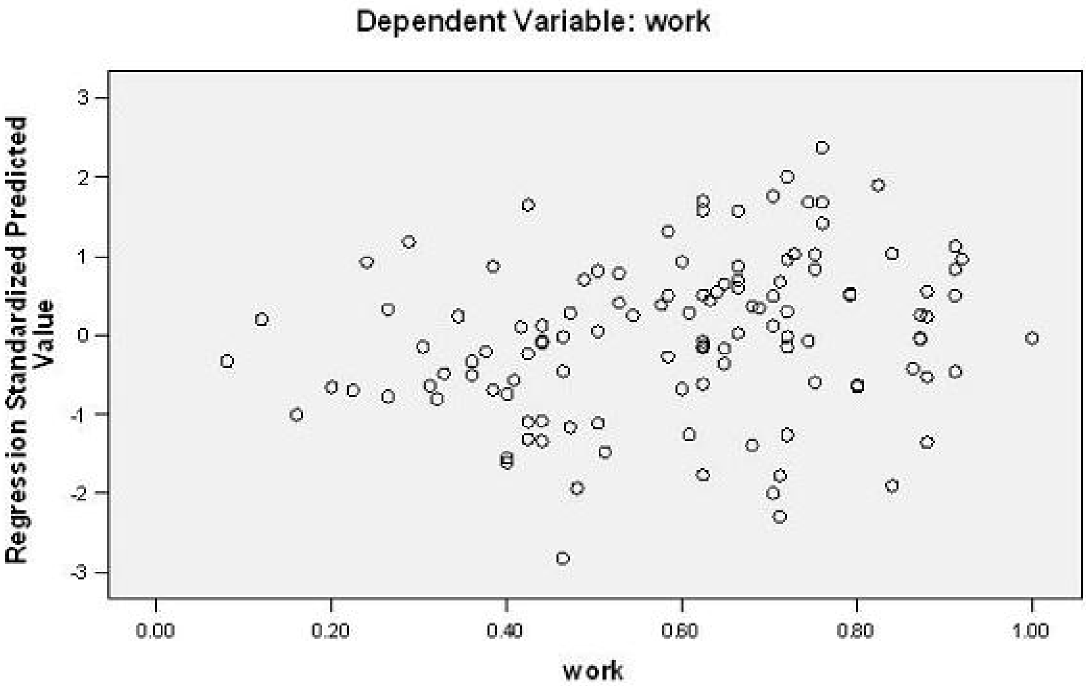

Figure J.15: Step 3-The sequential/global dimension was removed.

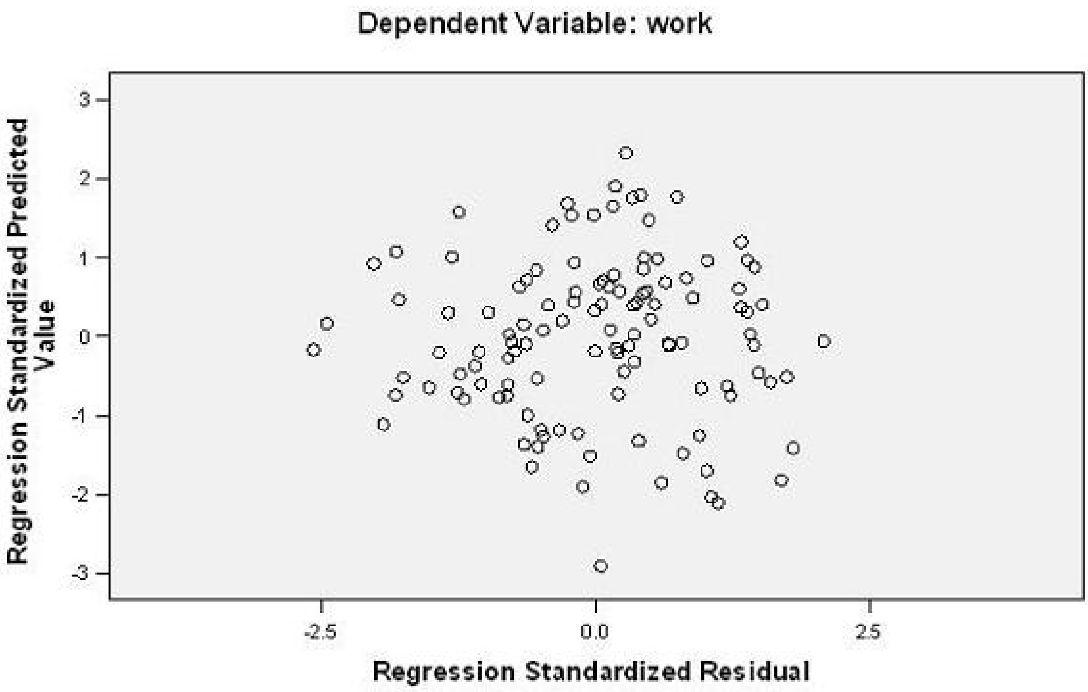

Figure J.16: Step 3-The sequential/global dimension was removed.

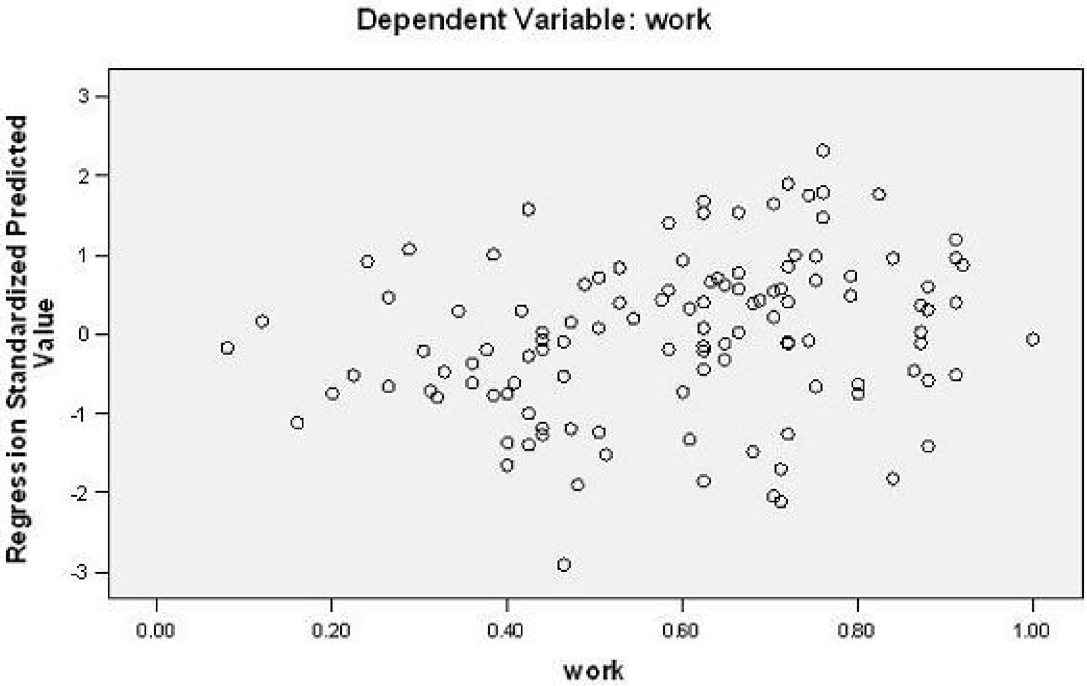

Figure J.17: Step 4-The visual/verbal dimension was removed.

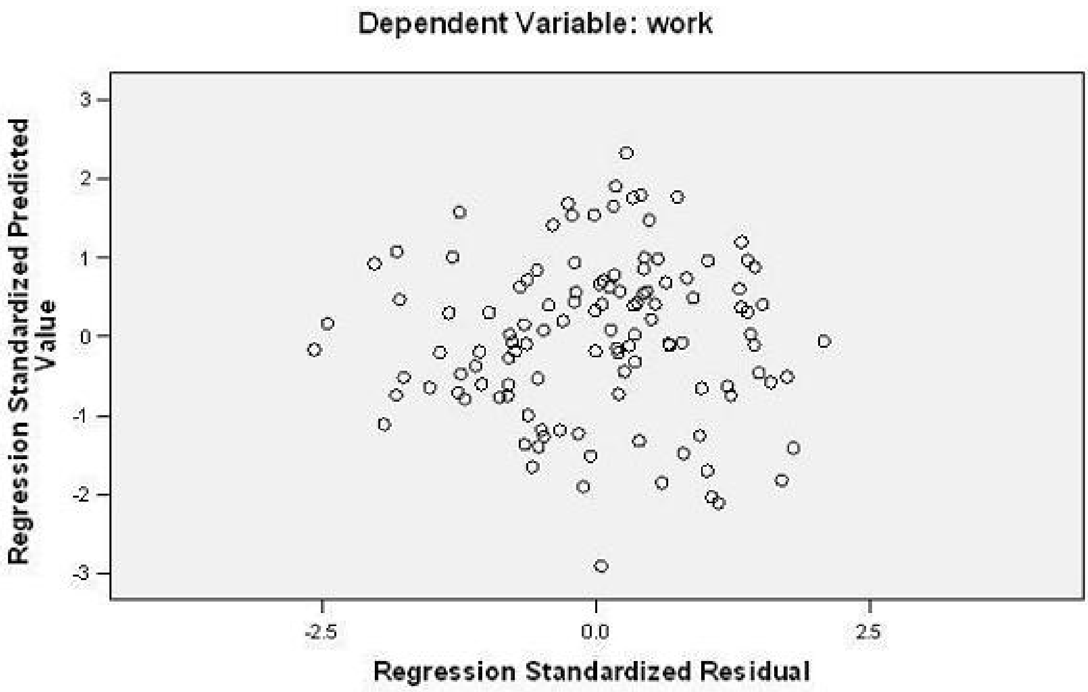

Figure J.18: Step 4-The visual/verbal dimension was removed.

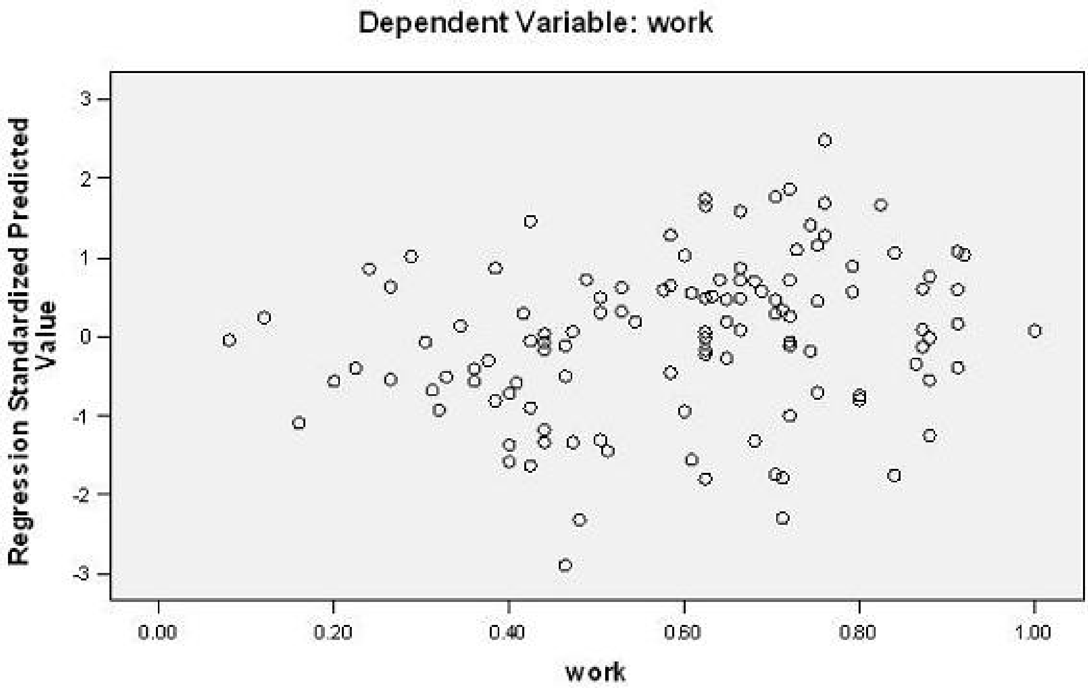

Figure J.19: Step 5-The active/reflective dimension was removed.

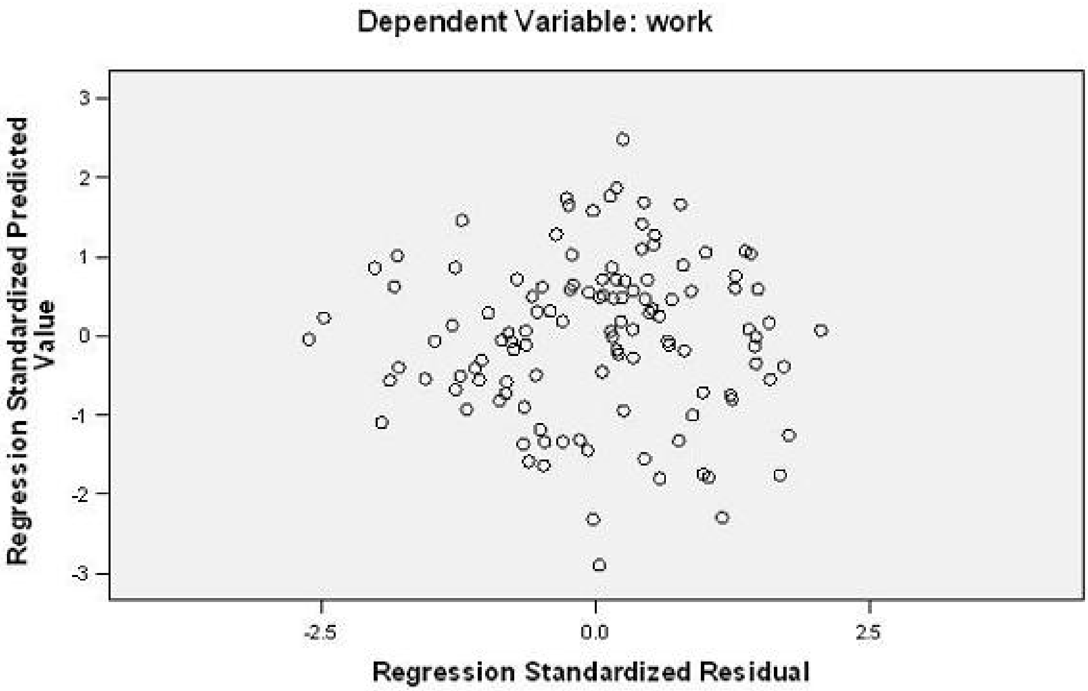

Figure J.20: Step 5-The active/reflective dimension was removed.

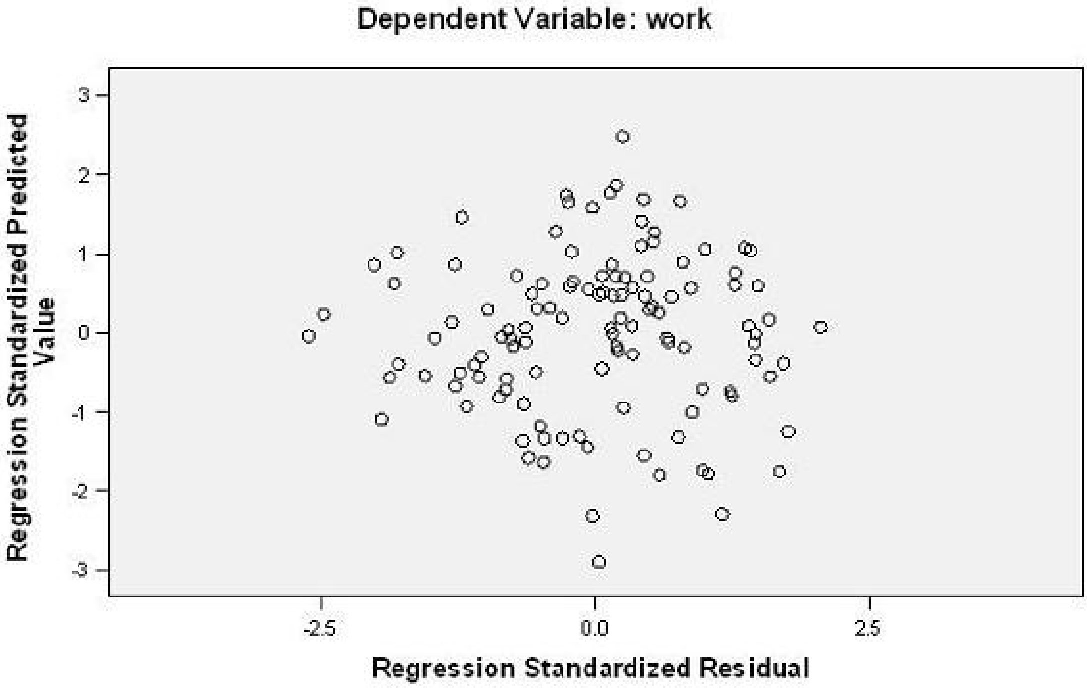

Figure J.21: Step 6-The MPEX pre-test was removed.

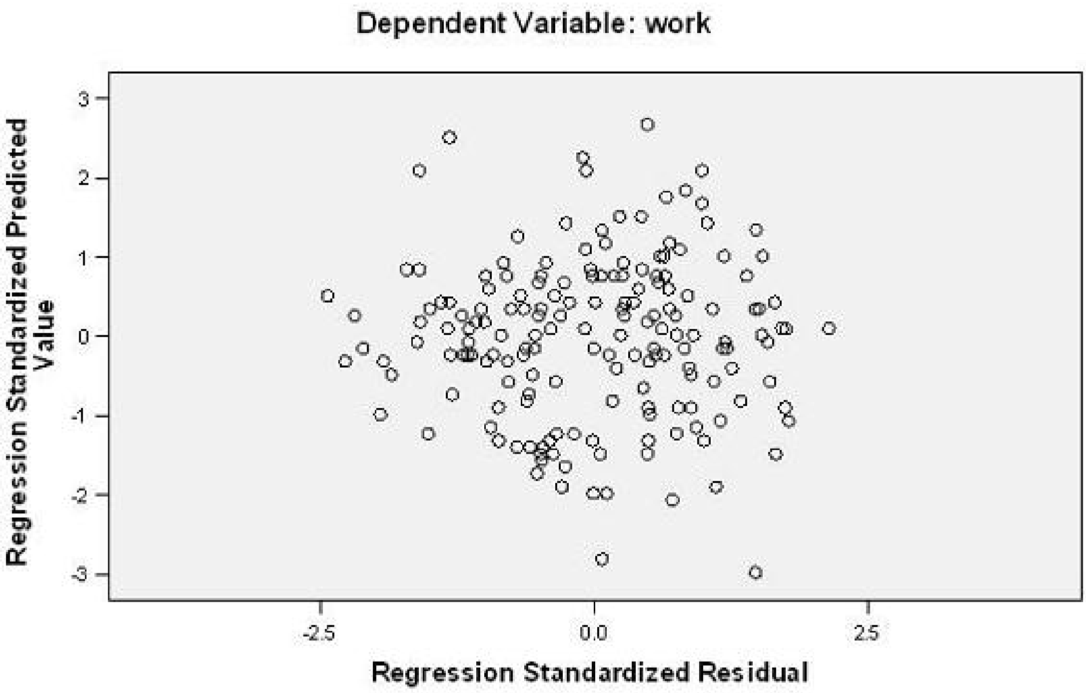

Figure J.22: Step 6-The MPEX pre-test was removed.

J.4 Test of Regression Assumption Four and Five for Research Question four-Homework-Style Problems

Step 1-All variables are included in the regression. This includes the lab attendance, help session attendance, time spent in the helproom, and Physics 1114 grade.

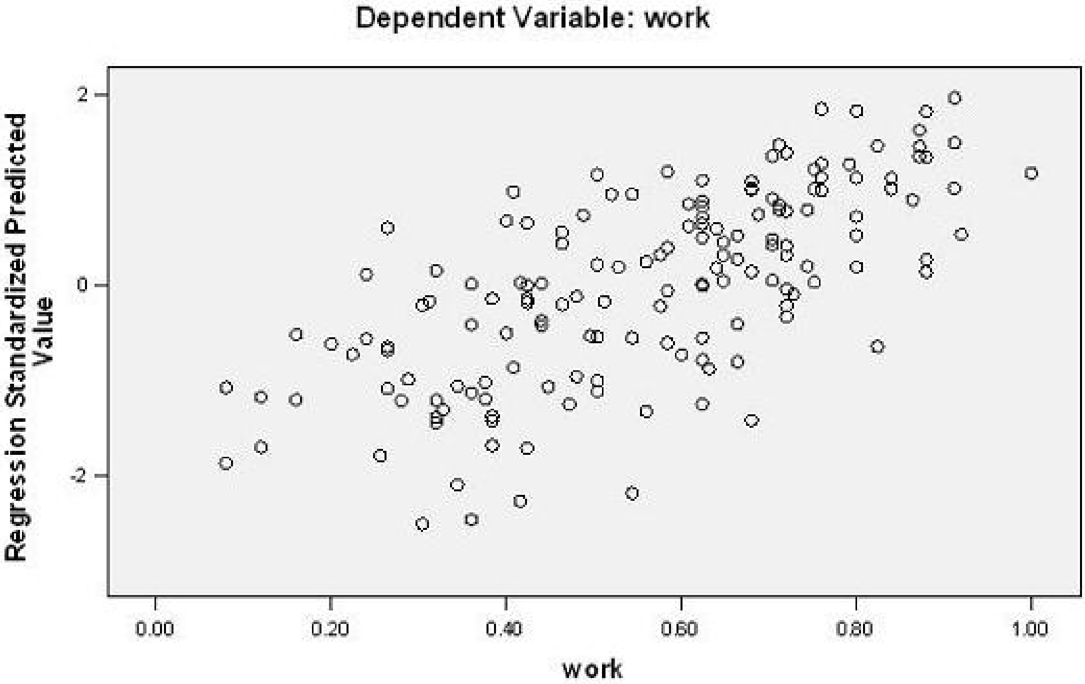

Figure J.23: Step 1-All variables entered.

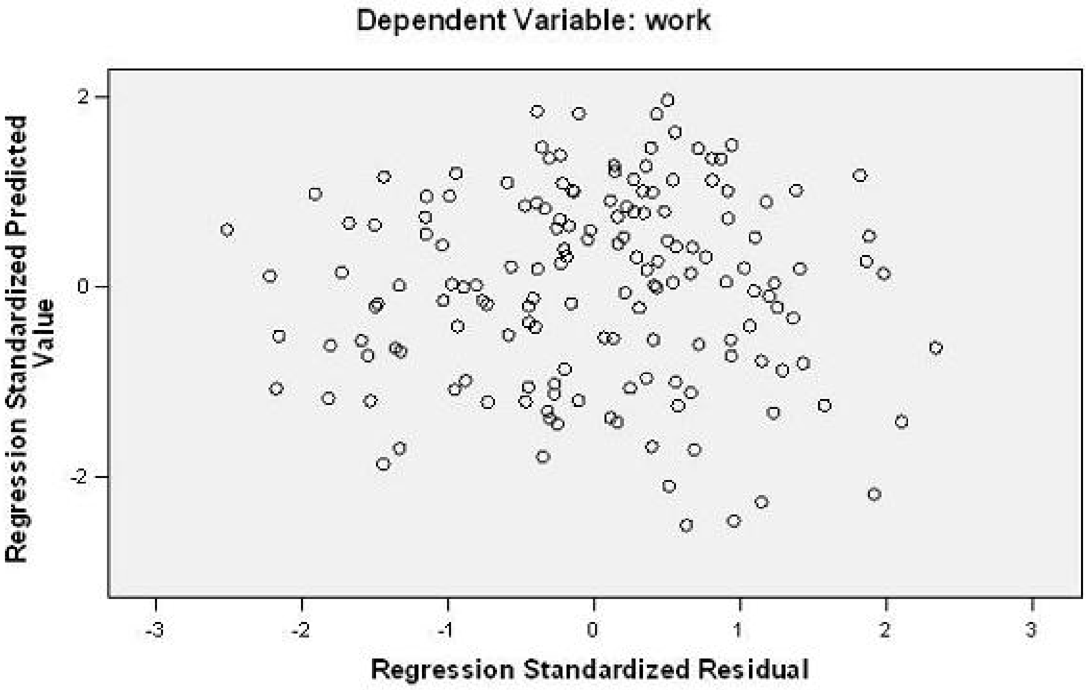

Figure J.24: Step 1-All variables entered.

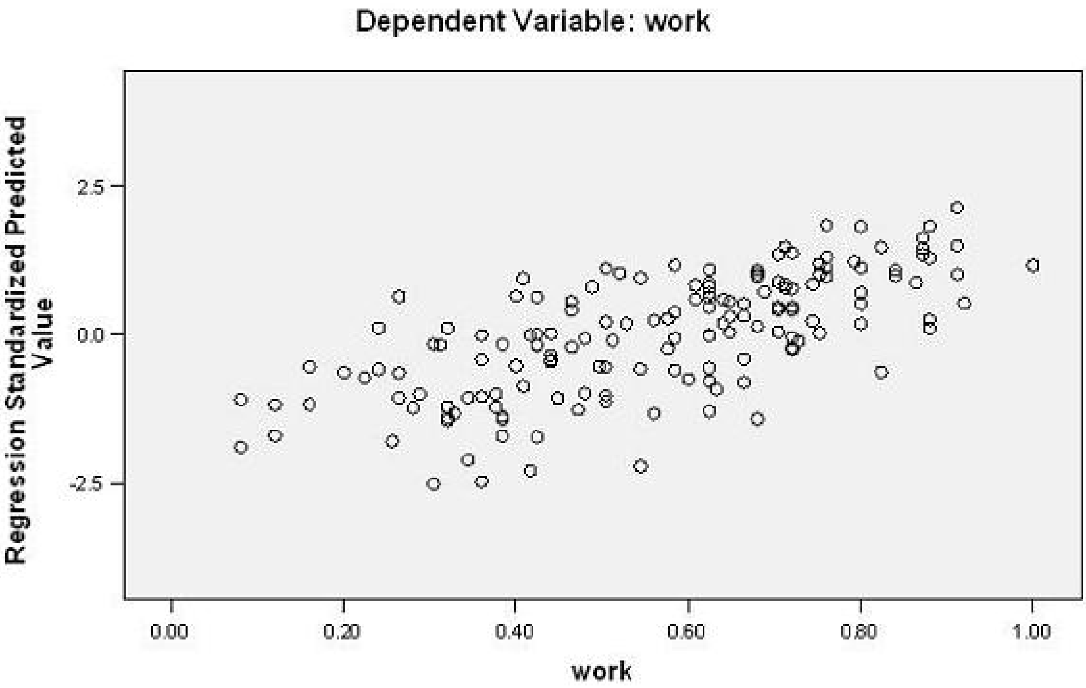

Figure J.25: Step 2-The time spent in the helproom was removed.

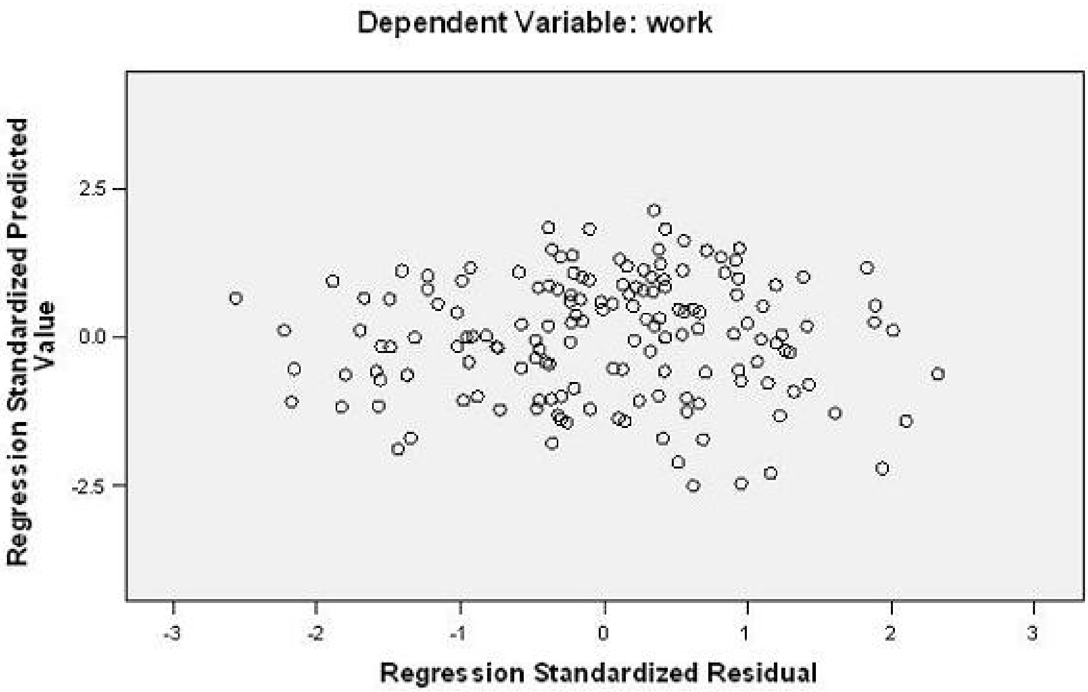

Figure J.26: Step 2-The time spent in the helproom was removed.

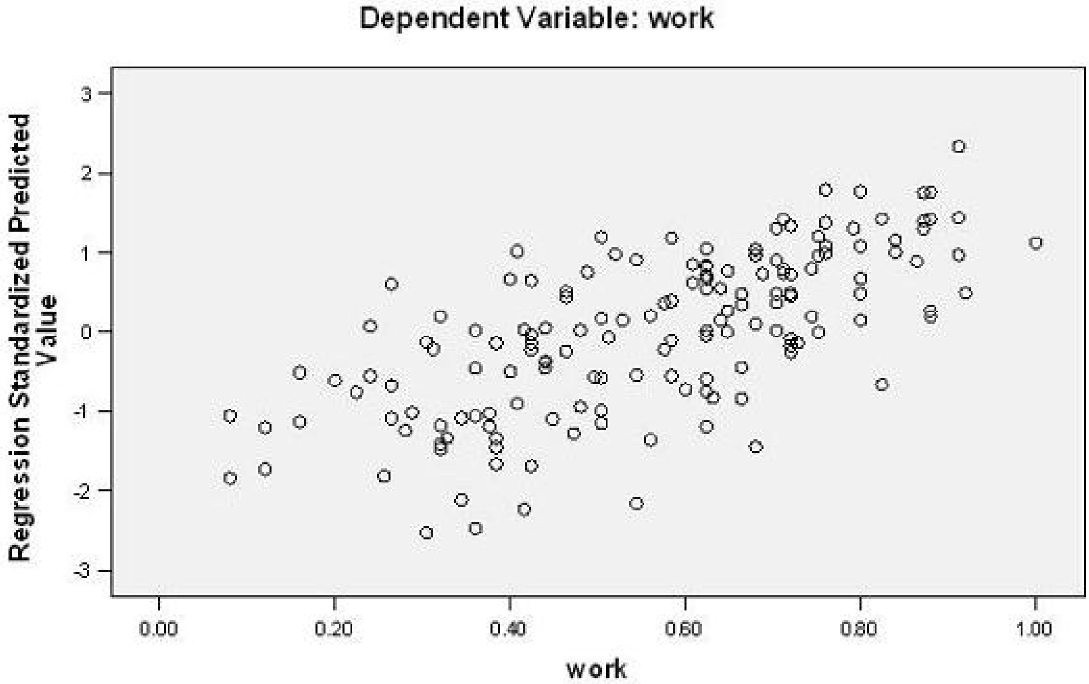

Figure J.27: Step 3-The help session attendance was removed.

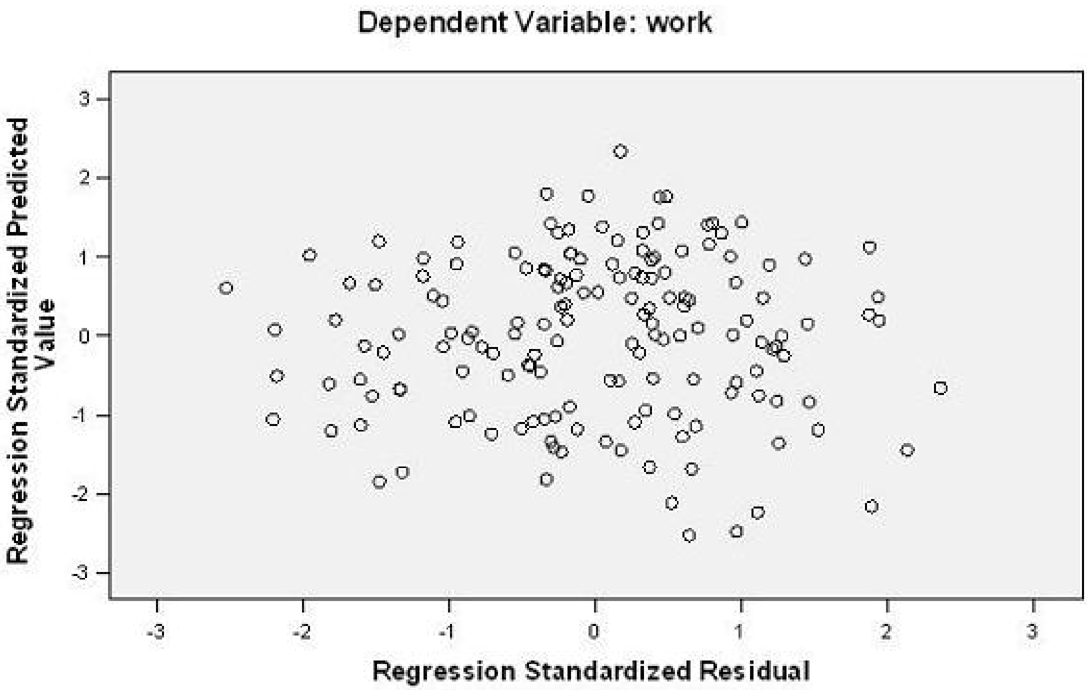

Figure J.28: Step 3-The help session attendance was removed.

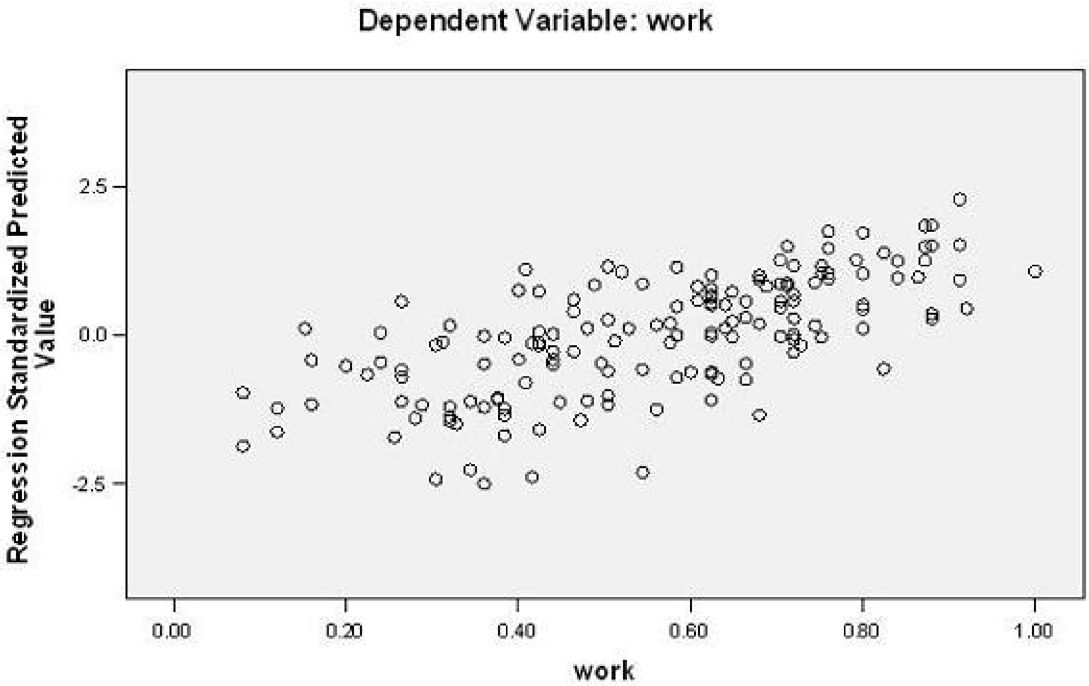

Figure J.29: Step 4-The lab attendance was removed.

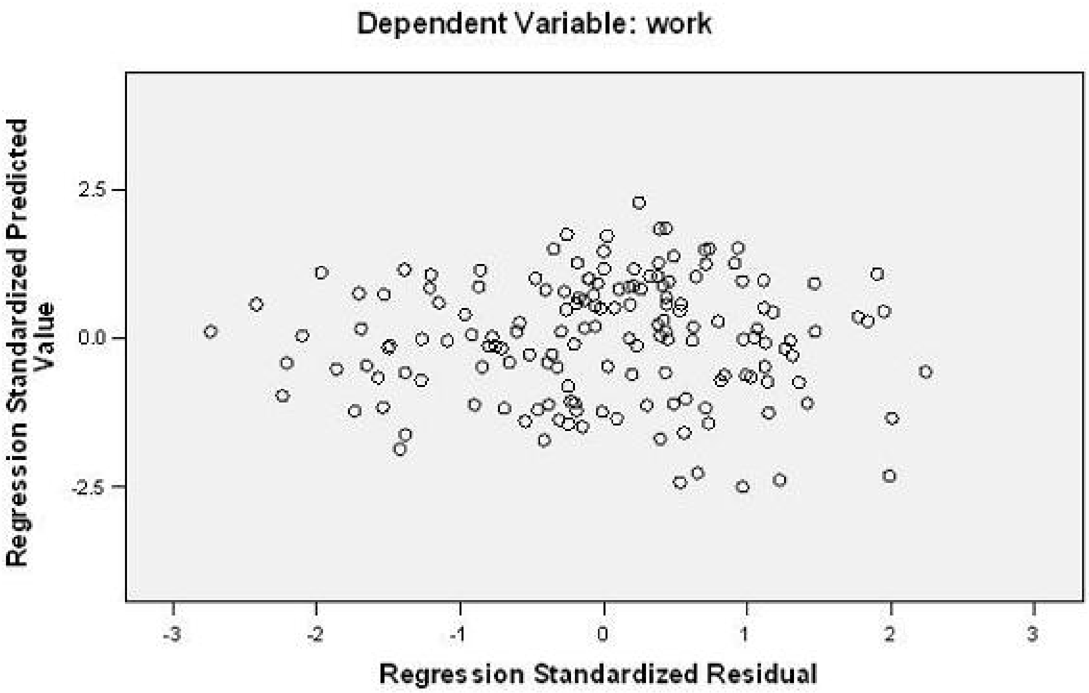

Figure J.30: Step 4-The lab attendance was removed.

J.5 Test of Regression Assumption Four and Five for Research Question five-Homework-Style Problems

Step 1-All variables are included in the regression. This includes the homework grade, HBL grade, lab grade, GPA, MPEX post-test, and Physics 1114 grade.

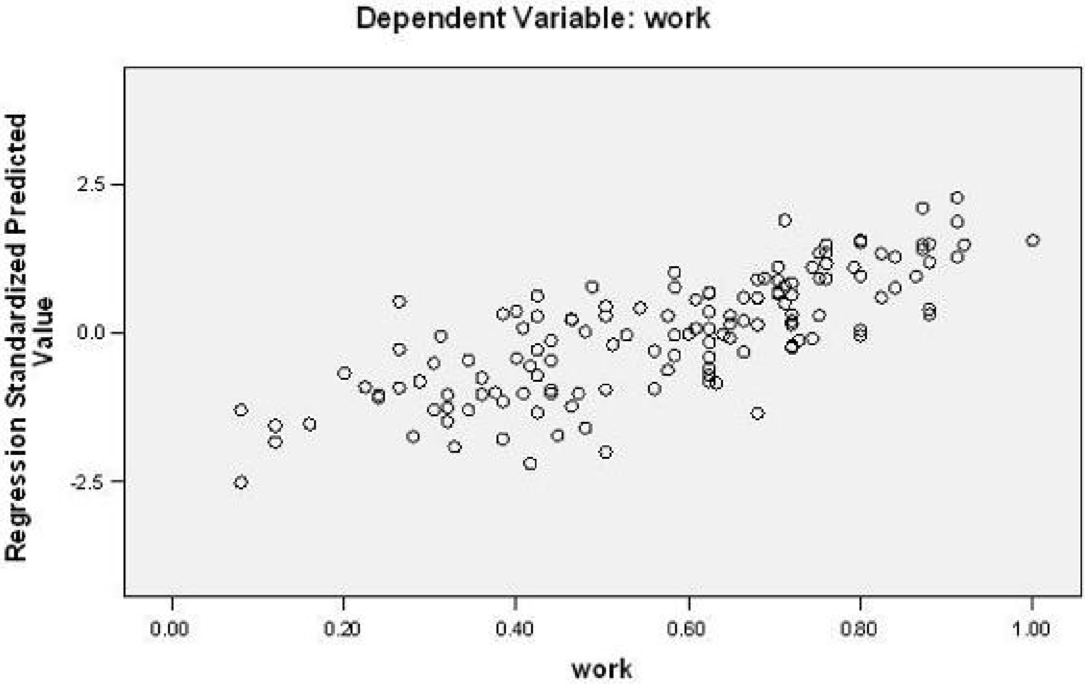

Figure J.31: Step 1-All variables entered.

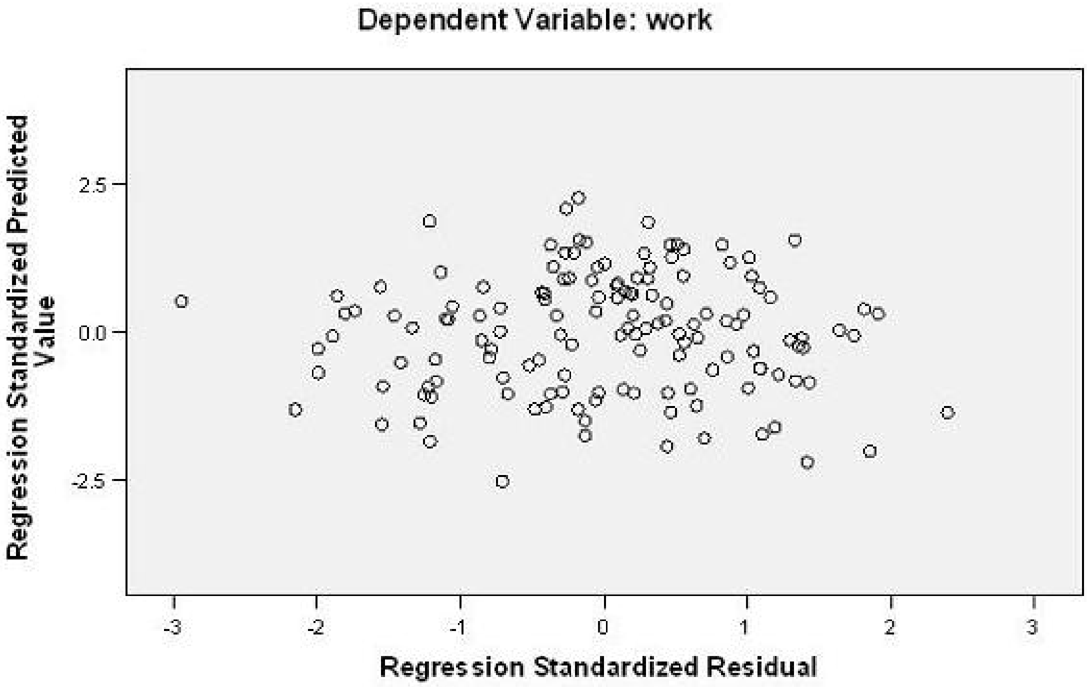

Figure J.32: Step 1-All variables entered.

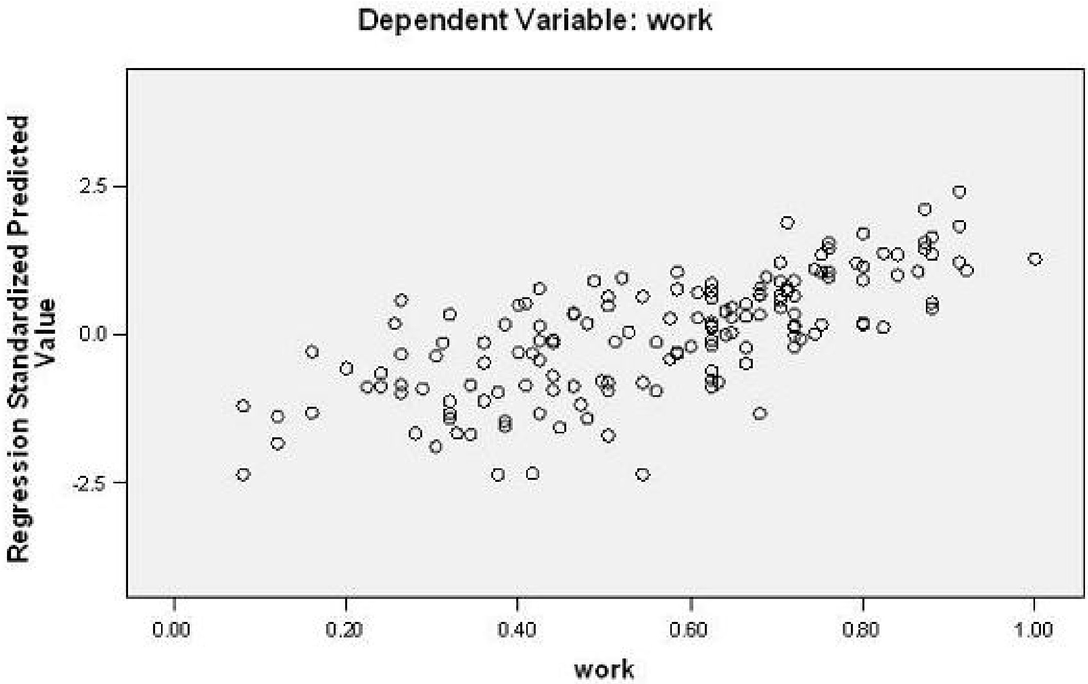

Figure J.33: Step 2-The MPEX post-test was removed.

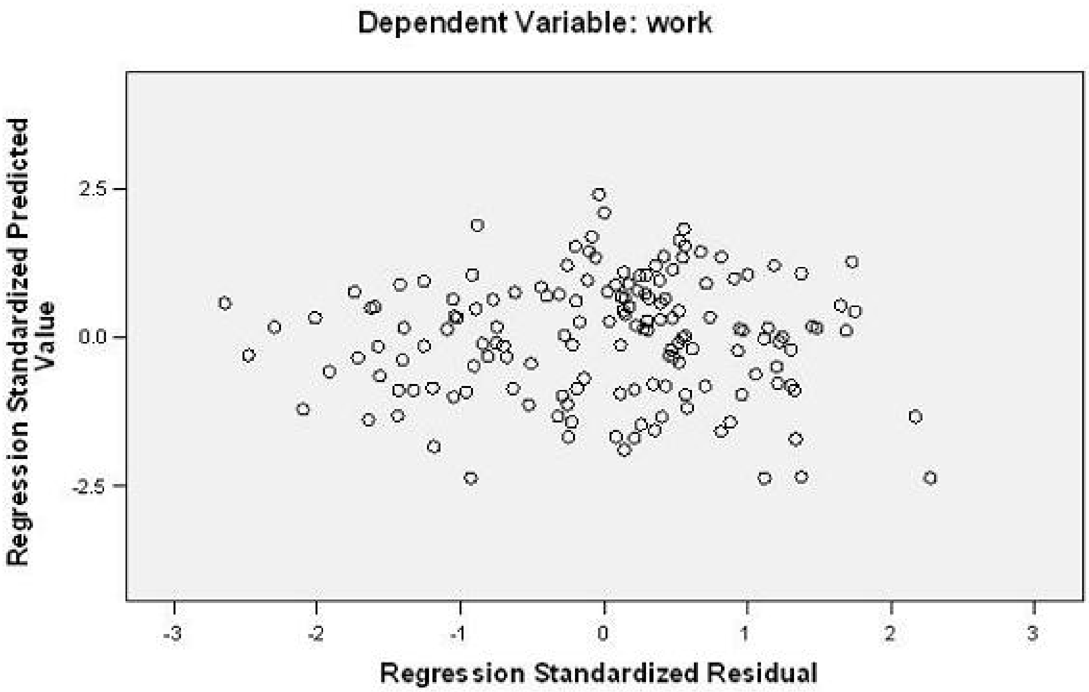

Figure J.34: Step 2-The MPEX post-test was removed.

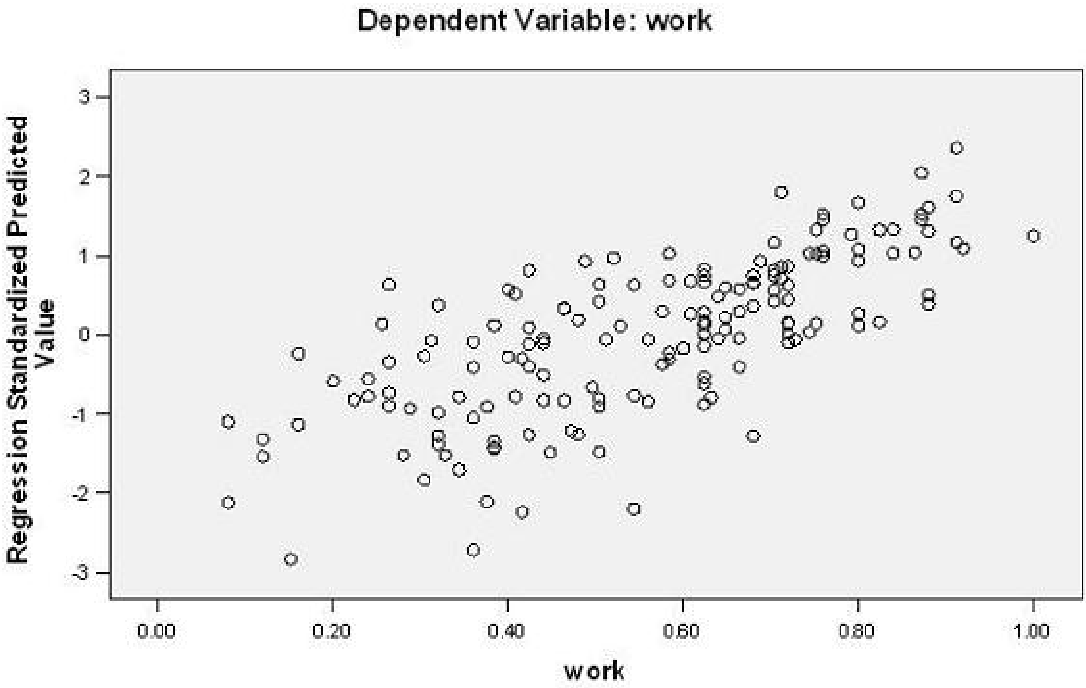

Figure J.35: Step 3-The GPA was removed.

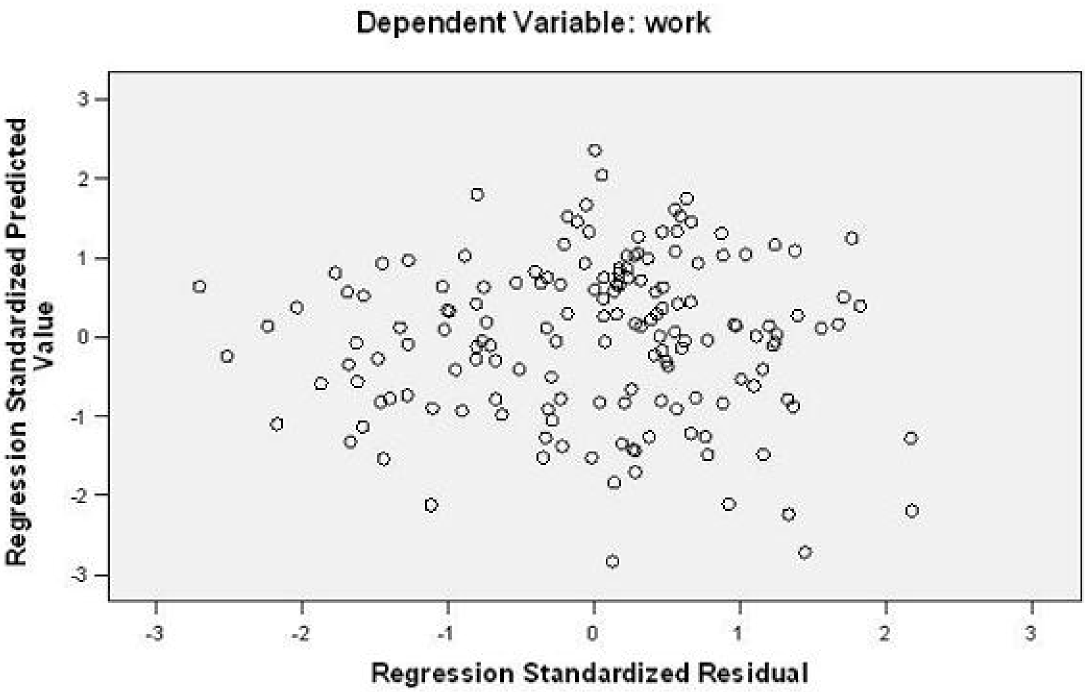

Figure J.36: Step 3-The GPA was removed.

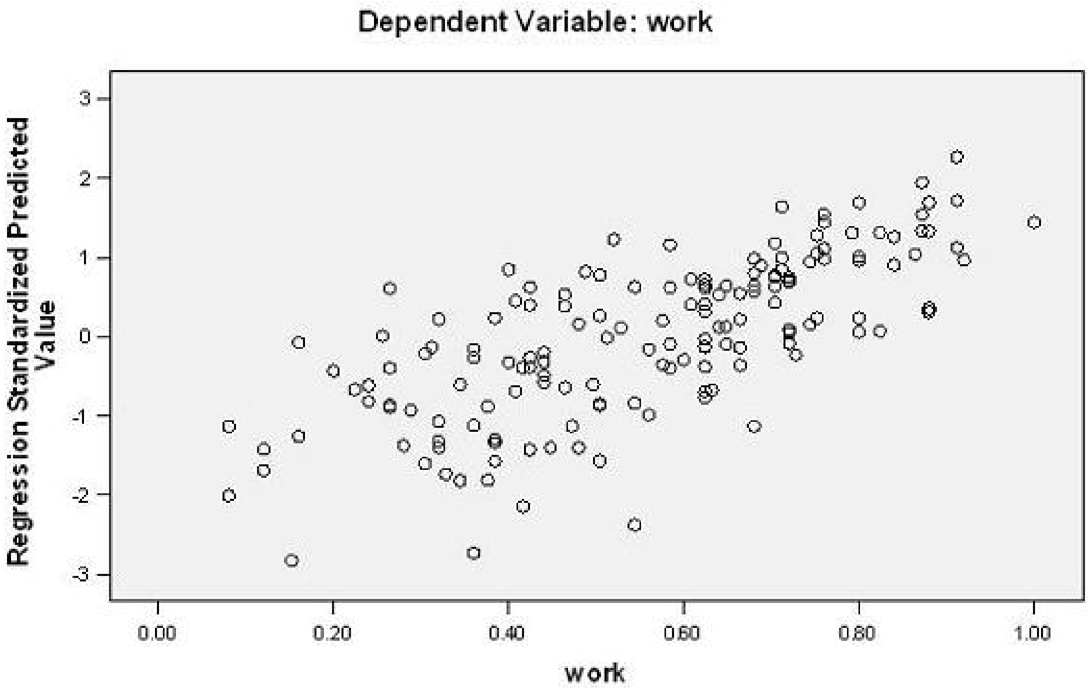

Figure J.37: Step 4-The HBL grade was removed.

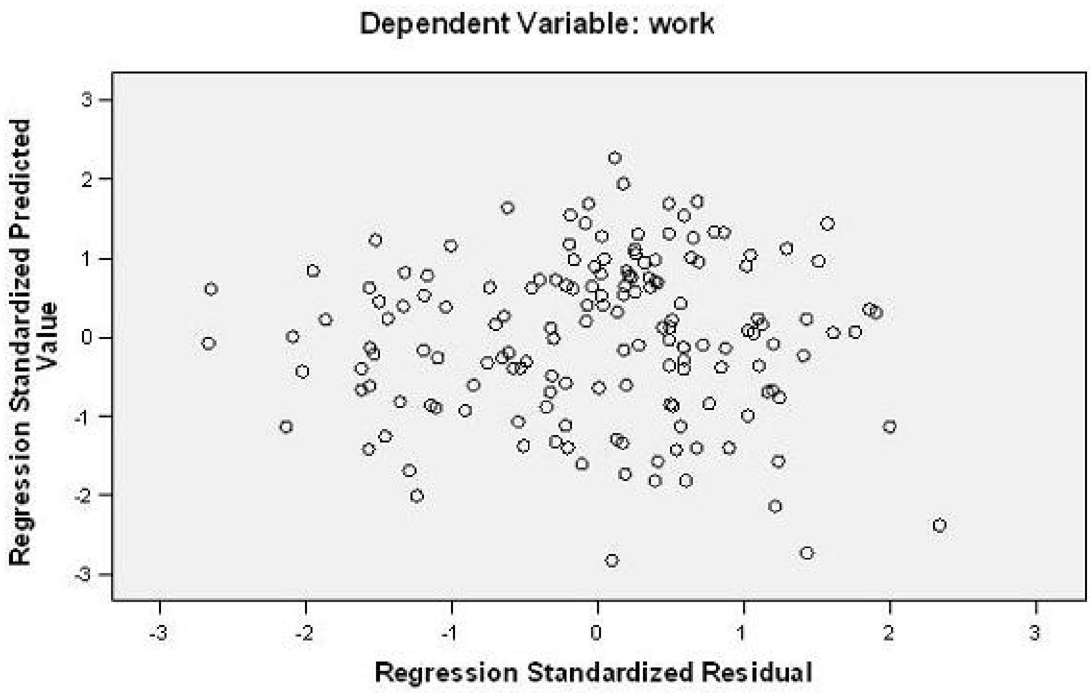

Figure J.38: Step 4-The HBL grade was removed.

J.5.1 Analysis

With the exception of research question three, the graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The predicted score versus residual seems to have a circular pattern on all of the research questions. Due to this assumption five is satisfied.

APPENDIX K

Test of Assumptions for multiple choice questions

K.1 Test of Regression Assumption Four and Five for Research Question One-Multiple Choice Problems

Step 1-All variables are included in the regression. This includes homework average, lab average, PRS score, and HBL average.

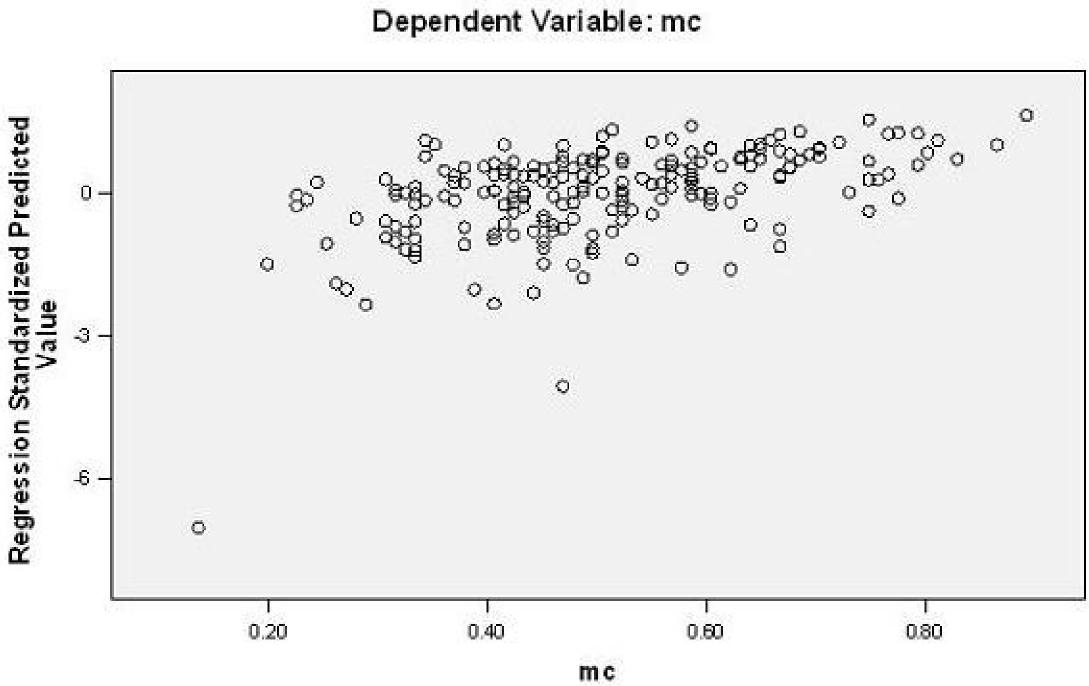

Figure K.1: Step 1-All variables entered.

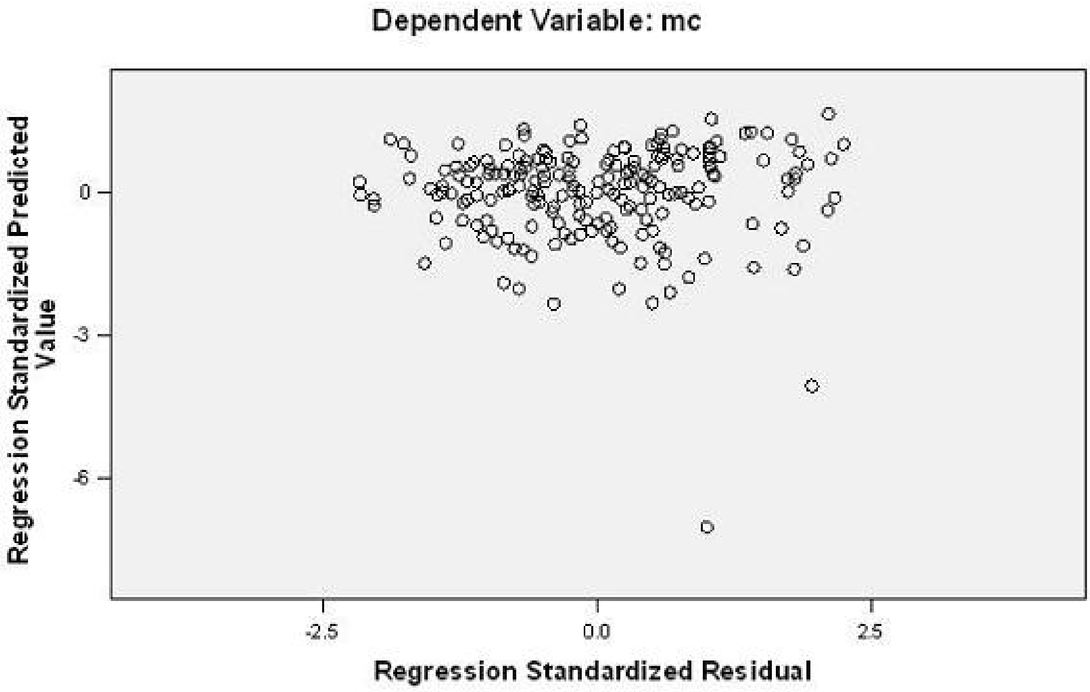

Figure K.2: Step 1-All variables entered.

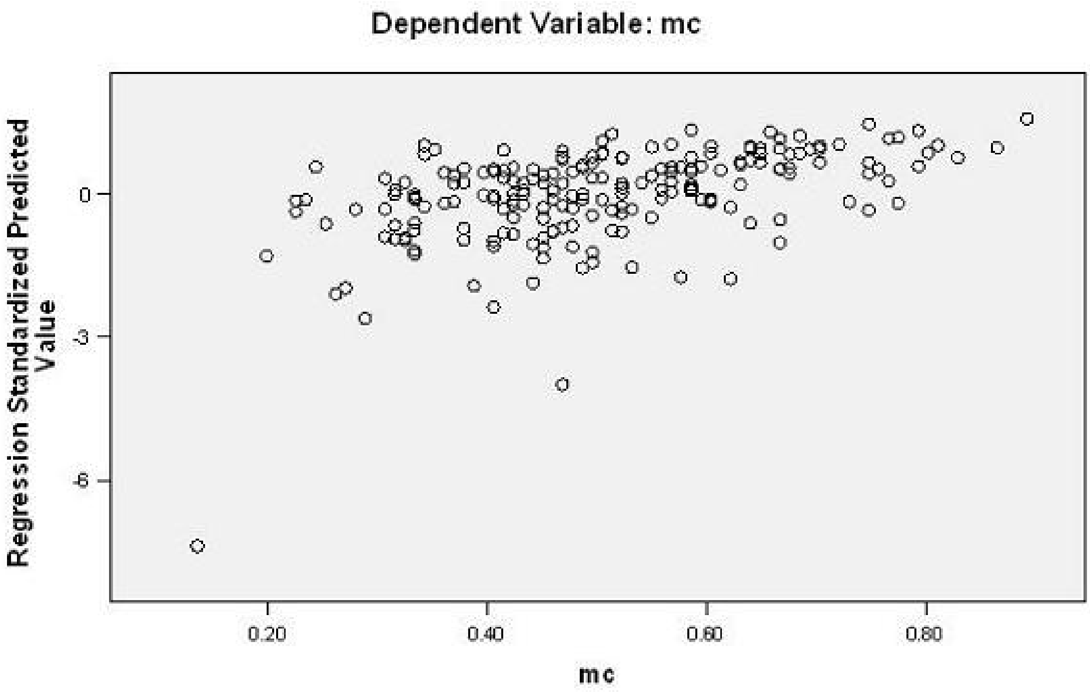

Figure K.3: Step 2-The clicker score was removed.

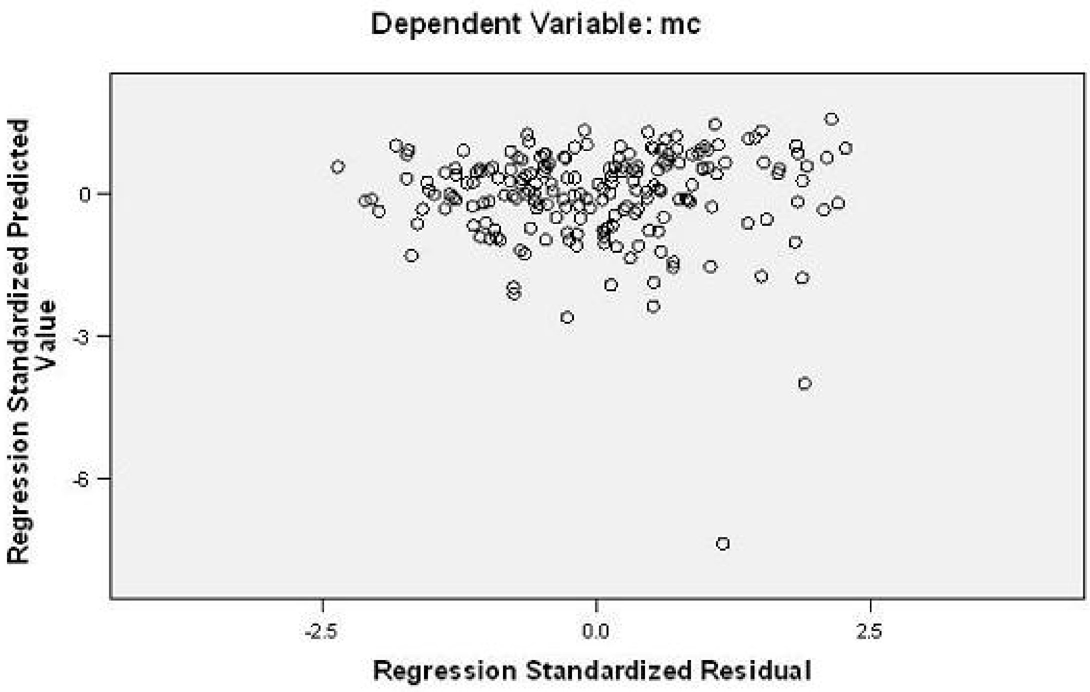

Figure K.4: Step 2-The clicker score was removed.

K.2 Test of Regression Assumption Four and Five for Research Question two-Multiple Choice Problems

Step 1-All variables are included in the regression. This includes ACT science score, ACT math score, and GPA.

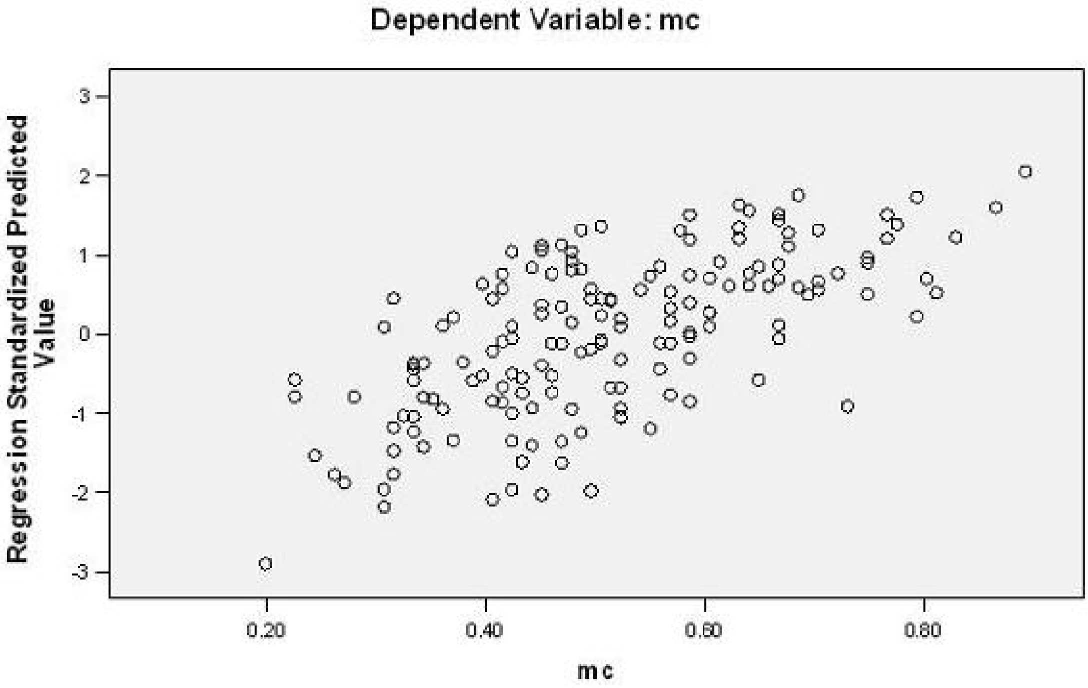

Figure K.5: Step 1-All variables entered.

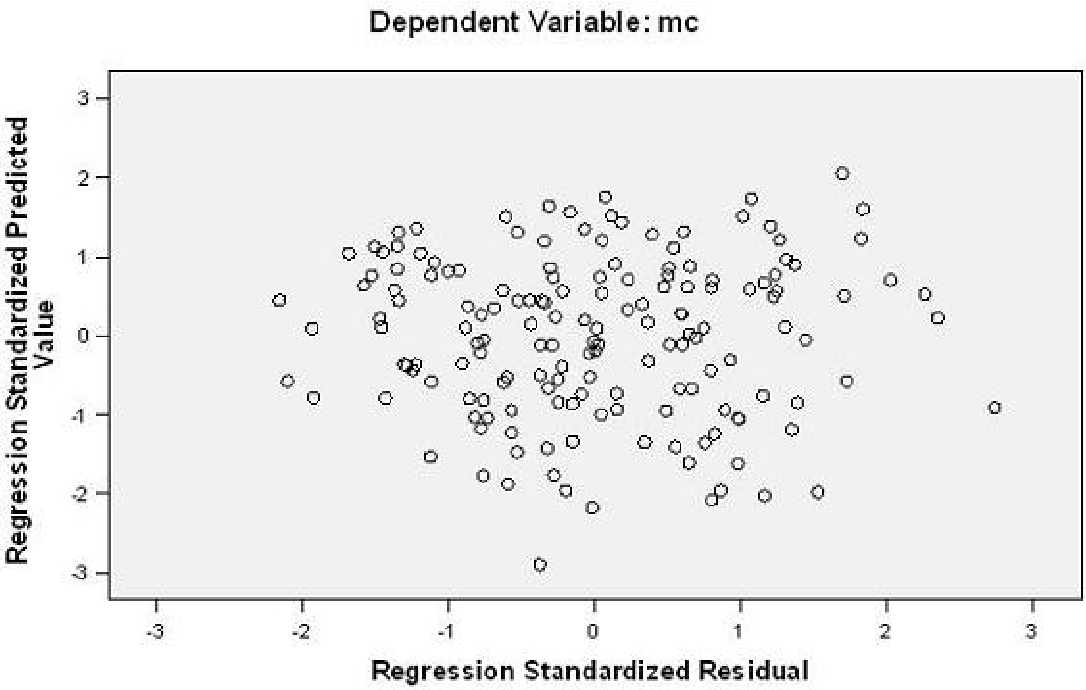

Figure K.6: Step 1-All variables entered.

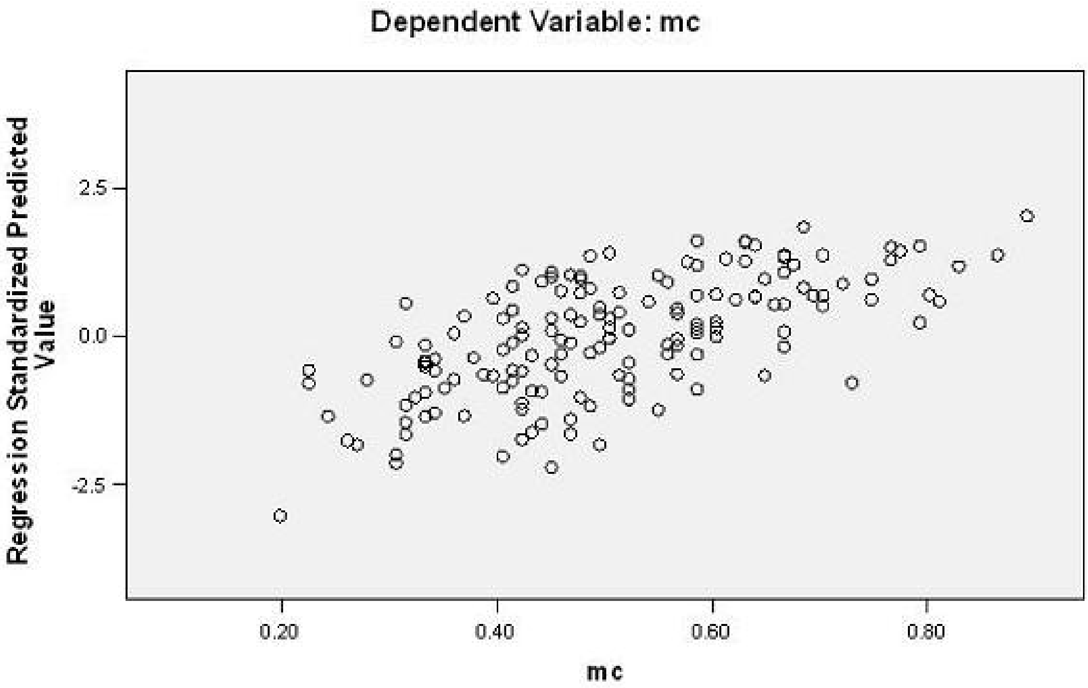

Figure K.7: Step 2-The ACT math score was removed.

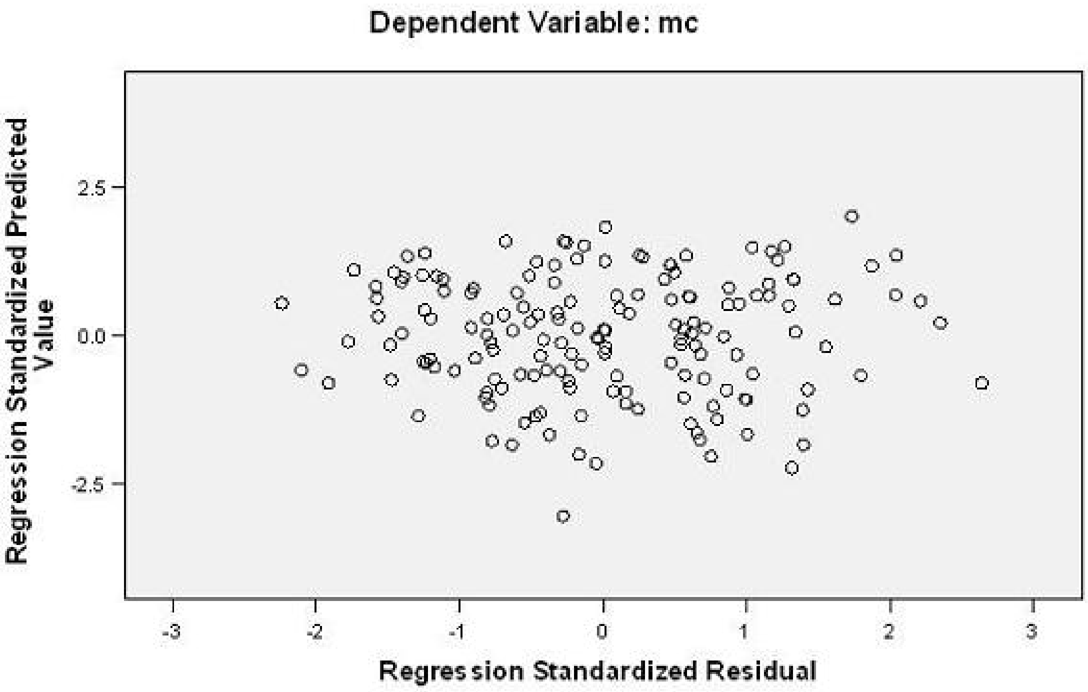

Figure K.8: Step 2-The ACT math score was removed.

K.3 Test of Regression Assumption Four and Five for Research Question three-Multiple Choice Problems

Step 1-All variables are included in the regression. This includes the MPEX pre-test, MPEX post-test, and the four learning style dimensions.

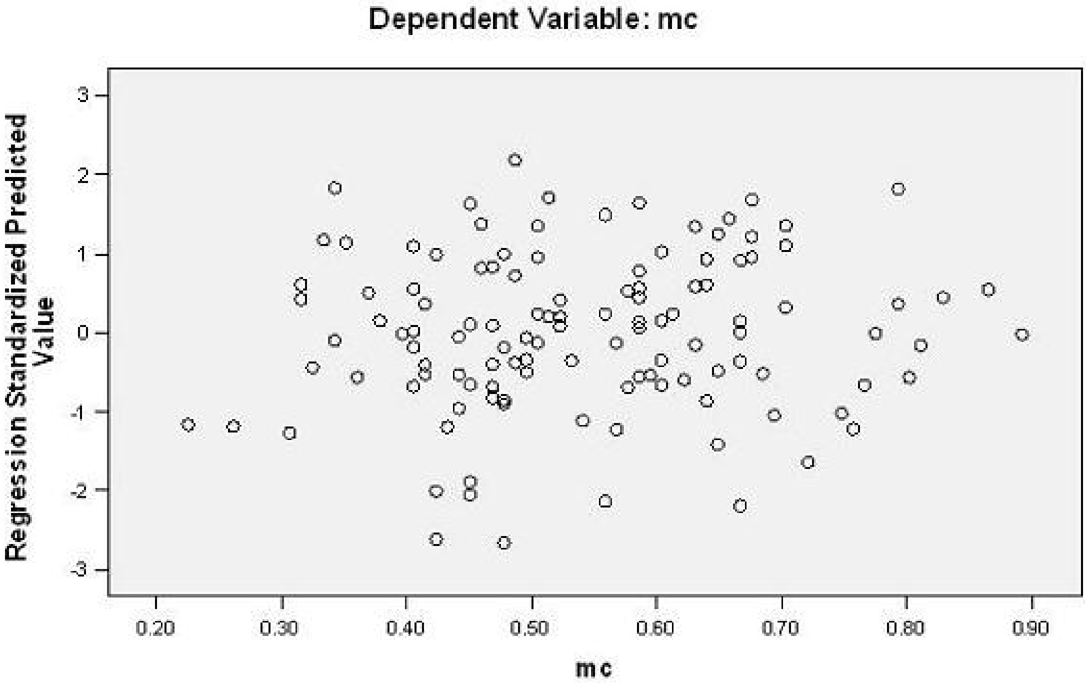

Figure K.9: Step 1-All variables entered.

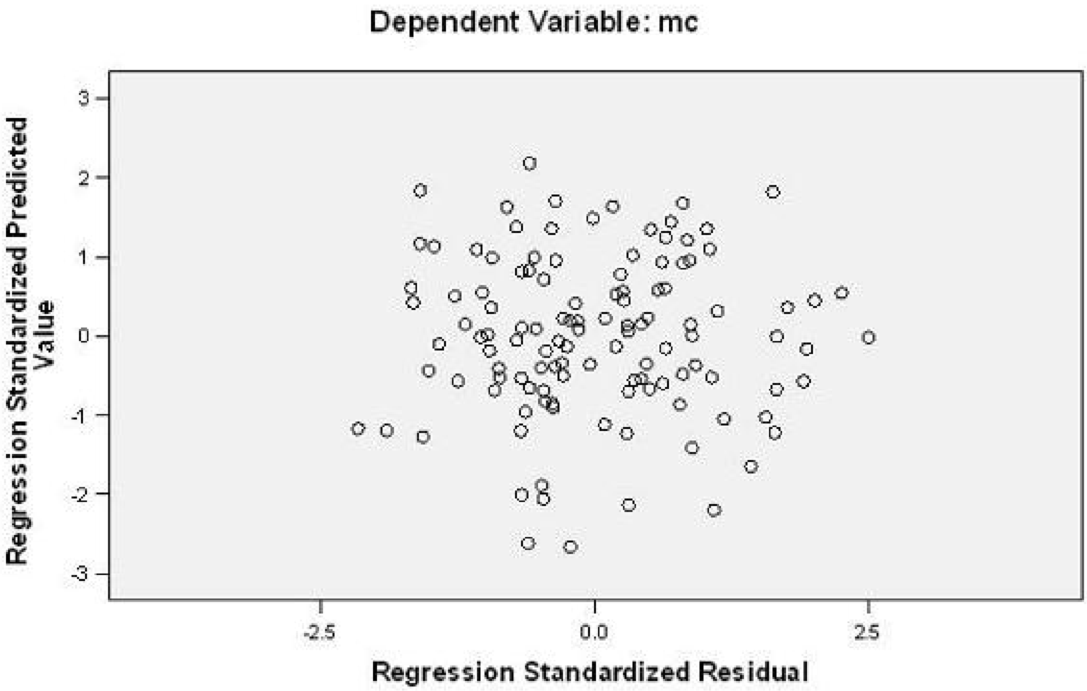

Figure K.10: Step 1-All variables entered.

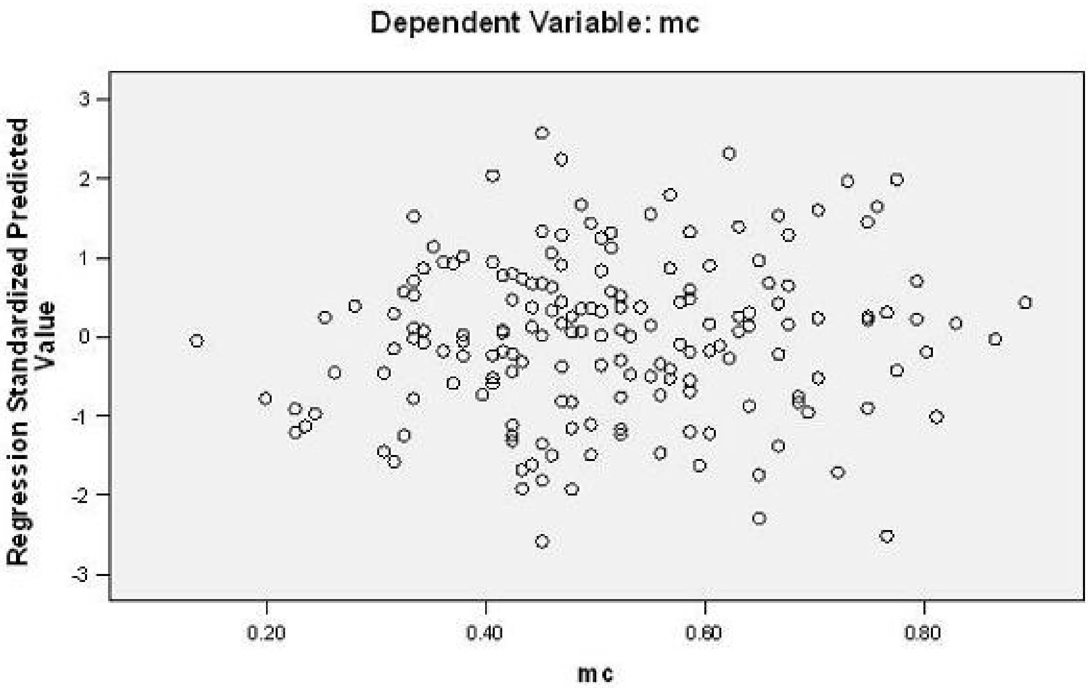

Figure K.11: Step 2-The MPEX pre-test was removed.

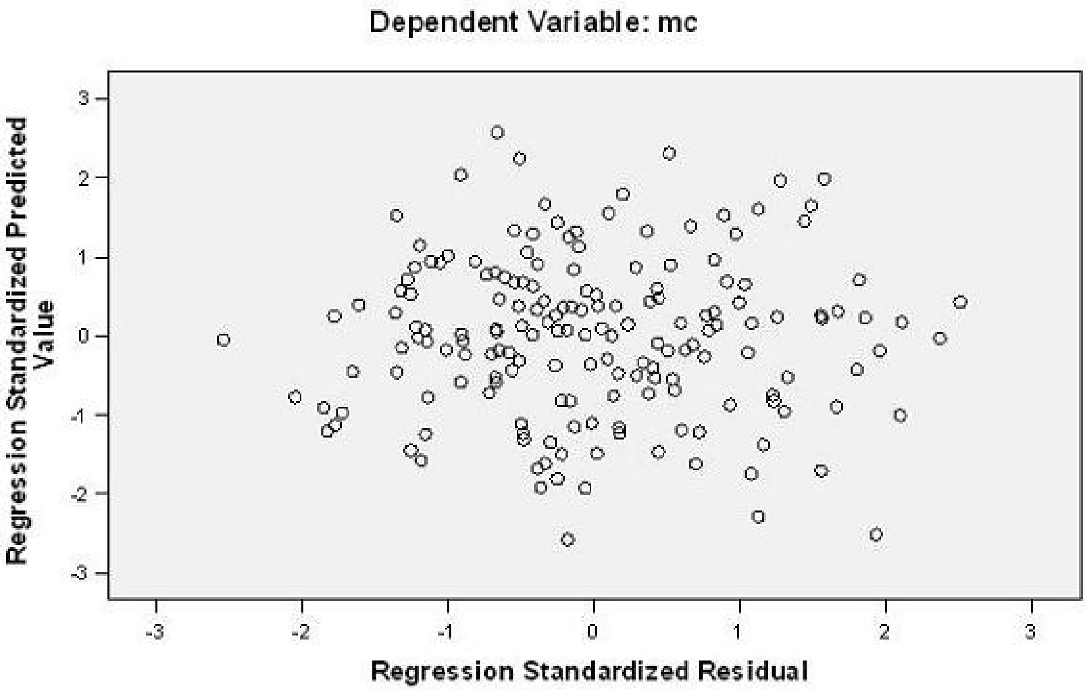

Figure K.12: Step 2-The MPEX pre-test was removed.

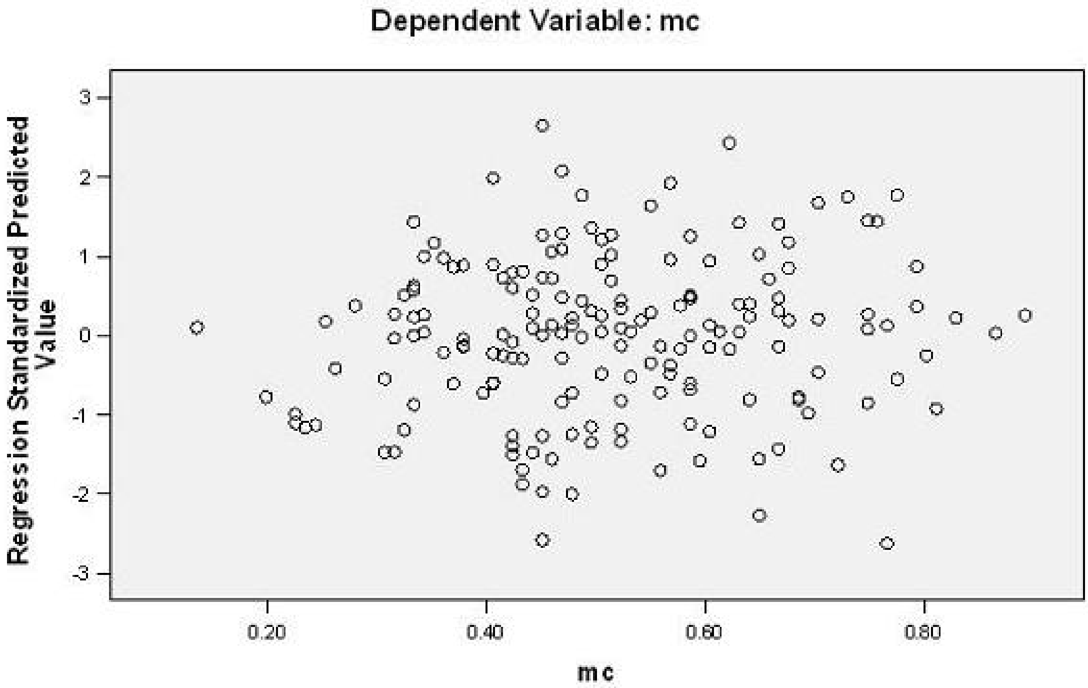

Figure K.13: Step 3-The active/reflective dimension was removed.

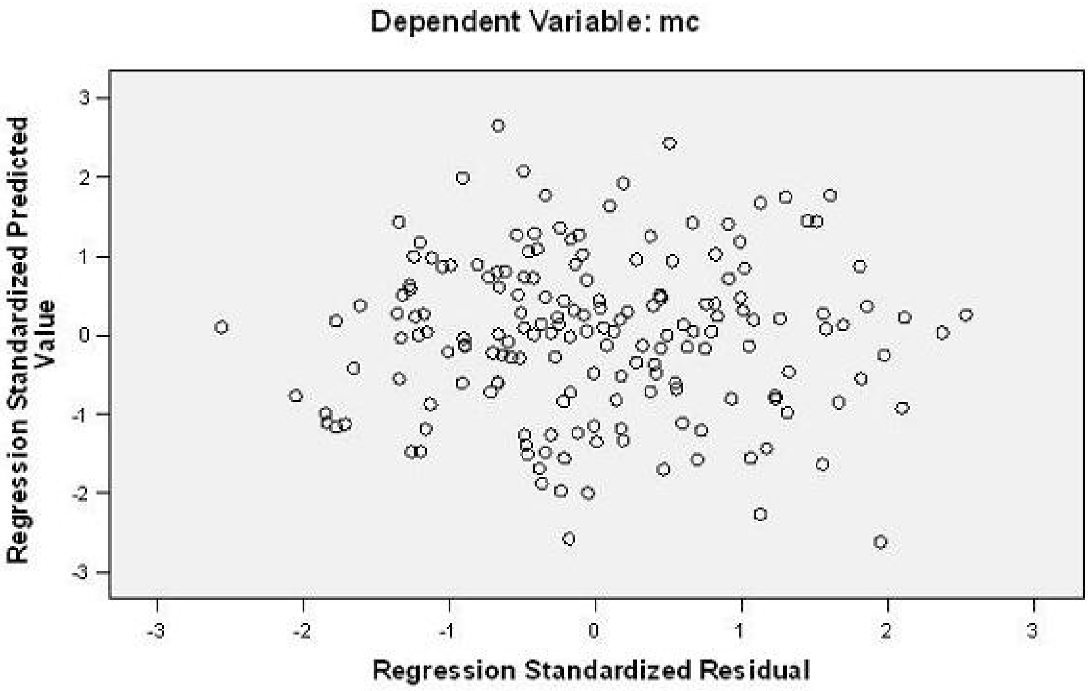

Figure K.14: Step 3-The active/reflective dimension was removed.

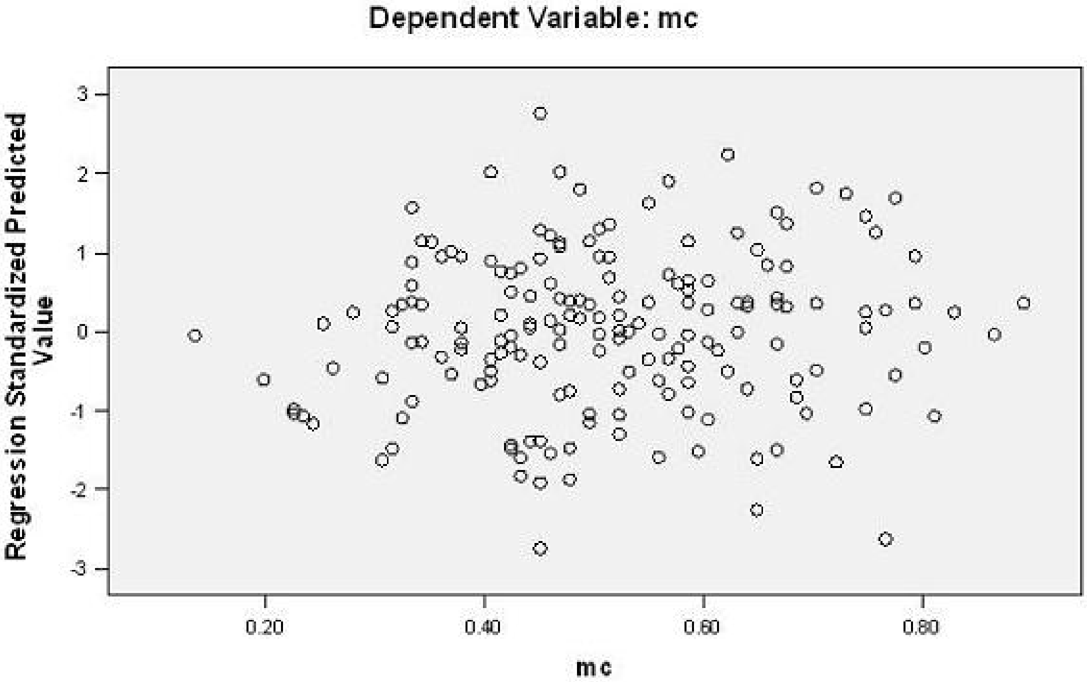

Figure K.15: Step 4-The sequential/global dimension was removed.

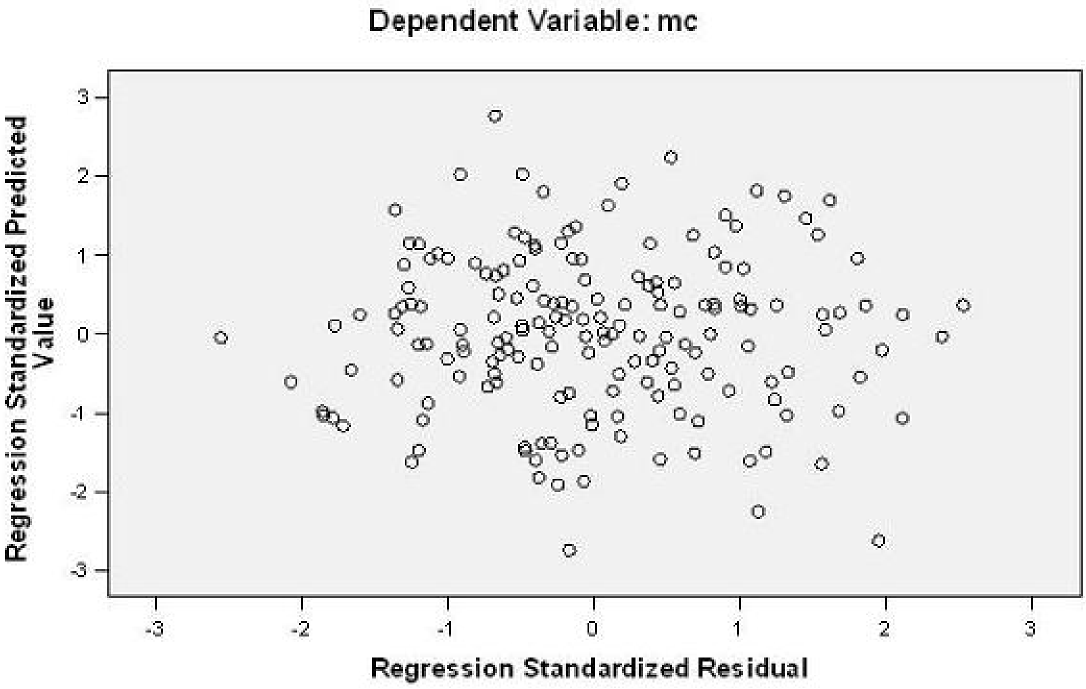

Figure K.16: Step 4-The sequential/global dimension was removed.

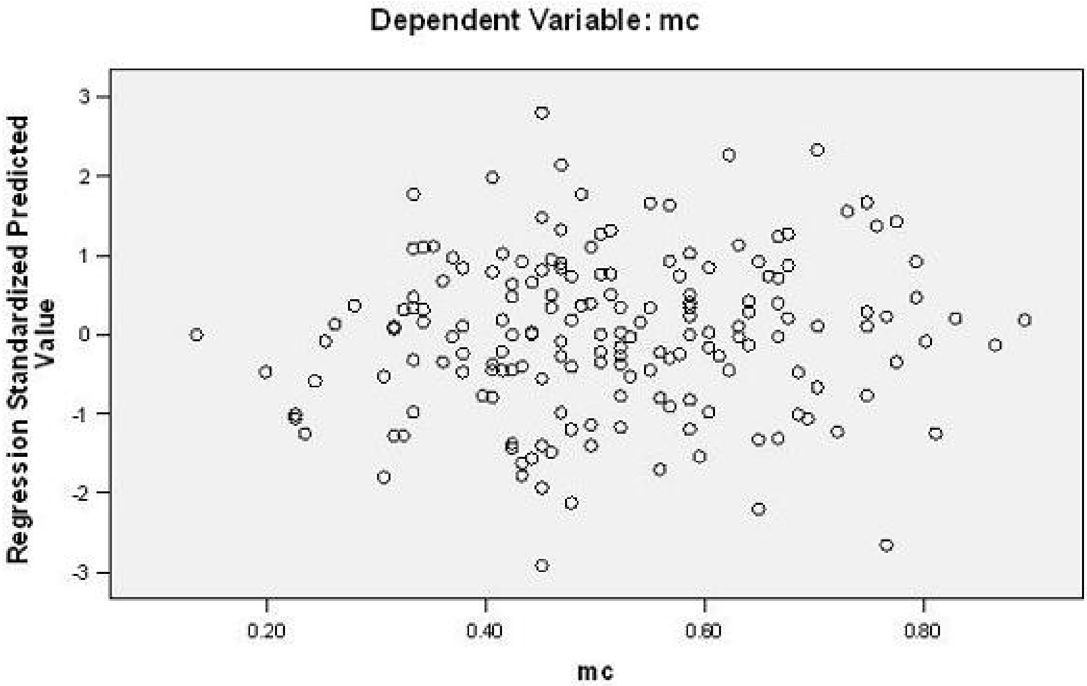

Figure K.17: Step 5-The sensing/intuitive dimension was removed.

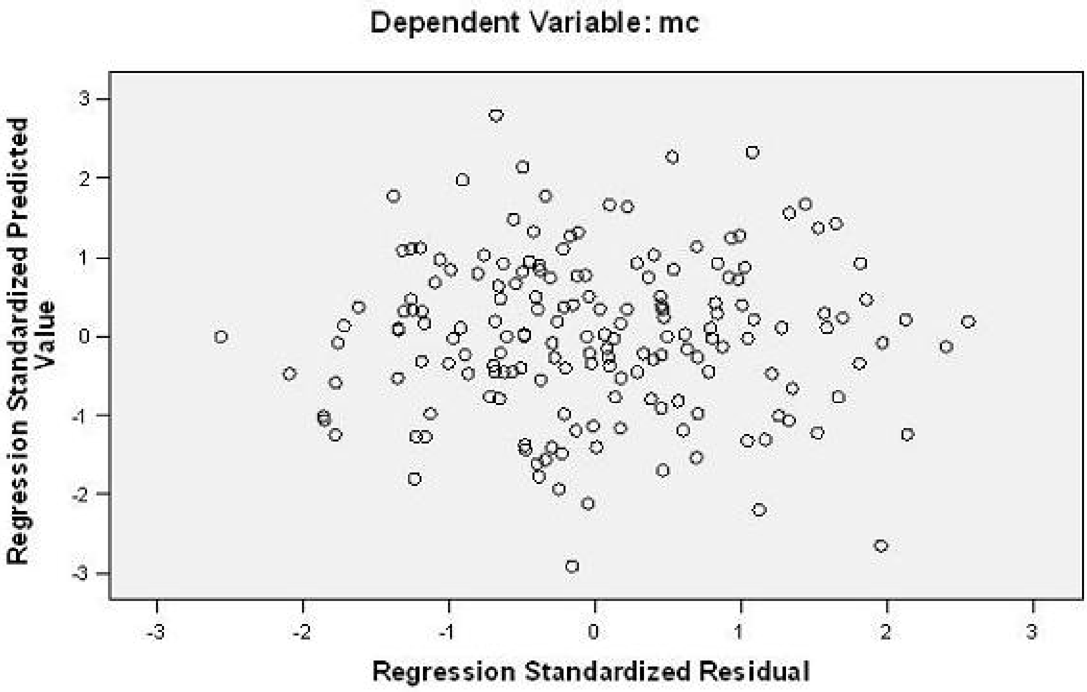

Figure K.18: Step 5-The sensing/intuitive dimension was removed.

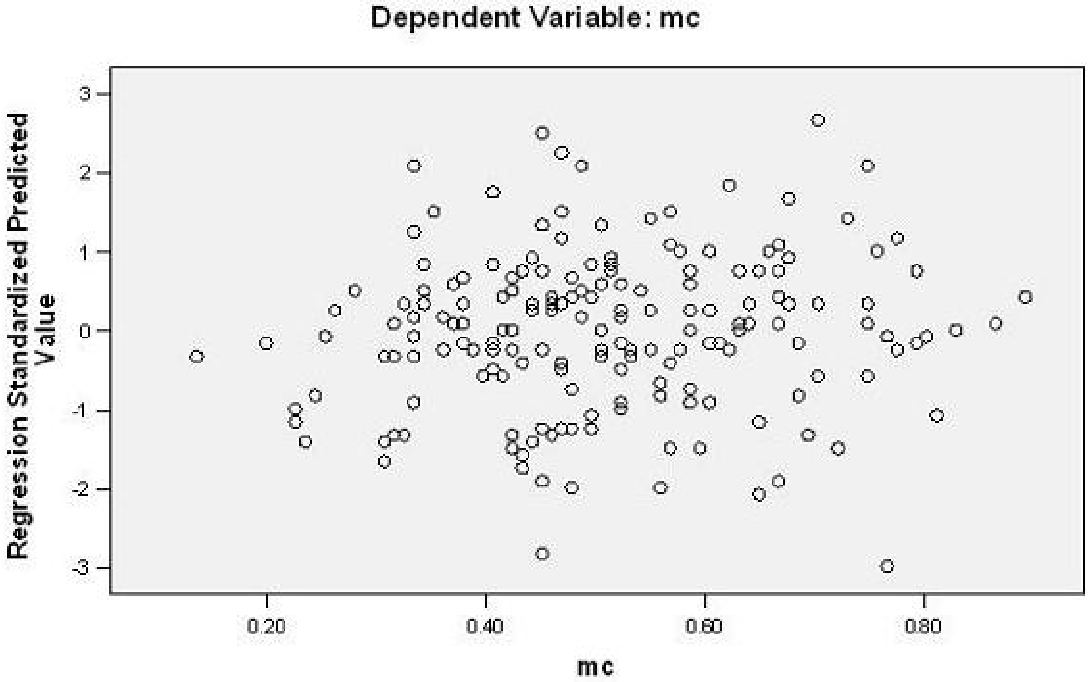

Figure K.19: Step 6-The visual/verbal dimension was removed.

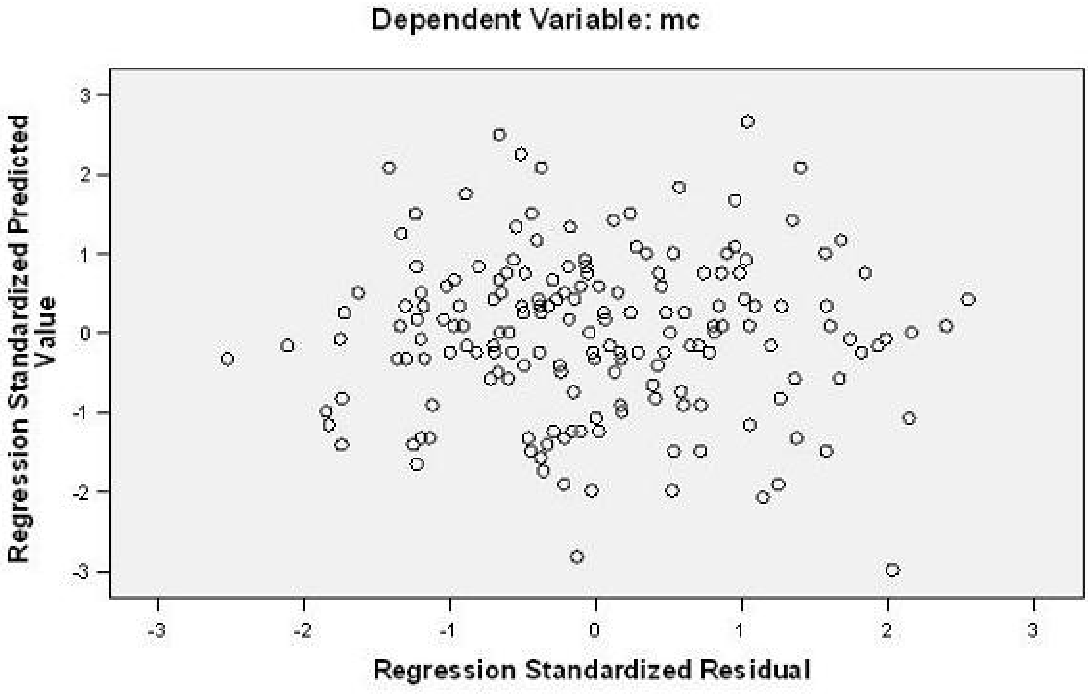

Figure K.20: Step 6-The visual/verbal dimension was removed.

K.4 Test of Regression Assumption Four and Five for Research Question four-Multiple Choice Problems

Step 1-All variables are included in the regression. This includes the lab attendance, help session attendance, time spent in the helproom, and Physics 1114 grade.

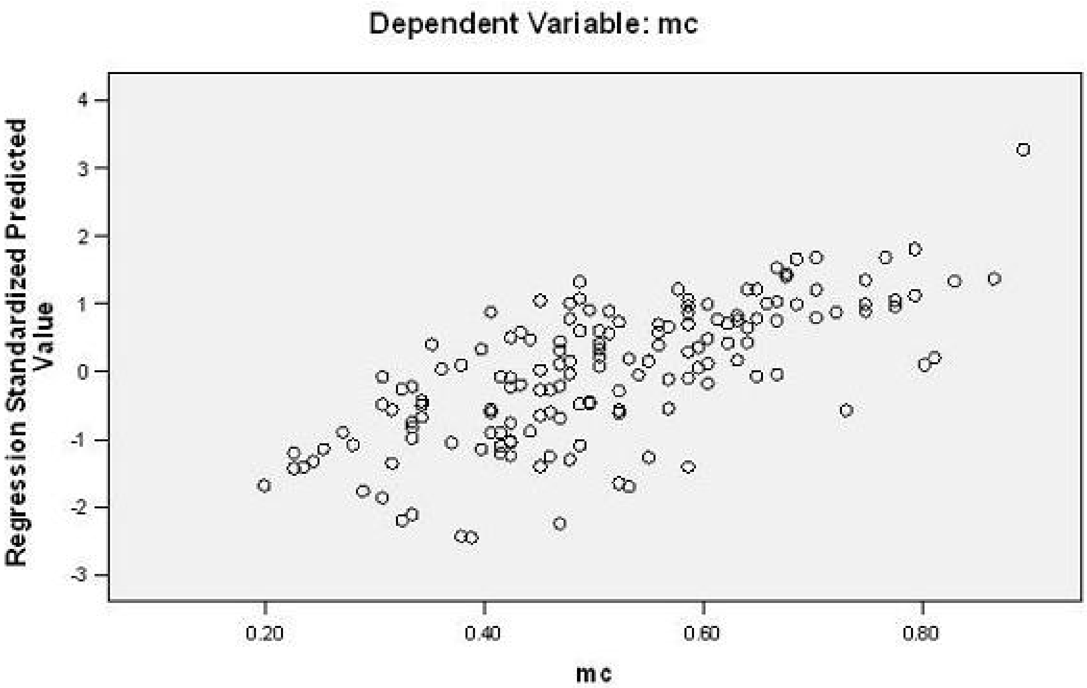

Figure K.21: Step 1-All variables entered.

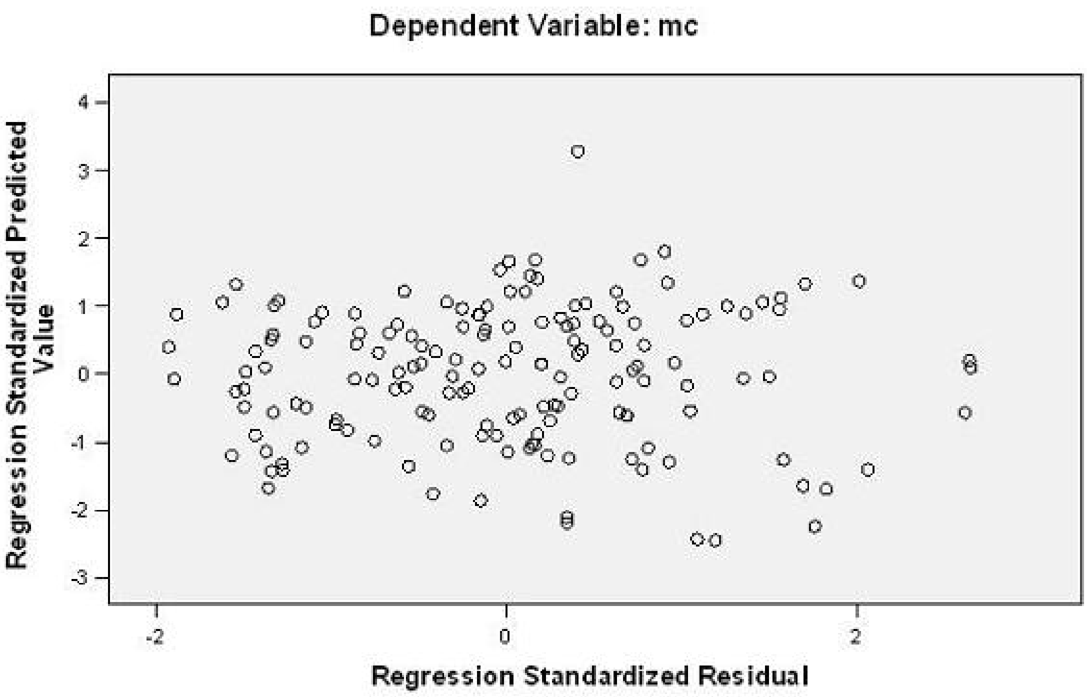

Figure K.22: Step 1-All variables entered.

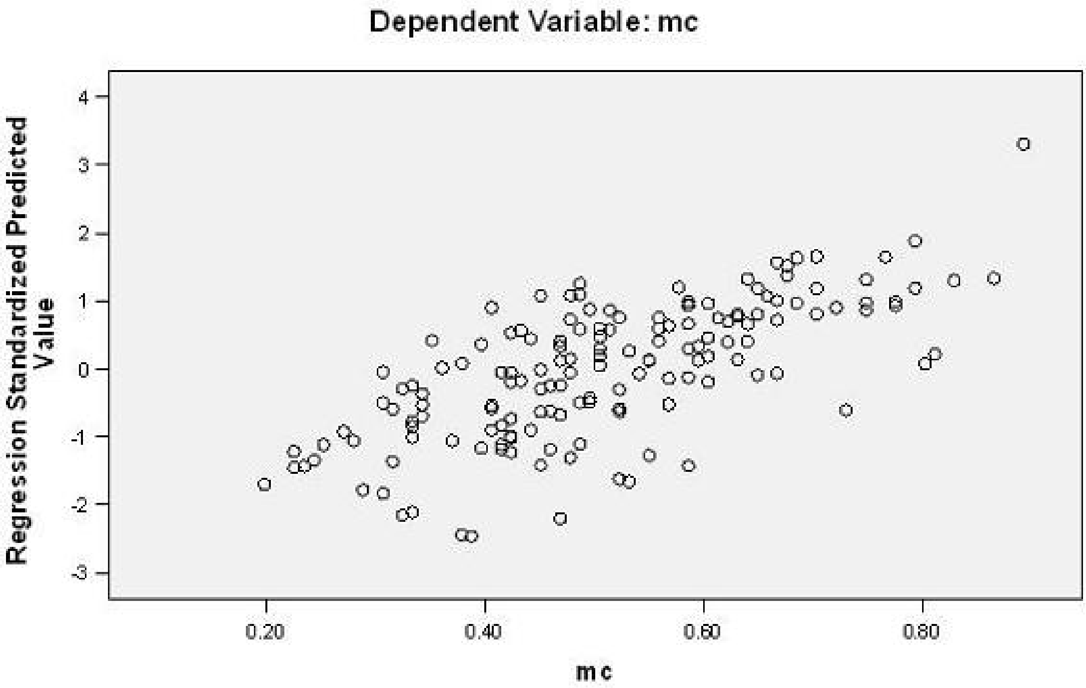

Figure K.23: Step 2-The help session attendance was removed.

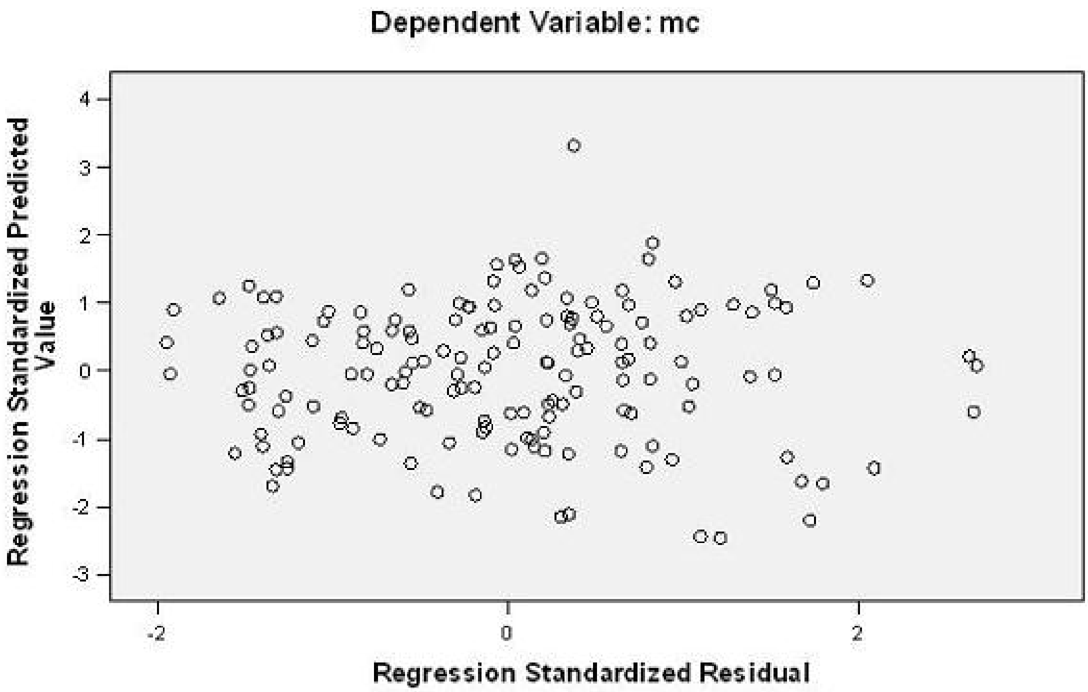

Figure K.24: Step 2-The help session attendance was removed.

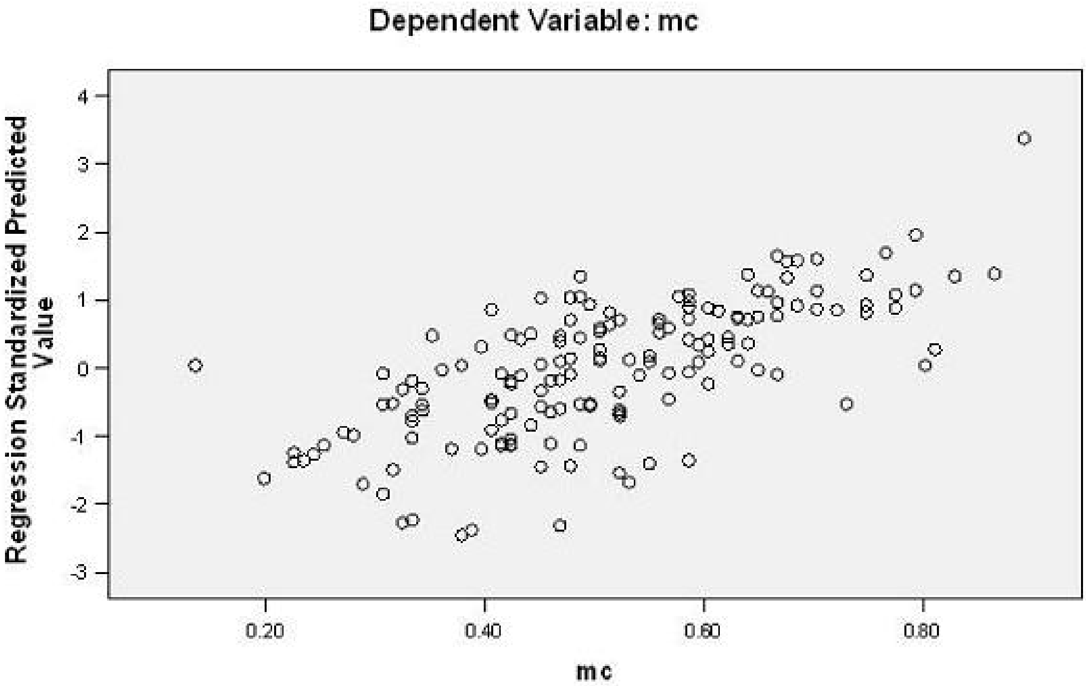

Figure K.25: Step 3-The lab attendance was removed.

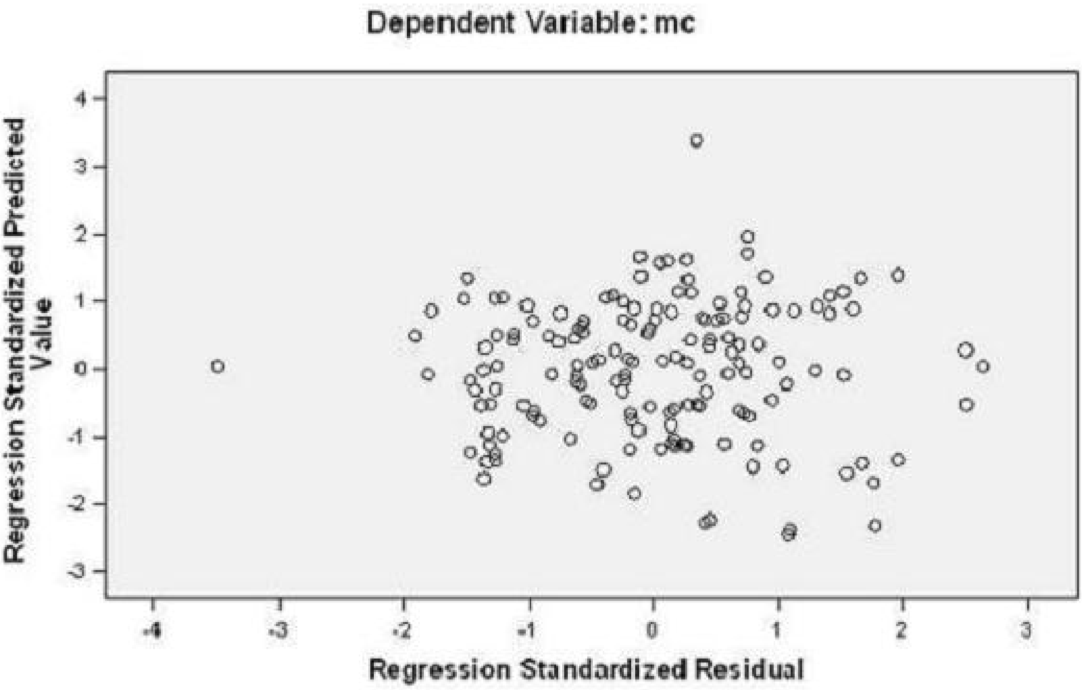

Figure K.26: Step 3-The lab attendance was removed.

K.5 Test of Regression Assumption Four and Five for Research Question five-Multiple Choice Problems

Step 1-All variables are included in the regression. This includes the homework grade, lab grade, HBL grade, GPA, ACT science score, time spent in the helproom, and Physics 1114 grade.

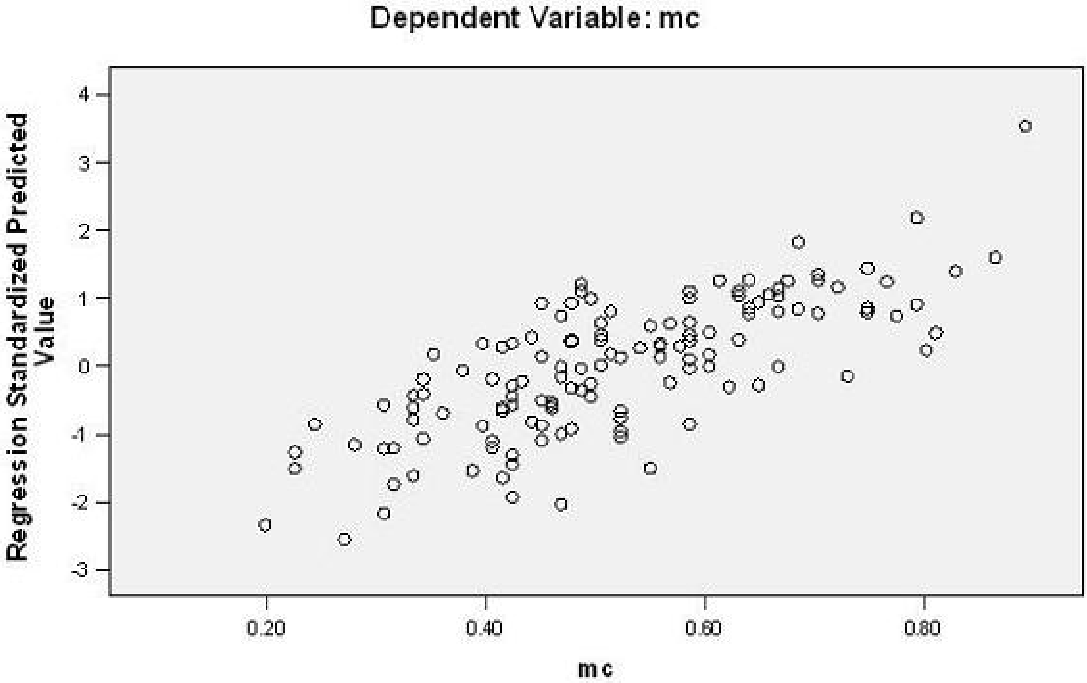

Figure K.27: Step 1-All variables entered.

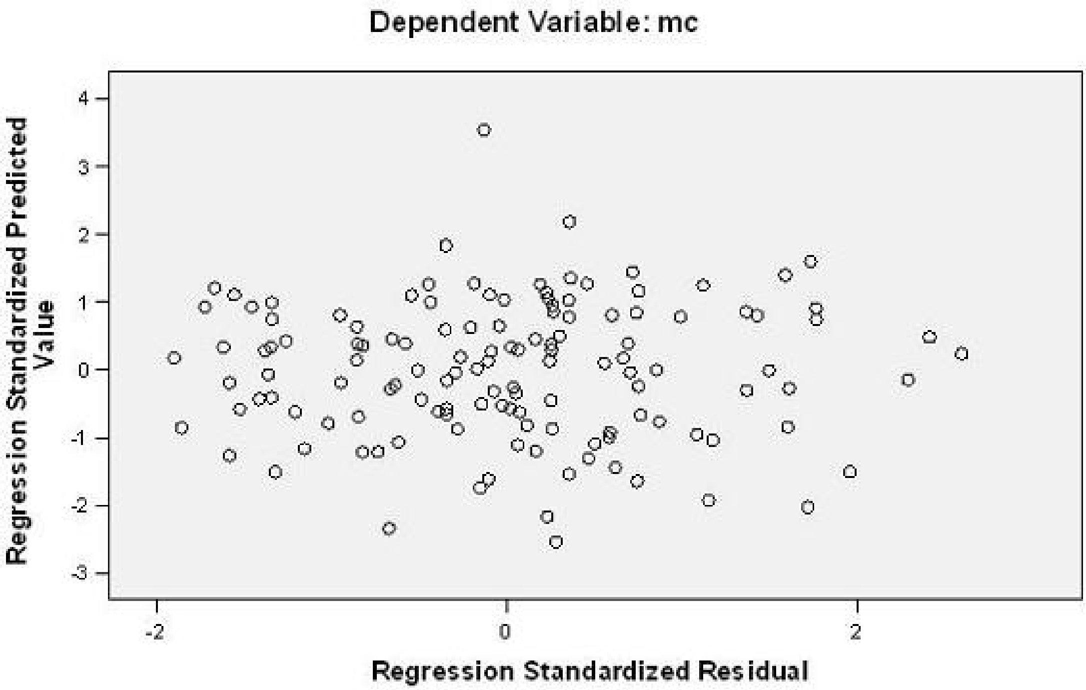

Figure K.28: Step 1-All variables entered.

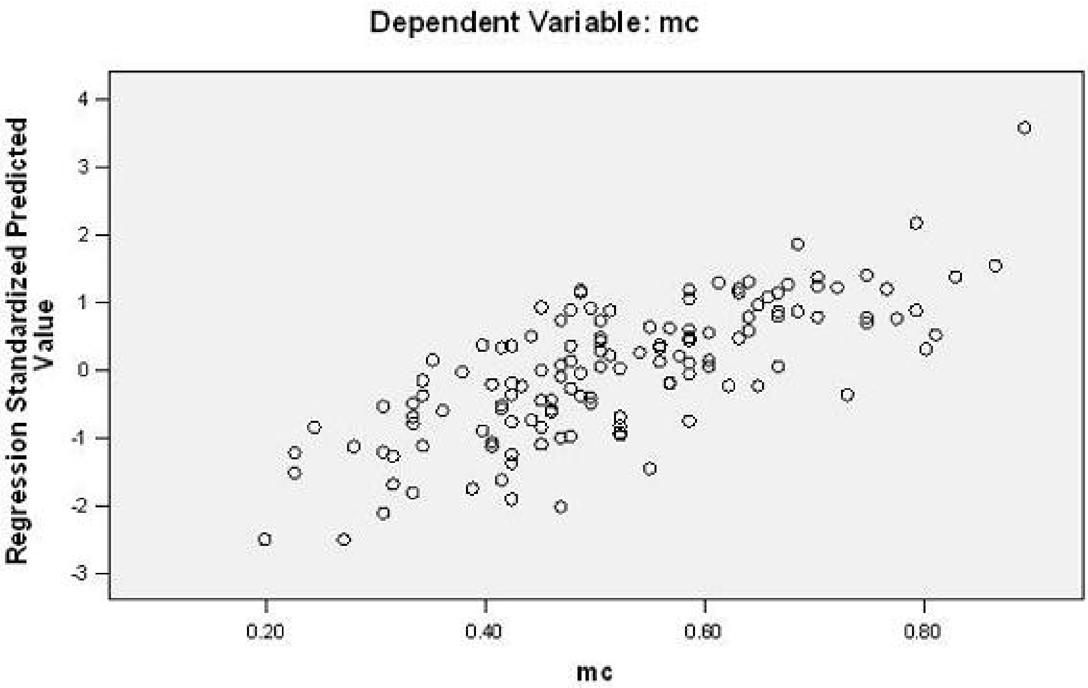

Figure K.29: Step 2-The homework grade was removed.

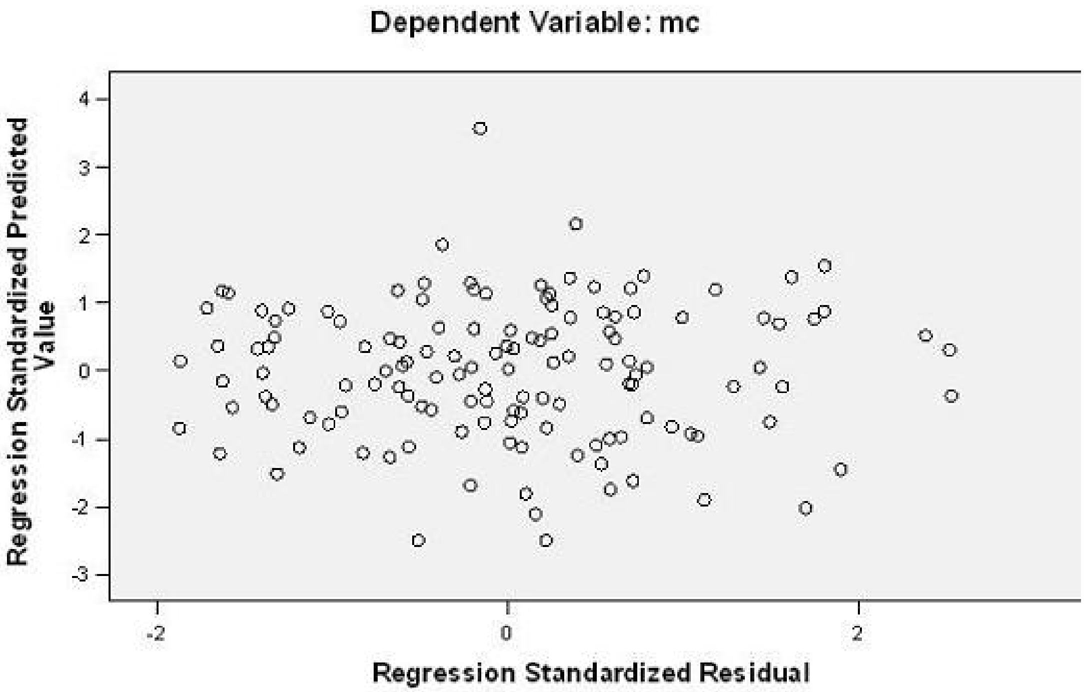

Figure K.30: Step 2-The homework grade was removed.

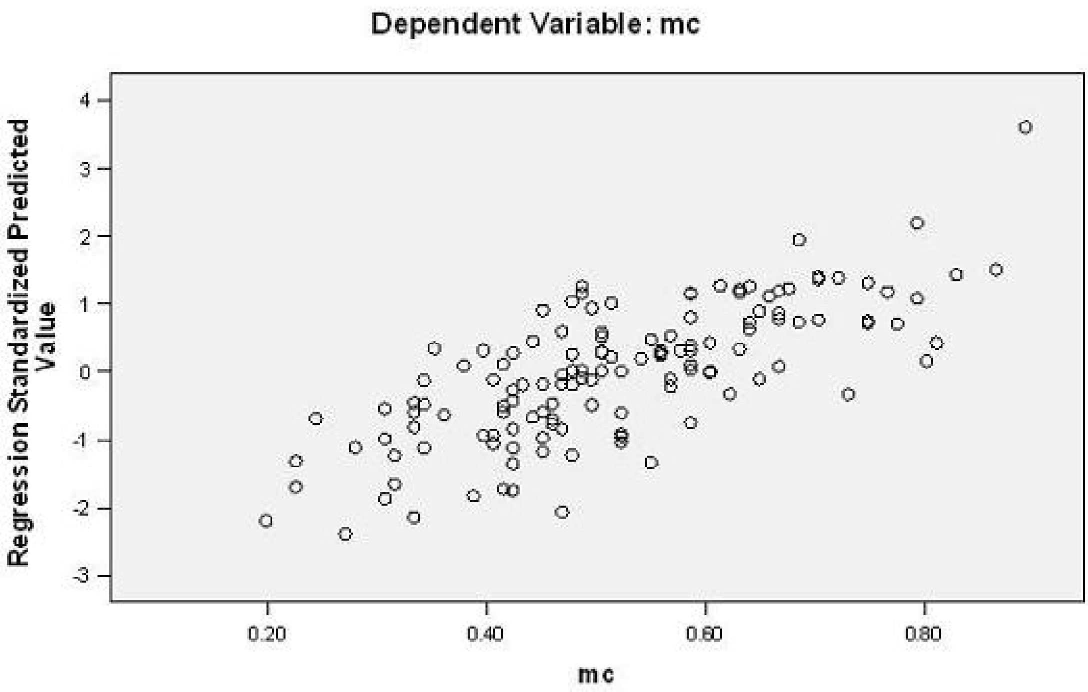

Figure K.31: Step 3-The GPA was removed.

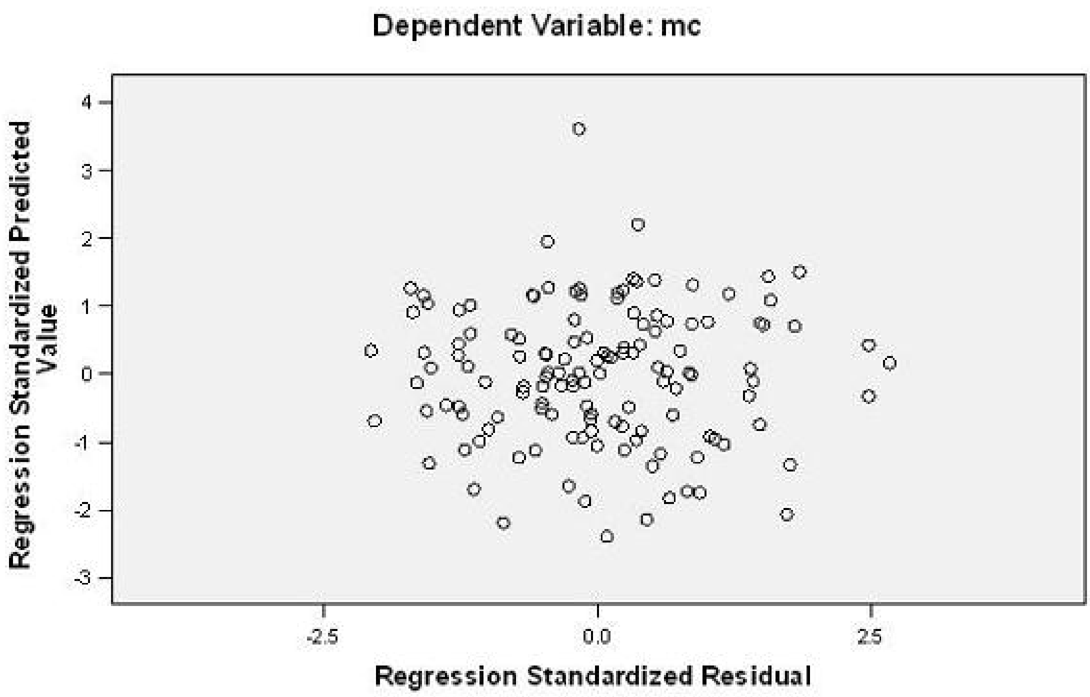

Figure K.32: Step 3-The GPA was removed.

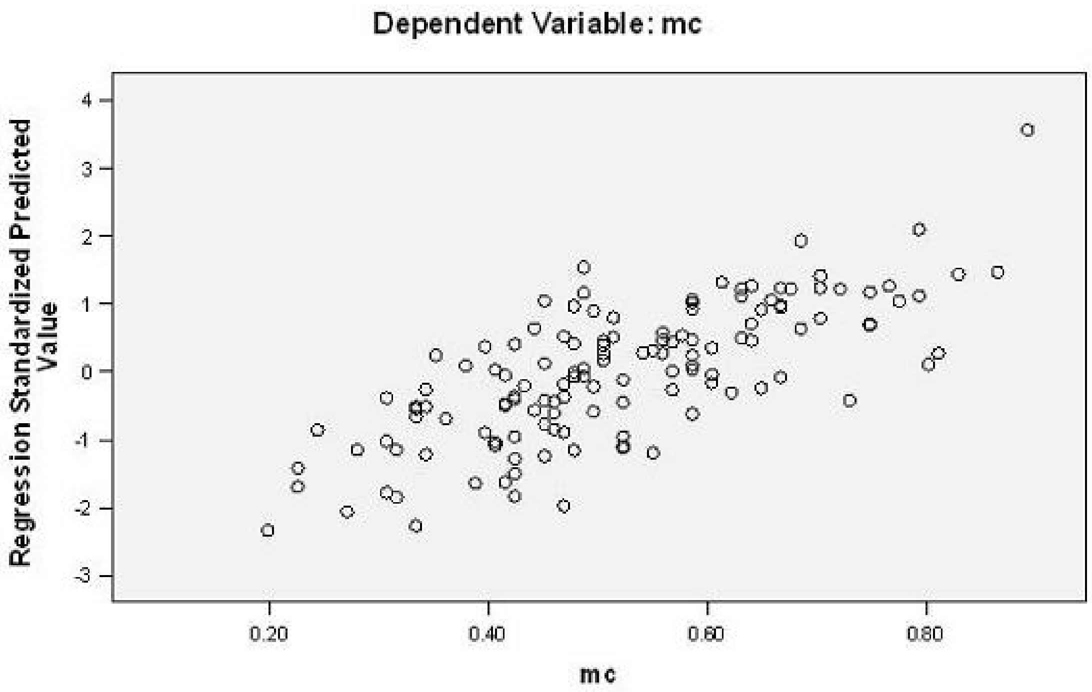

Figure K.33: Step 4-The HBL average was removed.

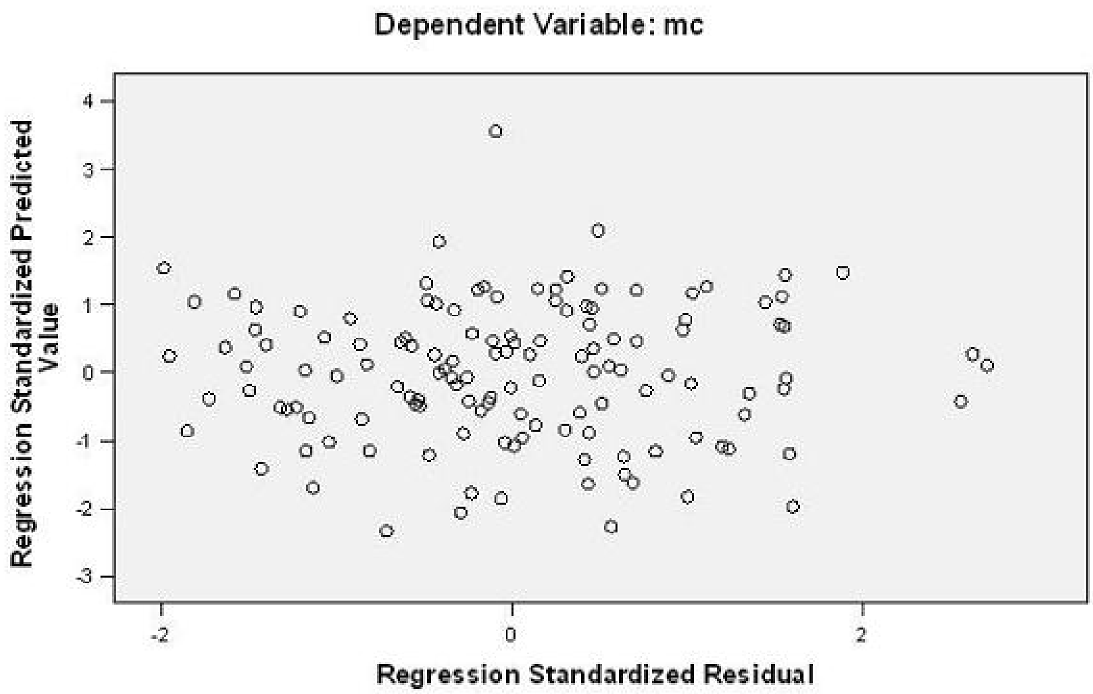

Figure K.34: Step 4-The HBL average was removed.

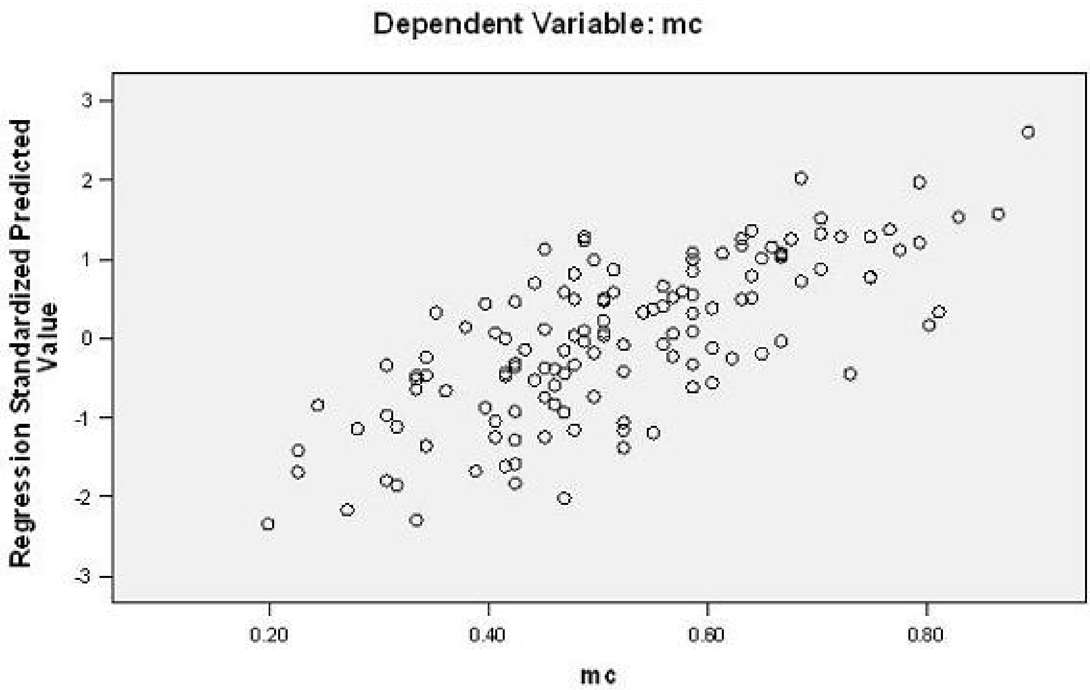

Figure K.35: Step 5-The time spent in the helproom was removed.

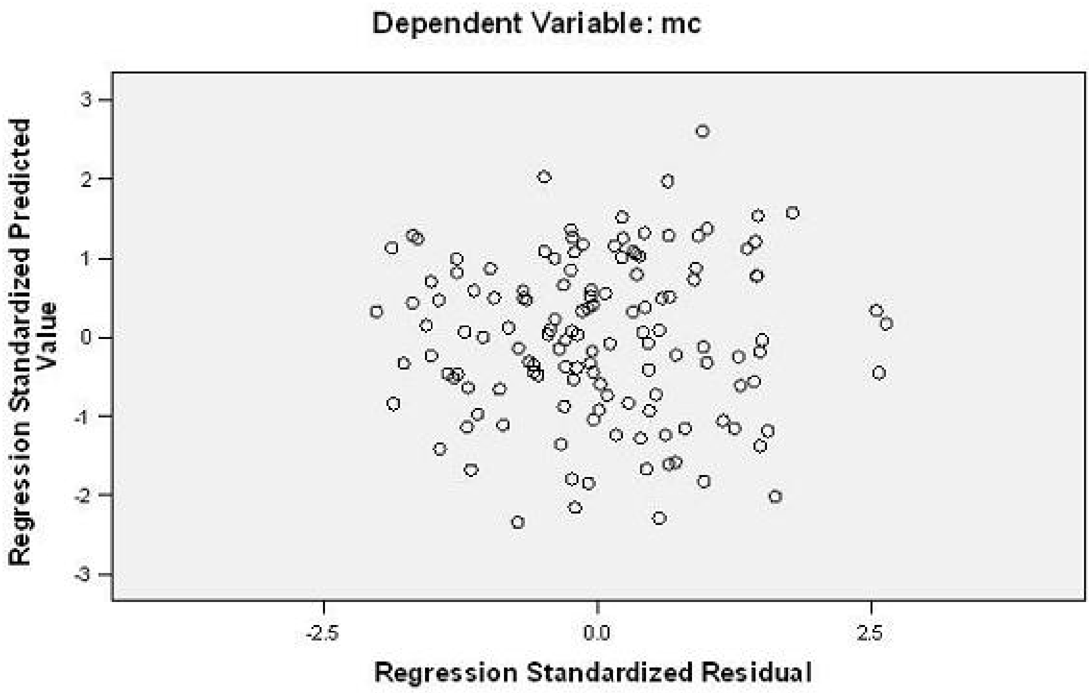

Figure K.36: Step 5-The time spent in the helproom was removed.

K.5.1 Analysis

With the exception of research question three, the graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The predicted score versus residual seems to have a circular pattern on all of the research questions. Due to this assumption five is satisfied.

APPENDIX L

Test of Assumptions for essay questions

L.1 Test of Regression Assumption Four and Five for Research Question One-Essay Problems

Step 1-All variables are included in the regression. This includes homework average, lab average, PRS score, and HBL average.

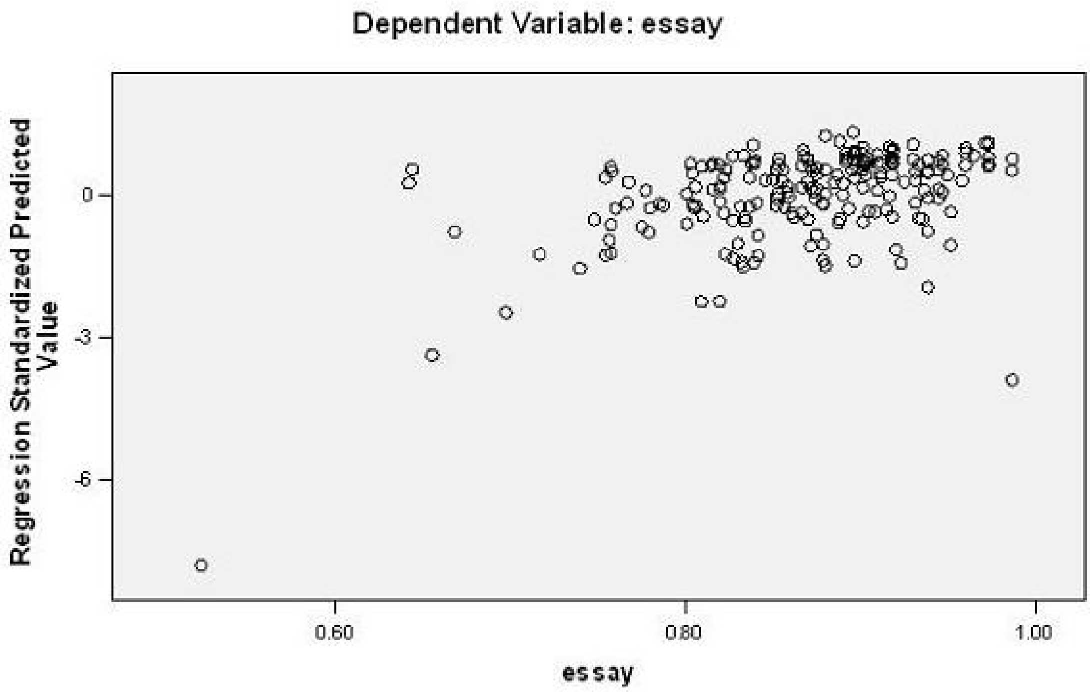

Figure L.1: Step 1-All variables entered.

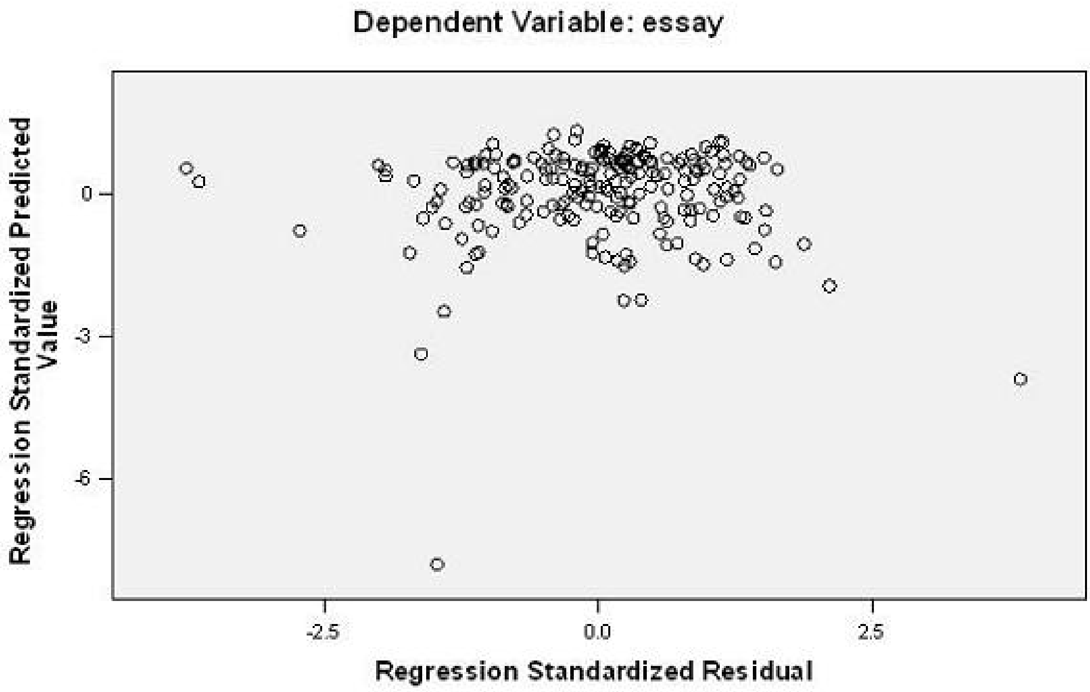

Figure L.2: Step 1-All variables entered.

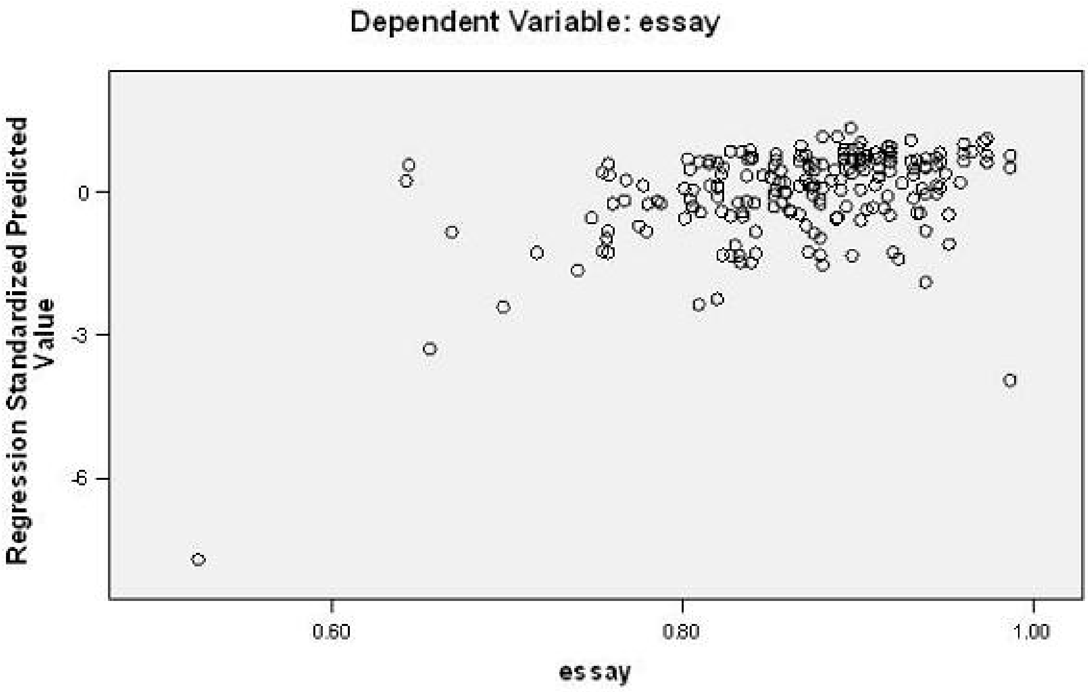

Figure L.3: Step 2-The clicker score was removed.

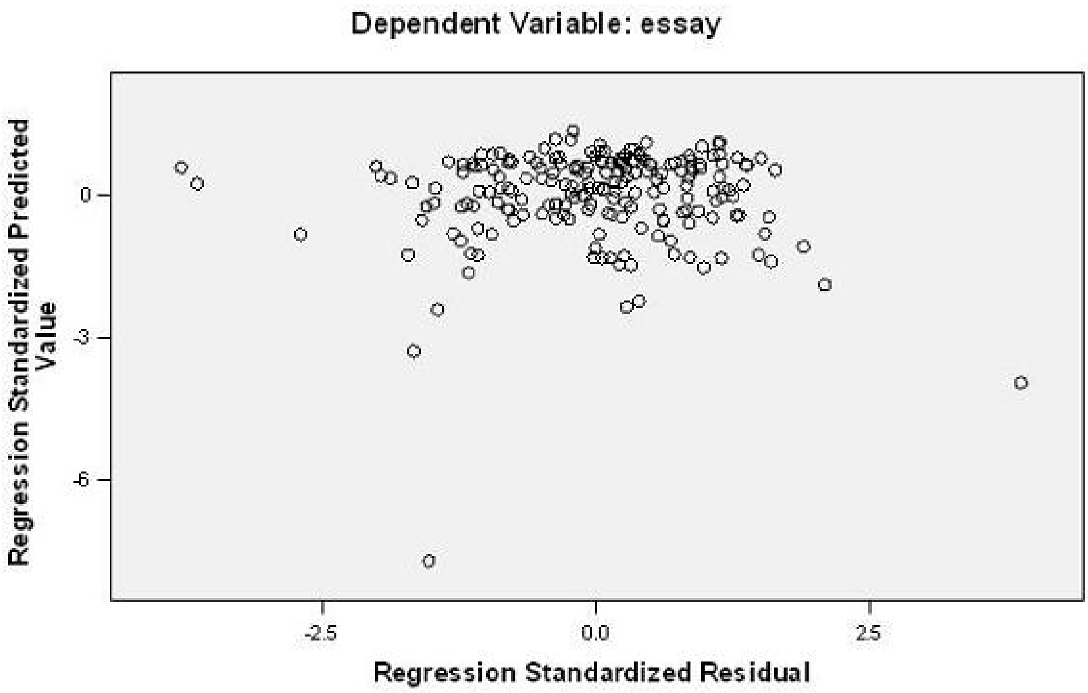

Figure L.4: Step 2-The clicker score was removed.

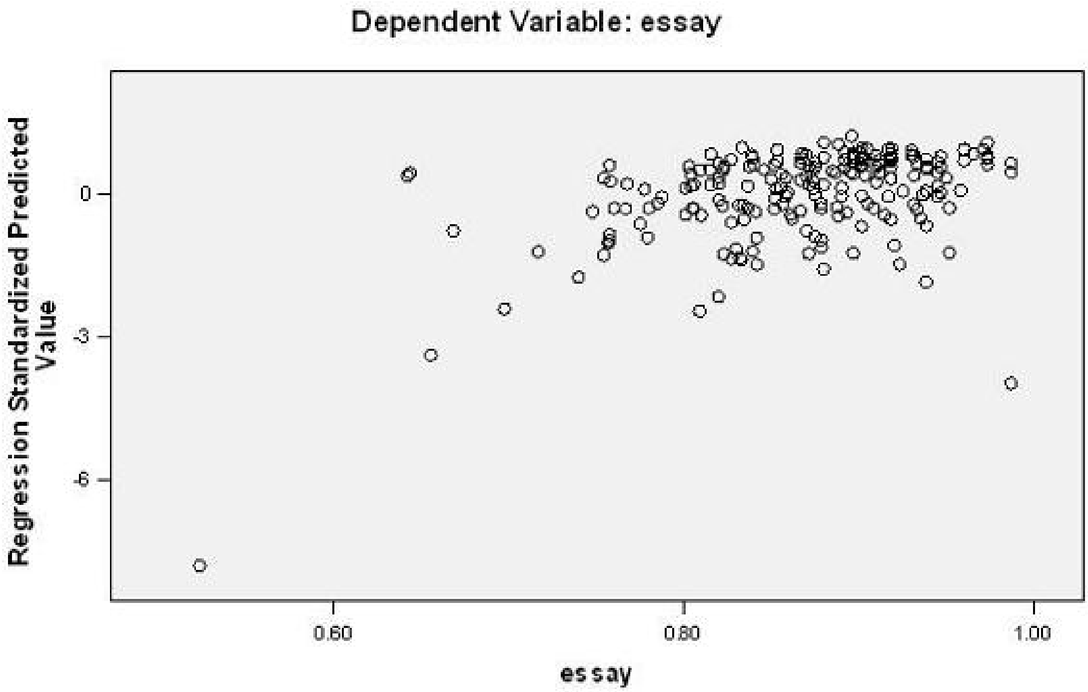

Figure L.5: Step 3-The HBL average was removed.

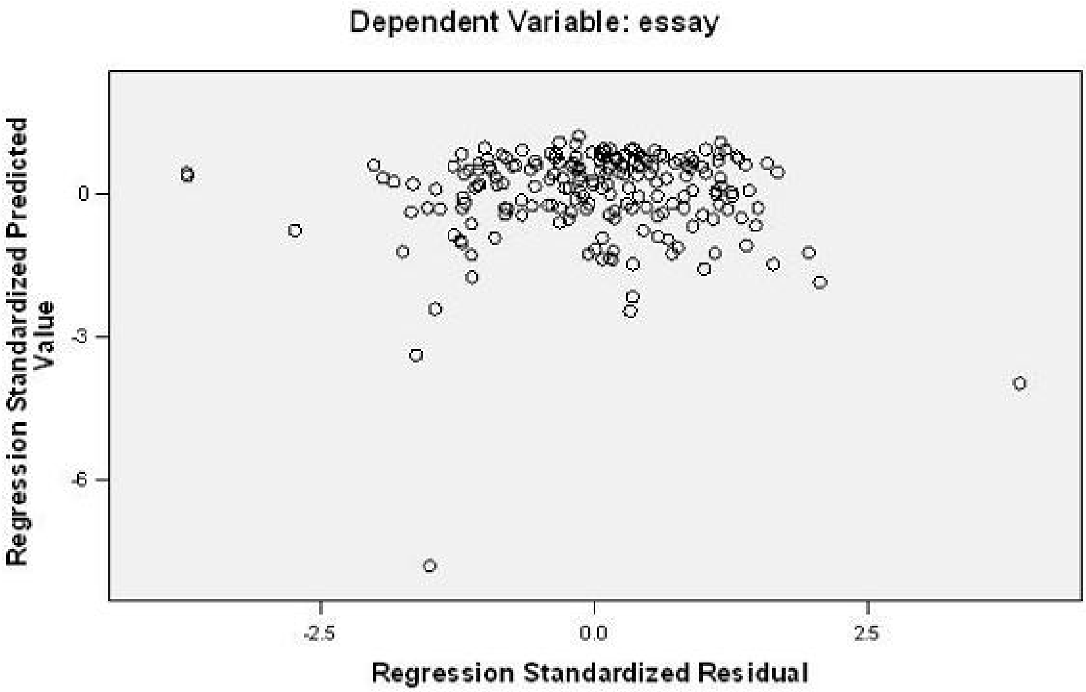

Figure L.6: Step 3-The HBL average was removed.

L.2 Test of Regression Assumption Four and Five for Research Question two-Essay Problems

Step 1-All variables are included in the regression. This includes ACT science score, ACT math score, and GPA.

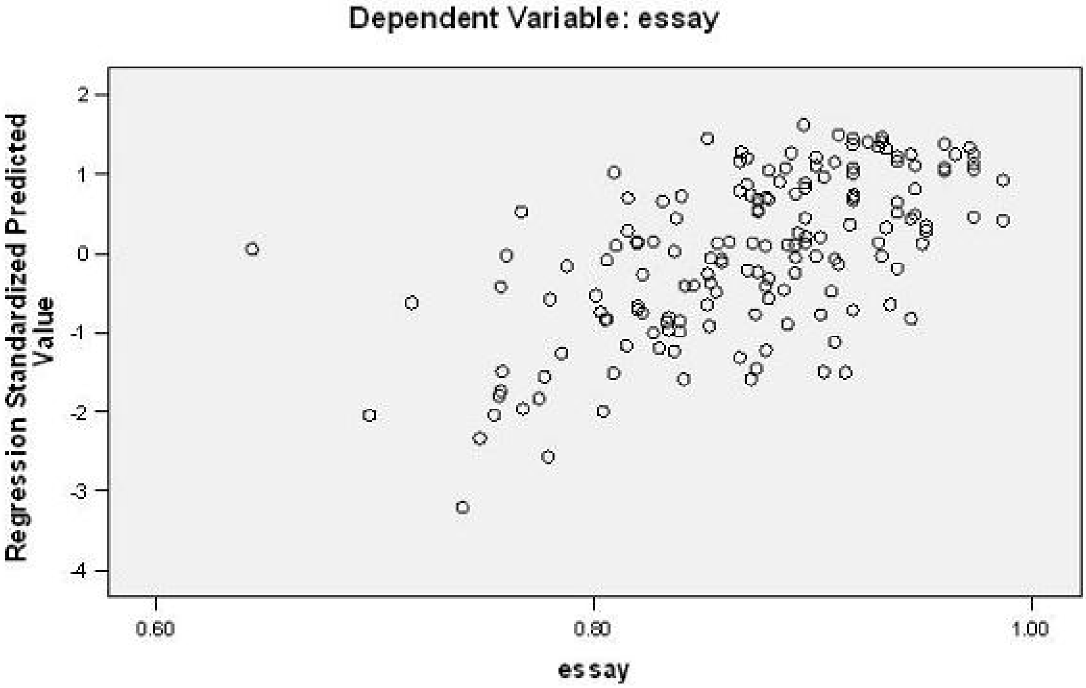

Figure L.7: Step 1-All variables entered.

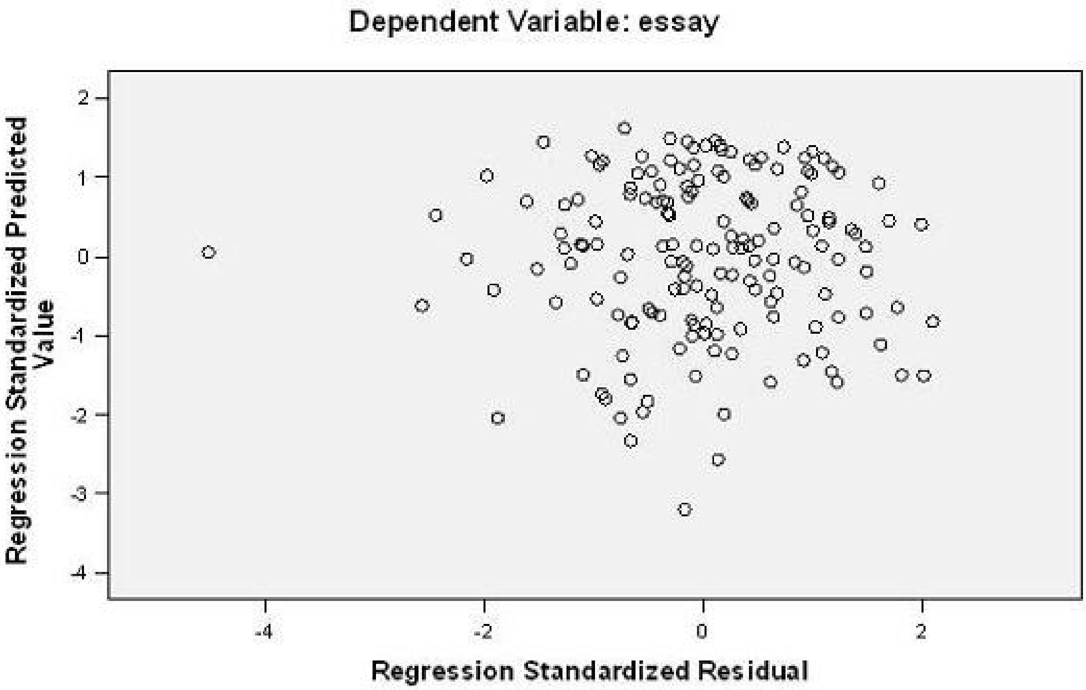

Figure L.8: Step 1-All variables entered.

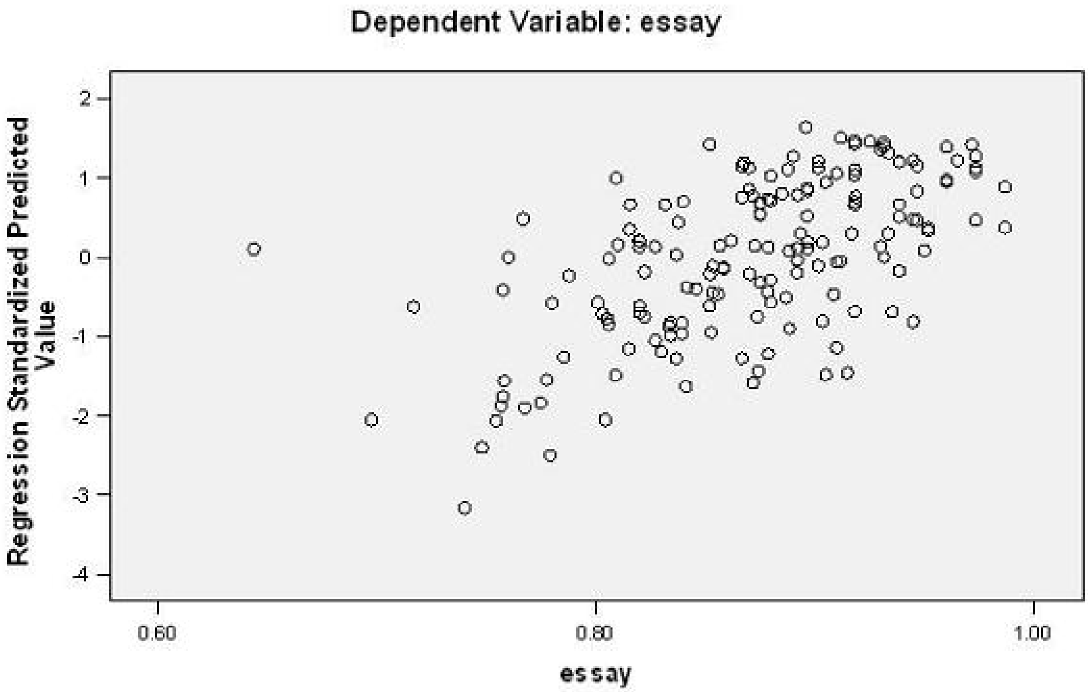

Figure L.9: Step 2-The ACT math score was removed.

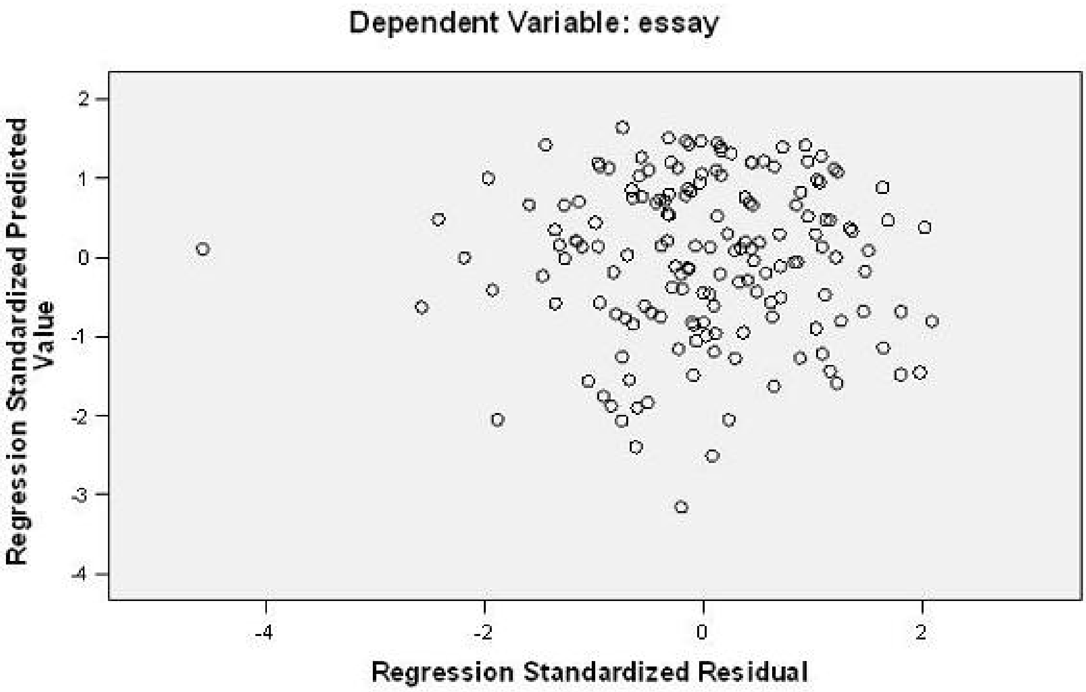

Figure L.10: Step 2-The ACT math score was removed.

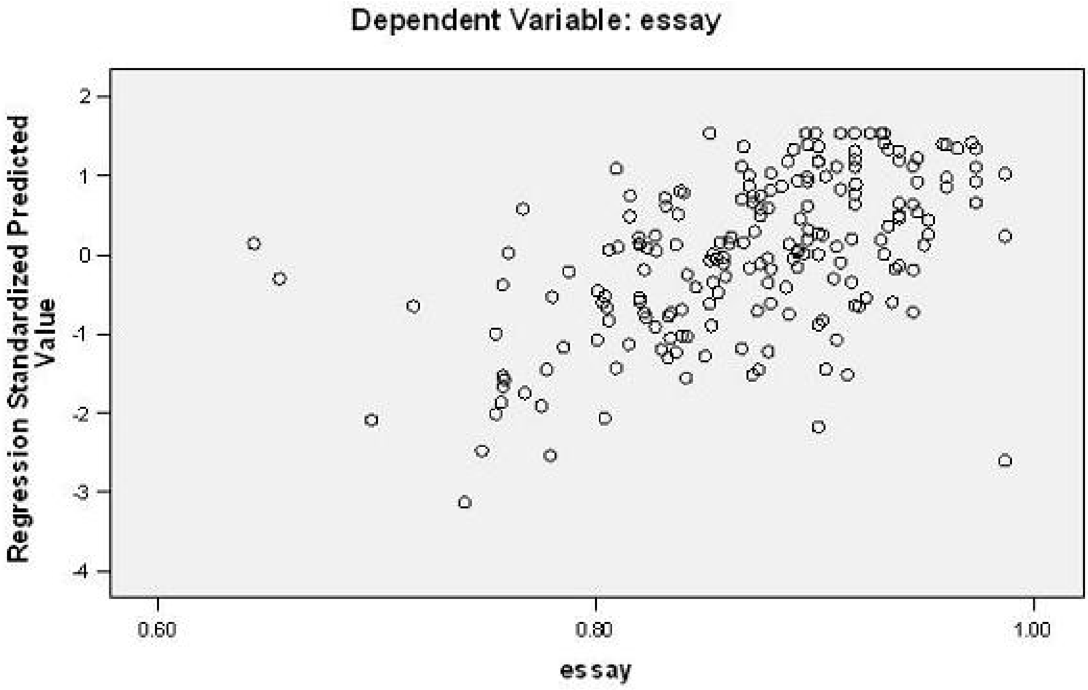

Figure L.11: Step 2-The ACT science score was removed.

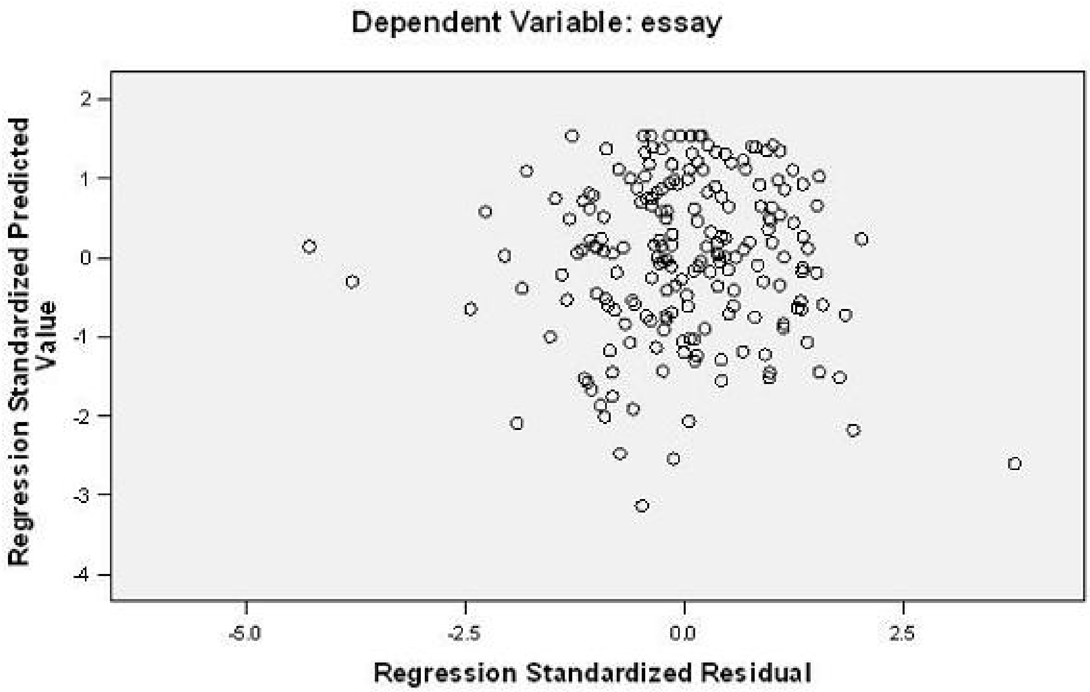

Figure L.12: Step 2-The ACT science score was removed.

L.3 Test of Regression Assumption Four and Five for Research Question three-Essay Problems

Step 1-All variables are included in the regression. This includes the MPEX pre-test, MPEX post-test, and the four learning style dimensions.

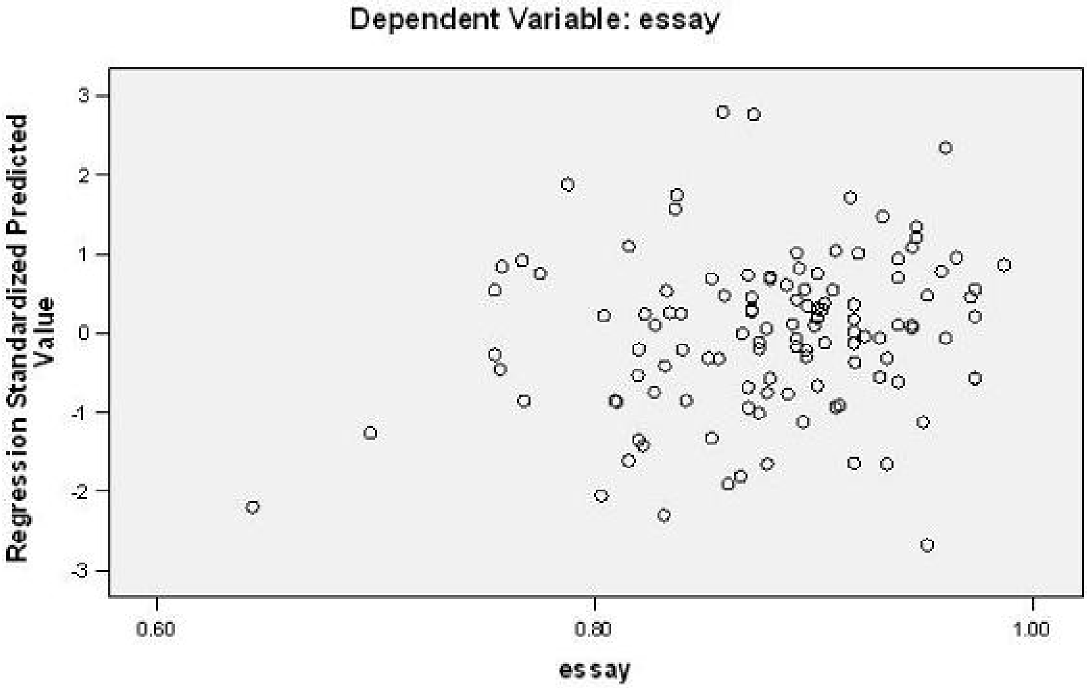

Figure L.13: Step 1-All variables entered.

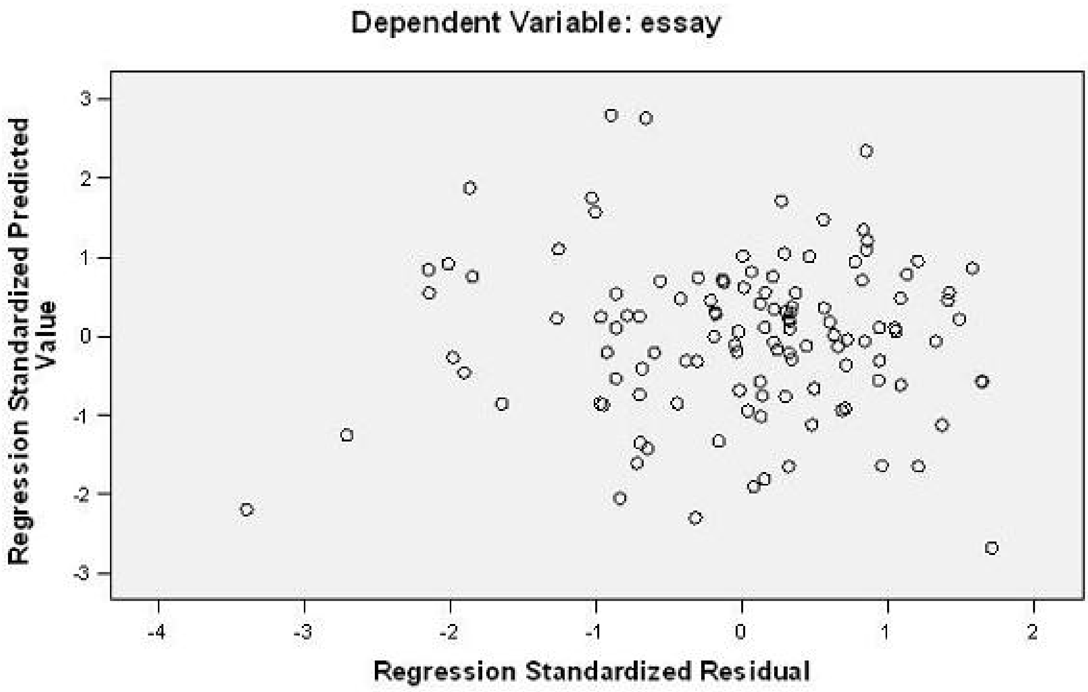

Figure L.14: Step 1-All variables entered.

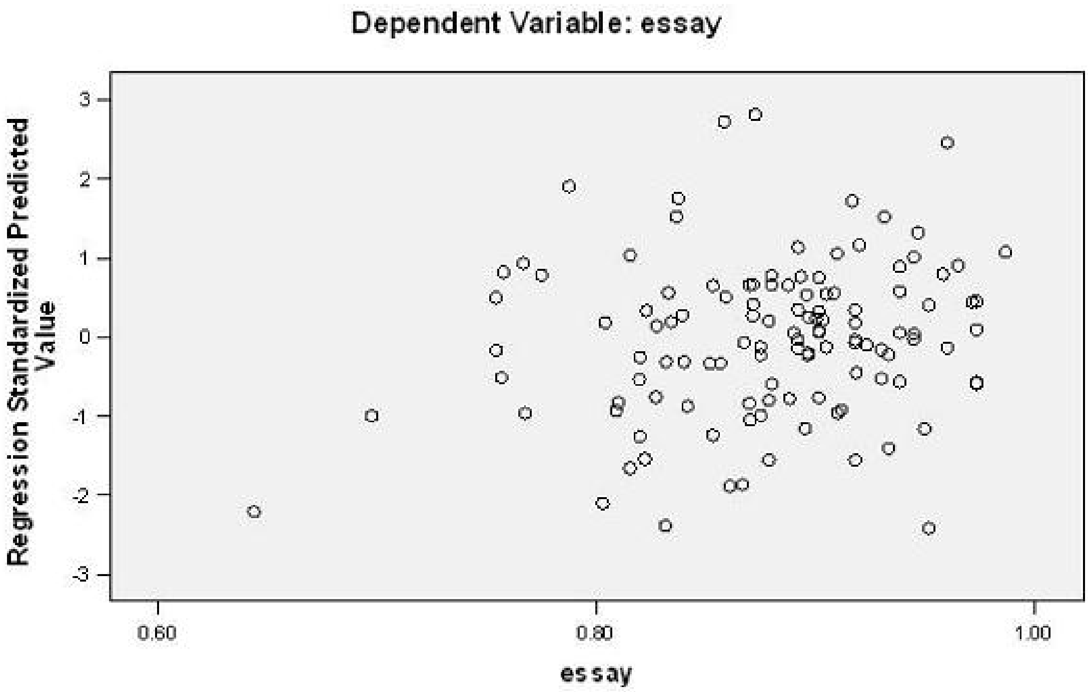

Figure L.15: Step 2-The sensing/intuitive was removed.

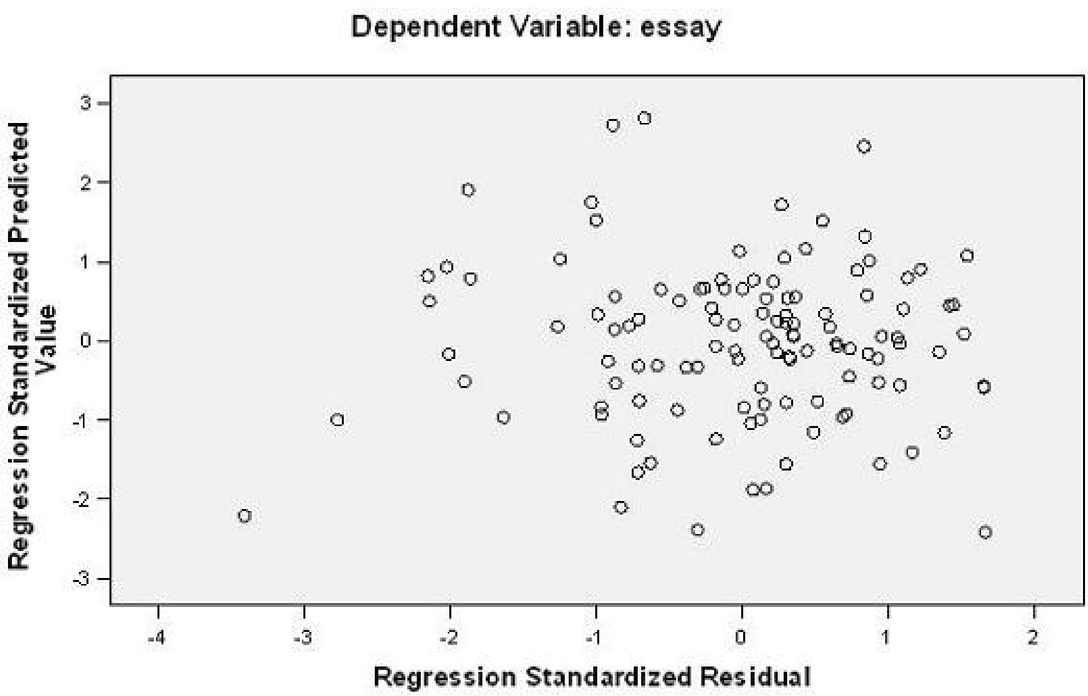

Figure L.16: Step 2-The sensing/intuitive was removed.

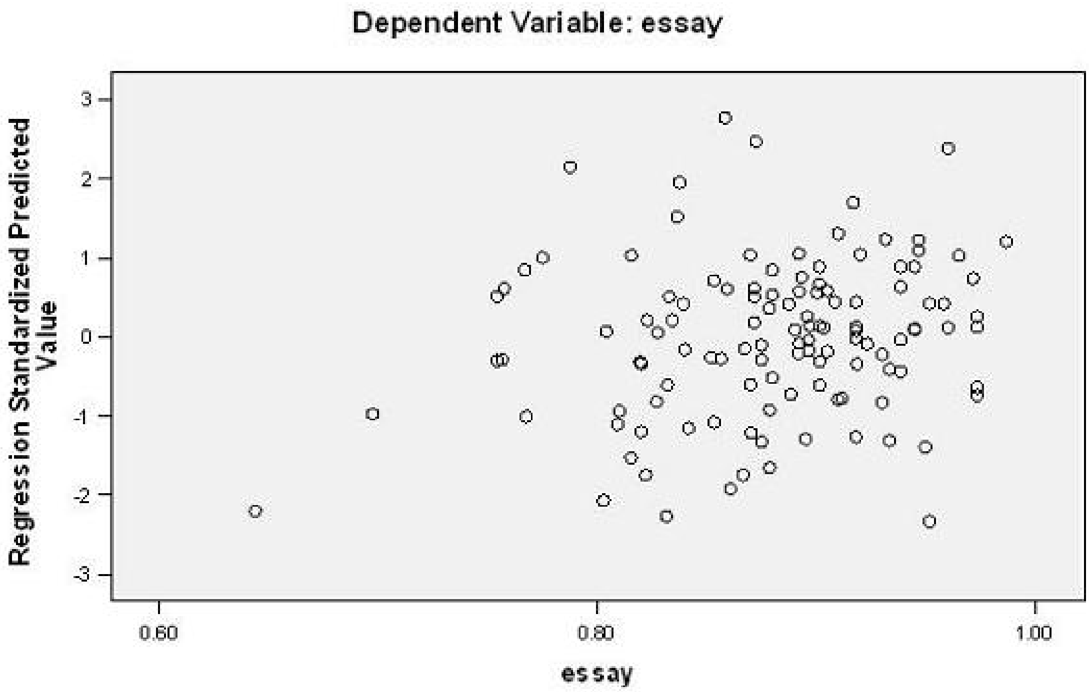

Figure L.17: Step 3-The active/reflective dimension was removed.

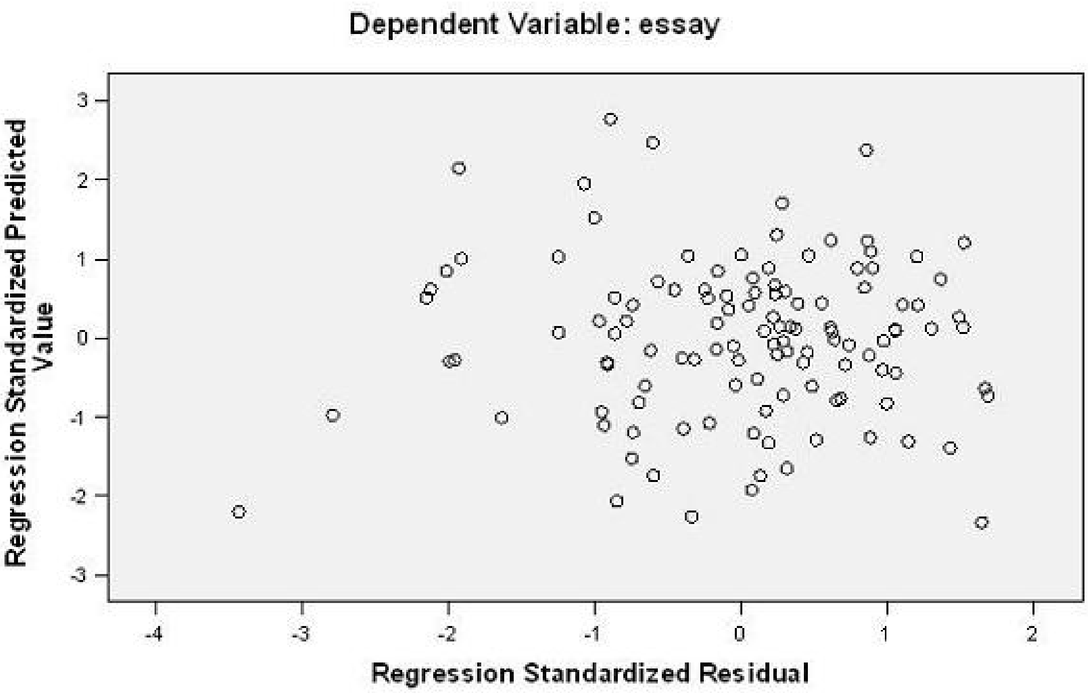

Figure L.18: Step 3-The active/reflective dimension was removed.

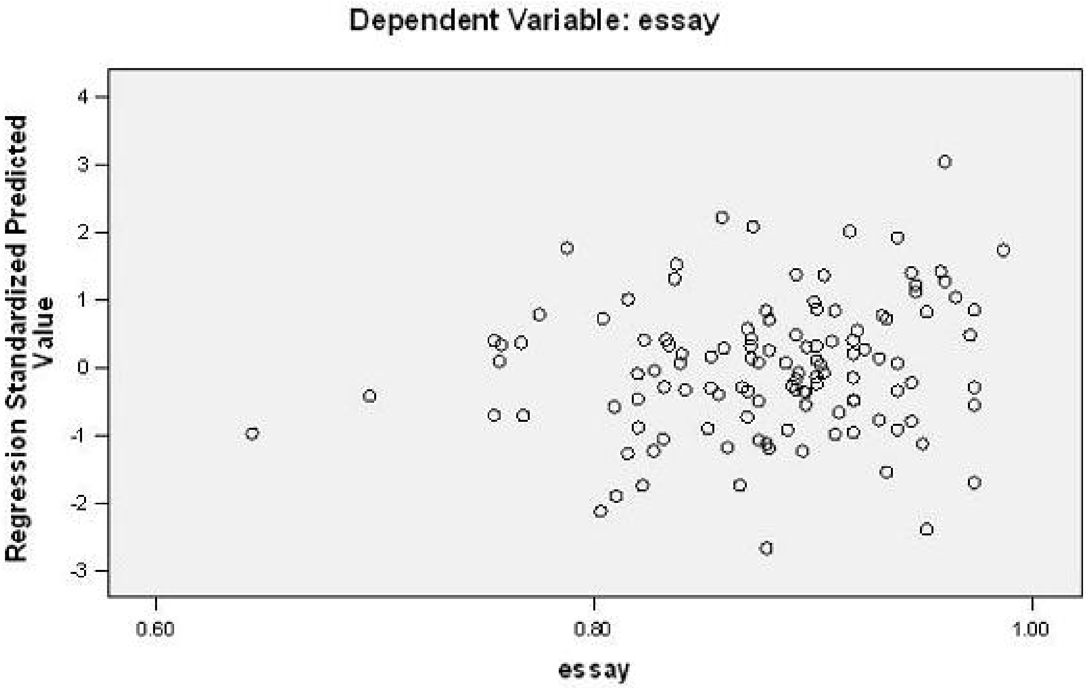

Figure L.19: Step 4-The sequential/global dimension was removed.

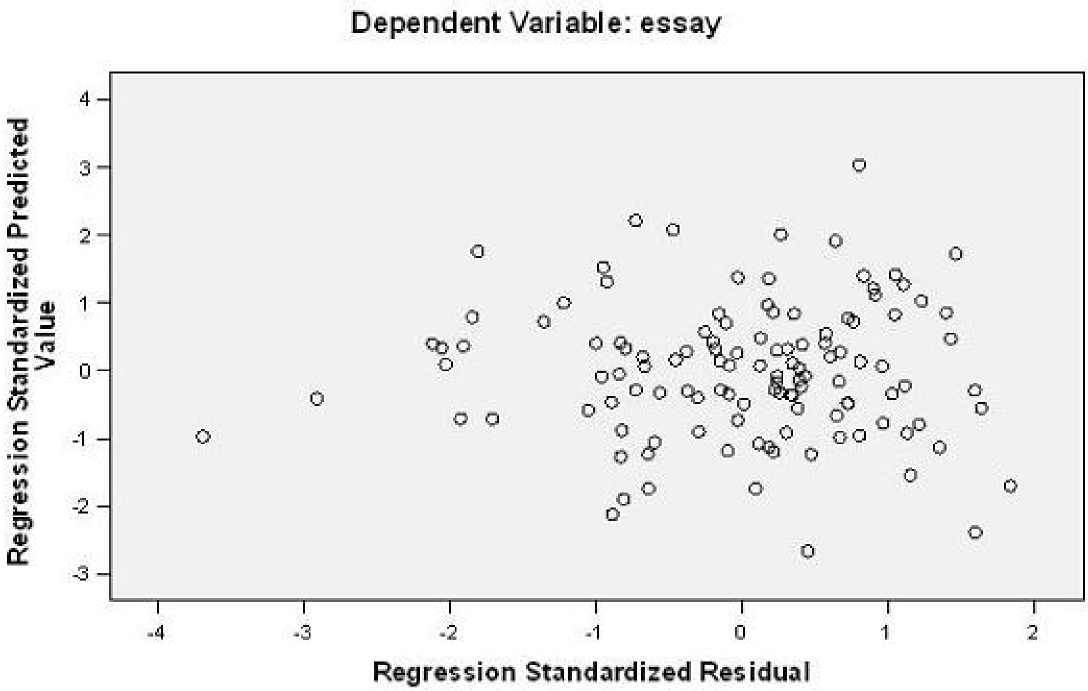

Figure L.20: Step 4-The sequential/global dimension was removed.

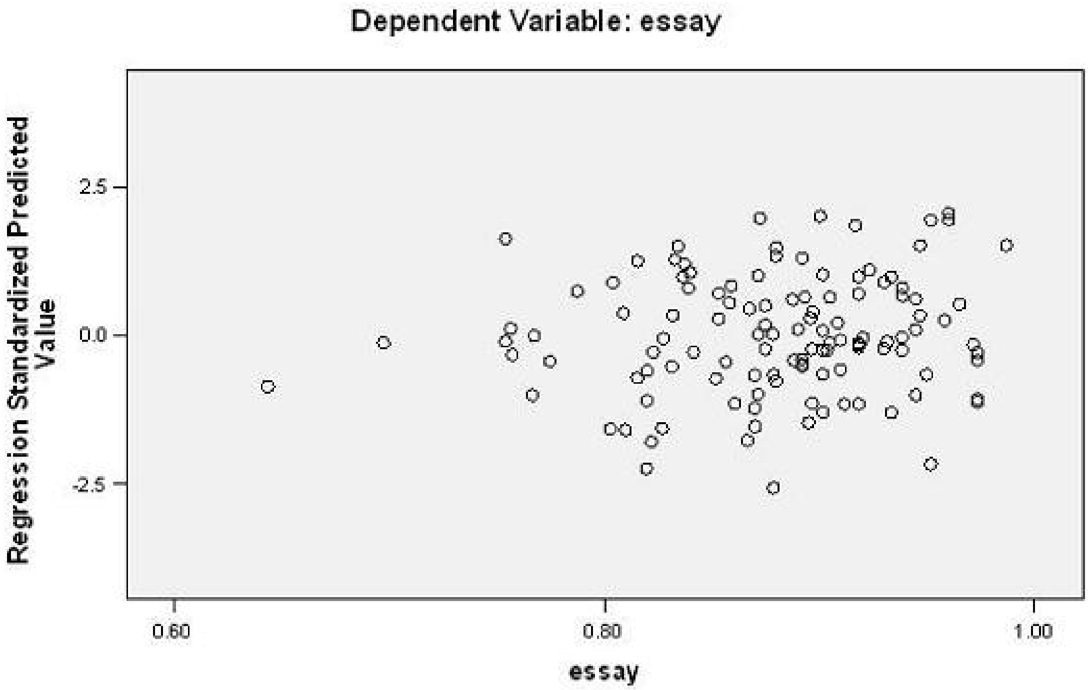

Figure L.21: Step 5-The visual/verbal dimension was removed.

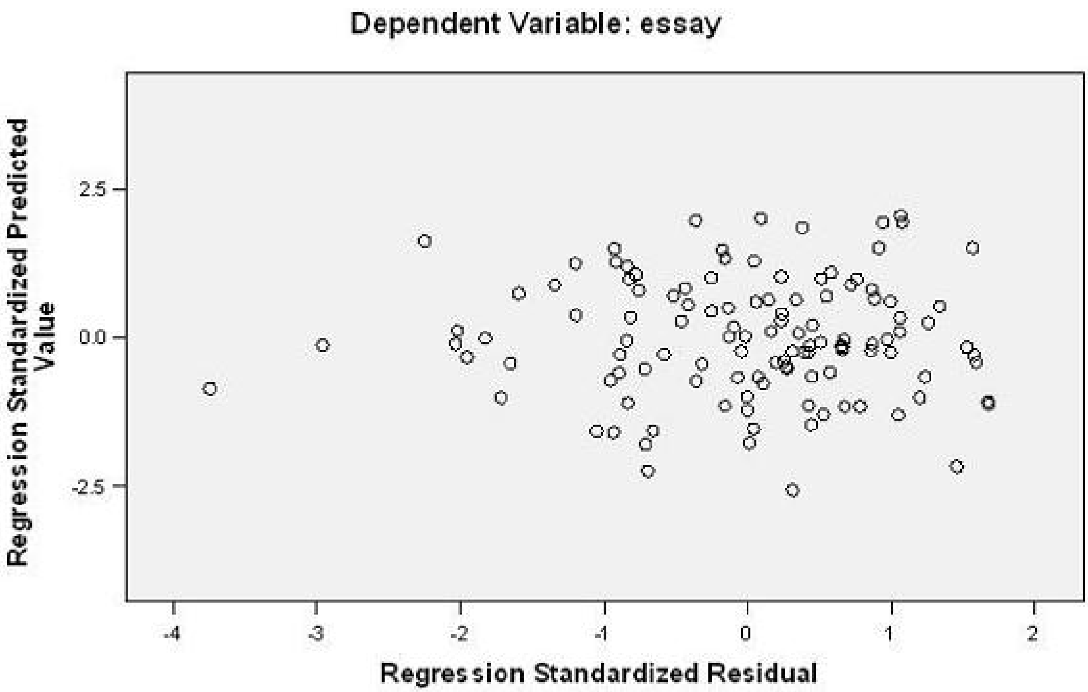

Figure L.22: Step 5-The visual/verbal dimension was removed.

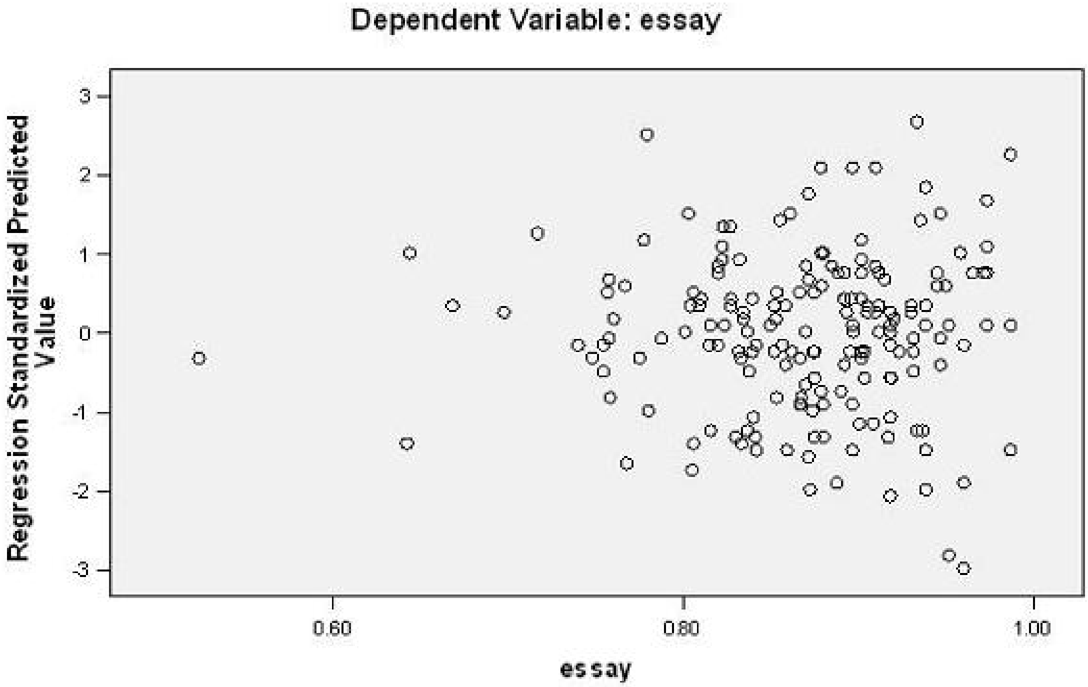

Figure L.23: Step 6-The visual/verbal dimension was removed.

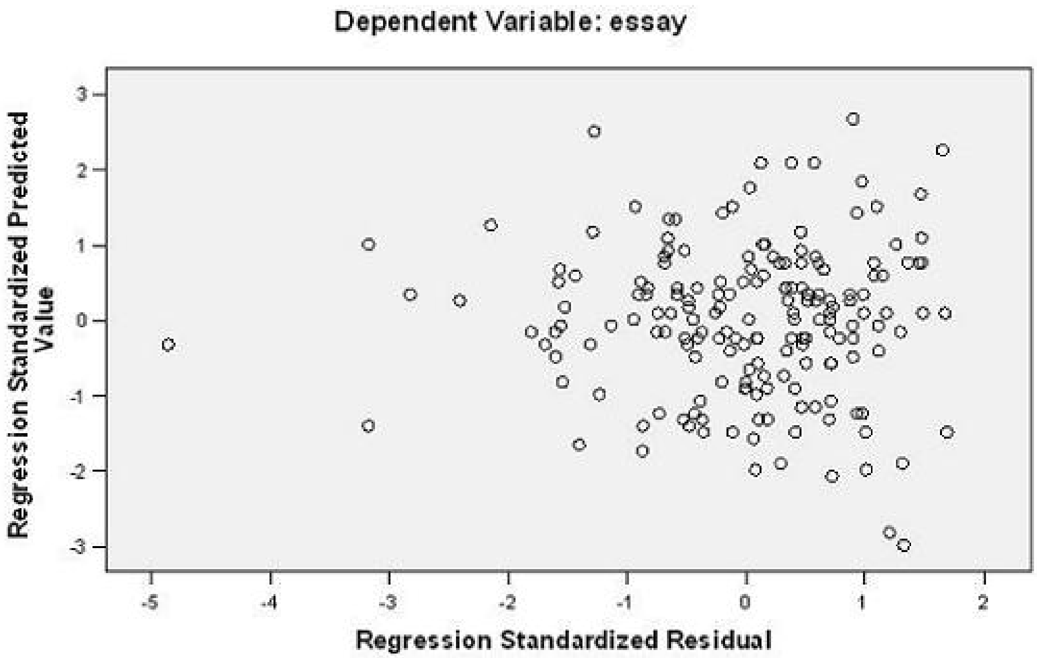

Figure L.24: Step 6-The visual/verbal dimension was removed.

L.4 Test of Regression Assumption Four and Five for Research Question four-Essay Problems

Step 1-All variables are included in the regression. This includes the lab attendance, help session attendance, time spent in the helproom, and Physics 1114 grade.

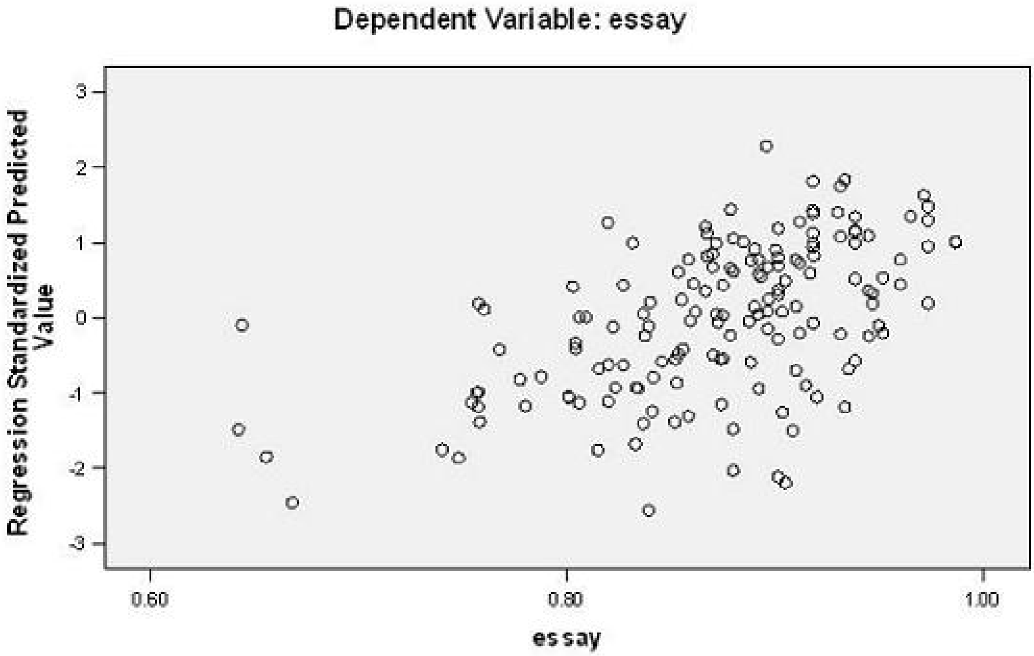

Figure L.25: Step 1-All variables entered.

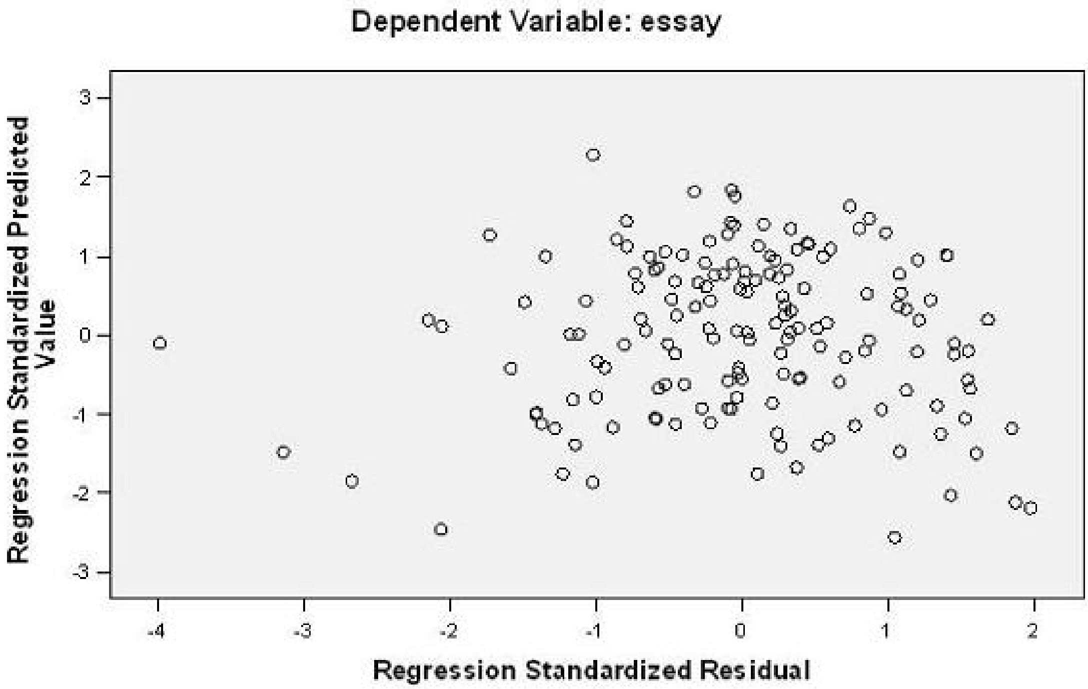

Figure L.26: Step 1-All variables entered.

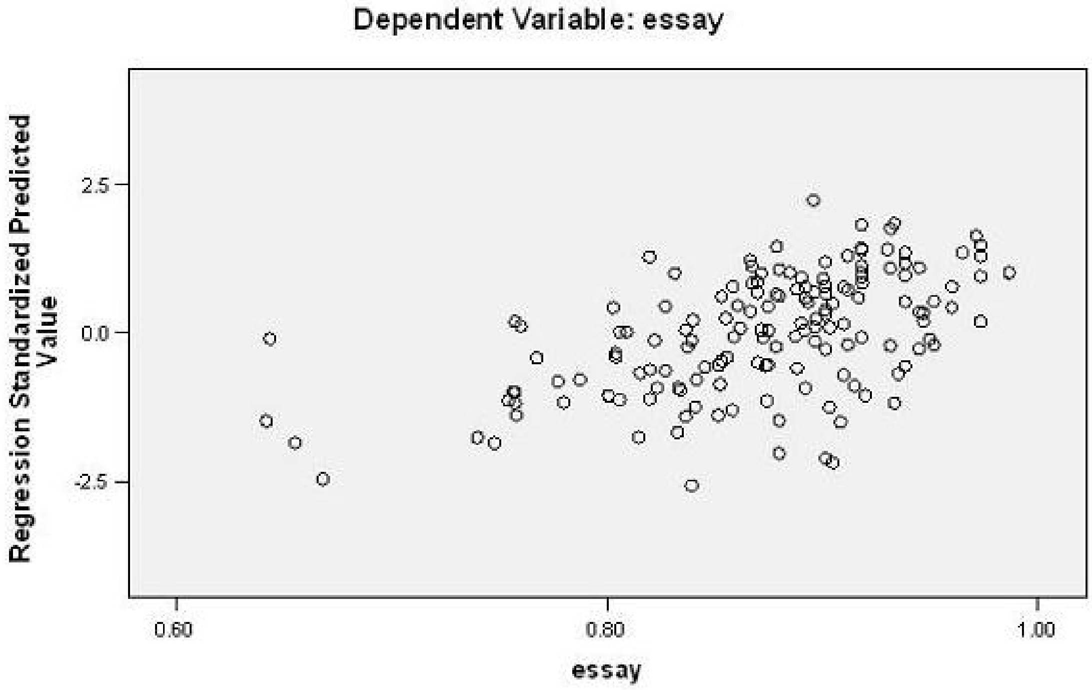

Figure L.27: Step 2-The time spent in the helproom was removed.

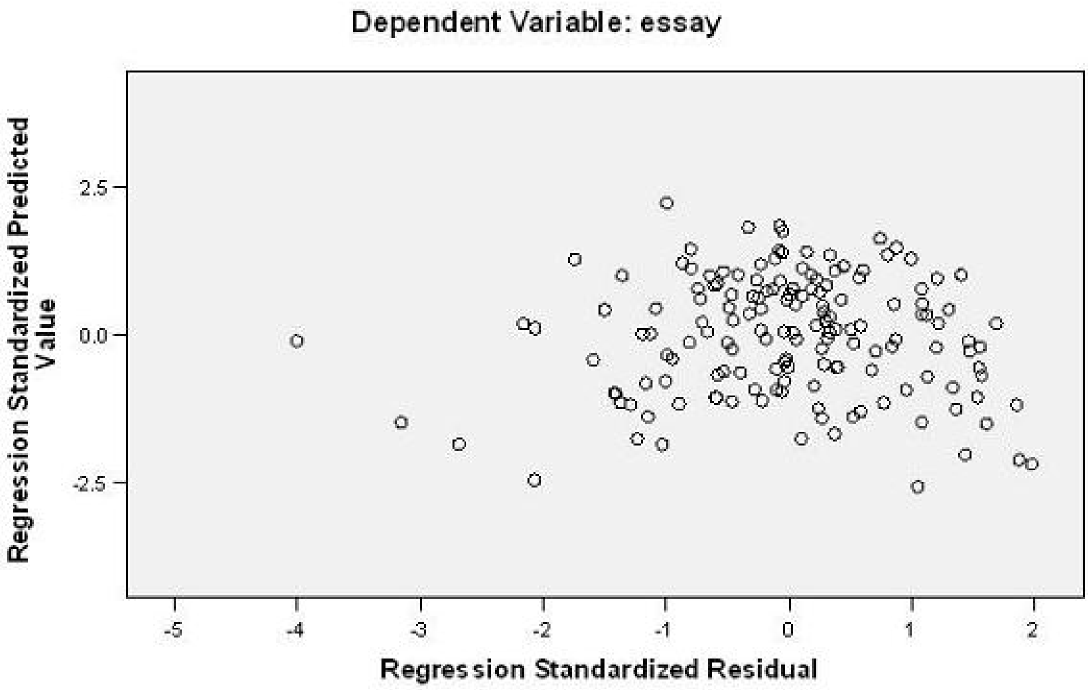

Figure L.28: Step 2-The time spent in the helproom was removed.

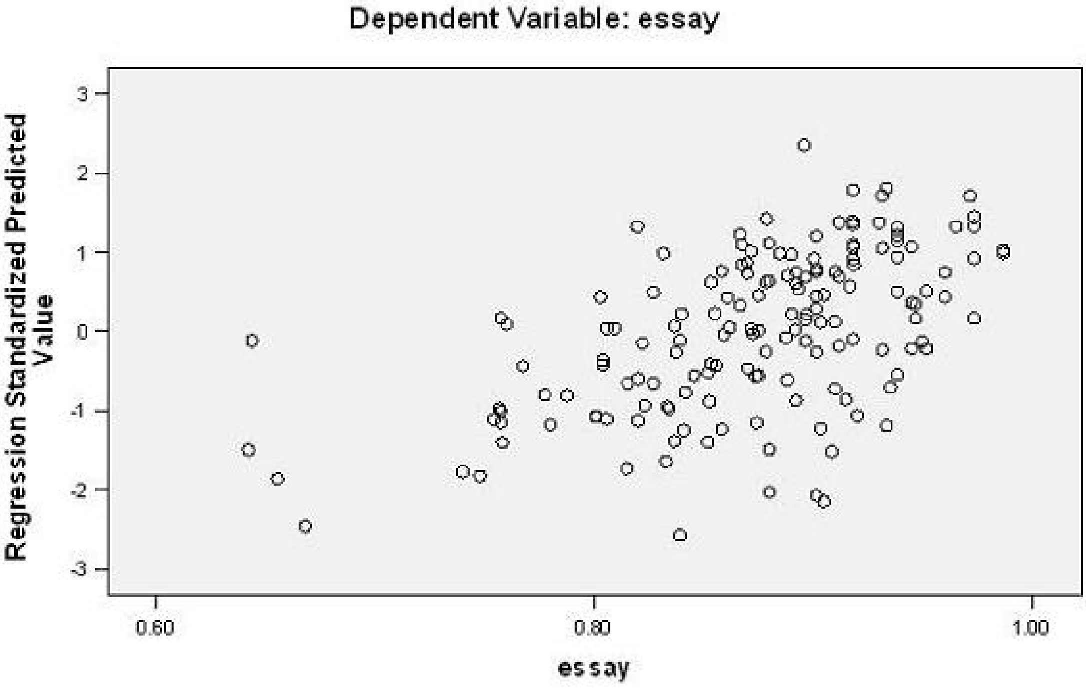

Figure L.29: Step 3-The help session was removed.

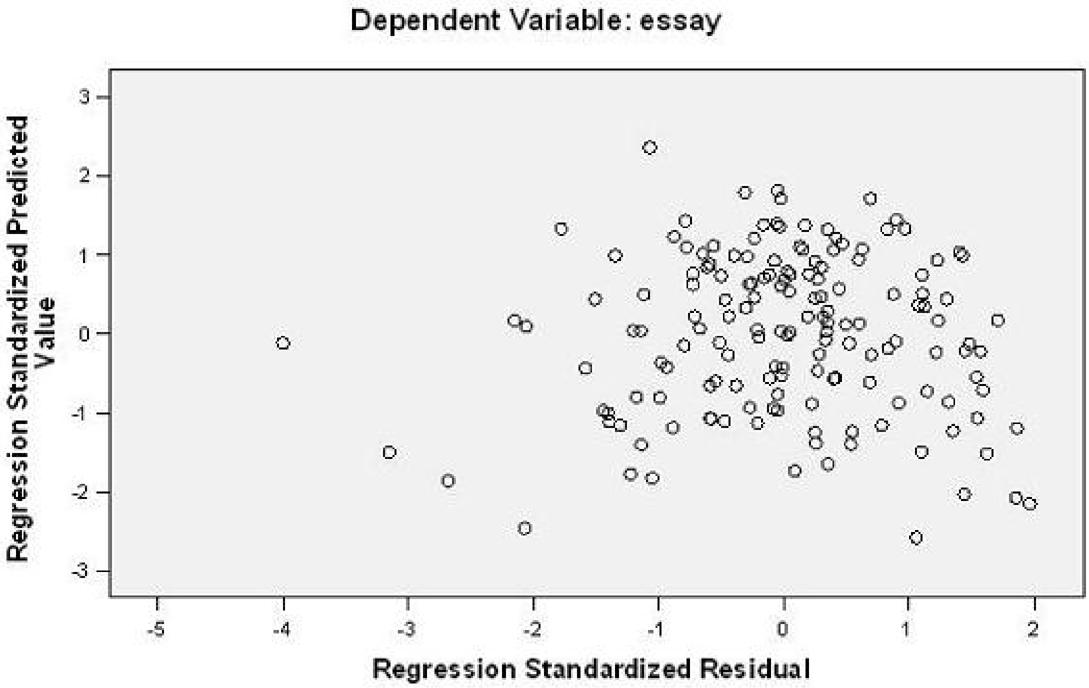

Figure L.30: Step 3-The help session was removed.

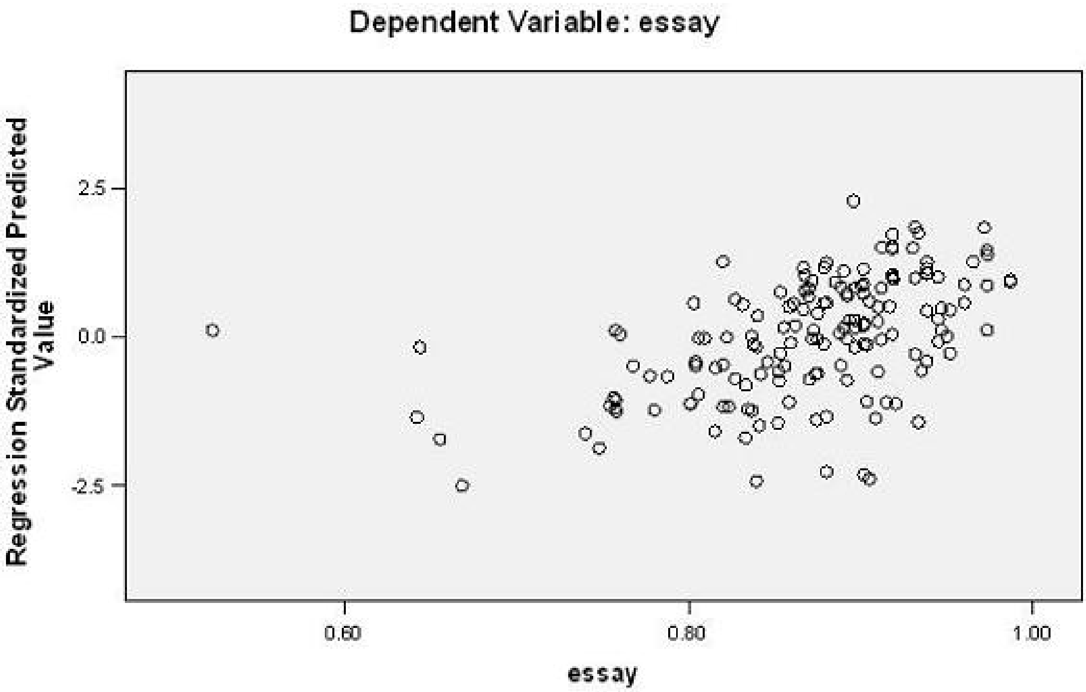

Figure L.31: Step 4-The lab attendance was removed.

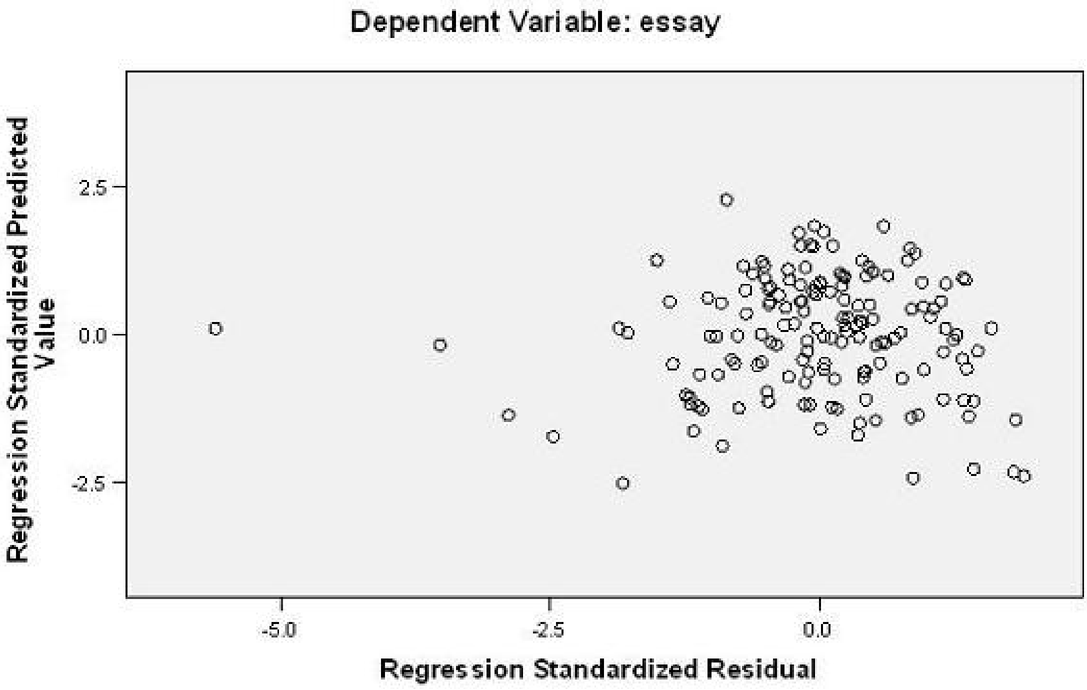

Figure L.32: Step 4-The lab attendance was removed.

L.5 Test of Regression Assumption Four and Five for Research Question five-Essay Problems

Step 1-All variables are included in the regression. This includes the homework grade, lab grade, GPA, and Physics 1114 grade.

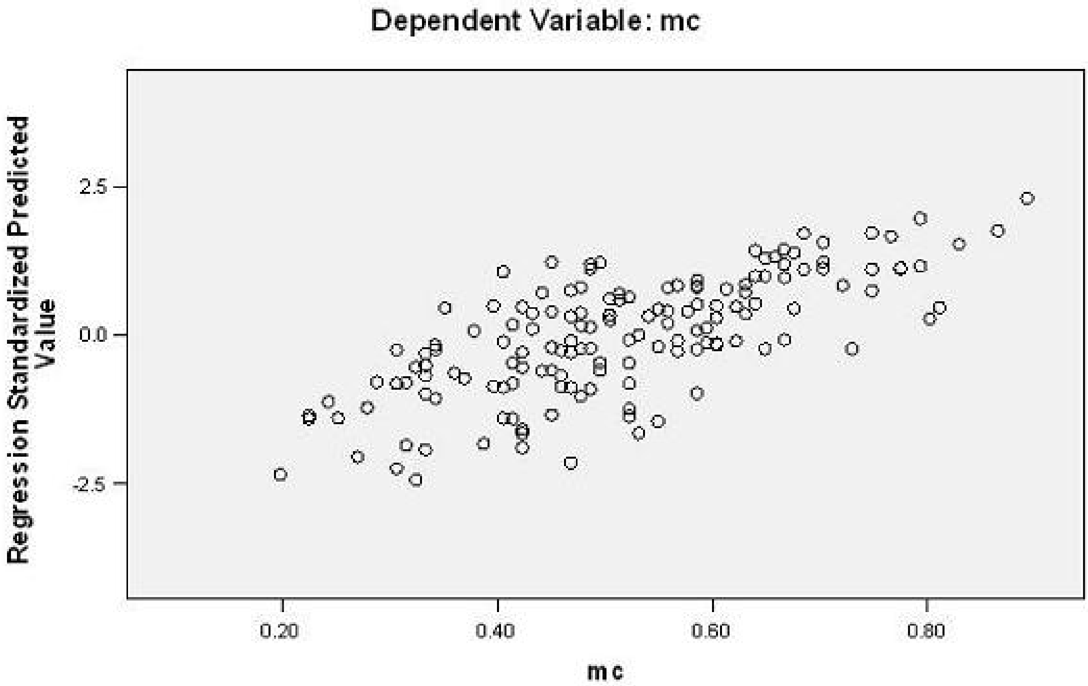

Figure L.33: Step 1-All variables entered.

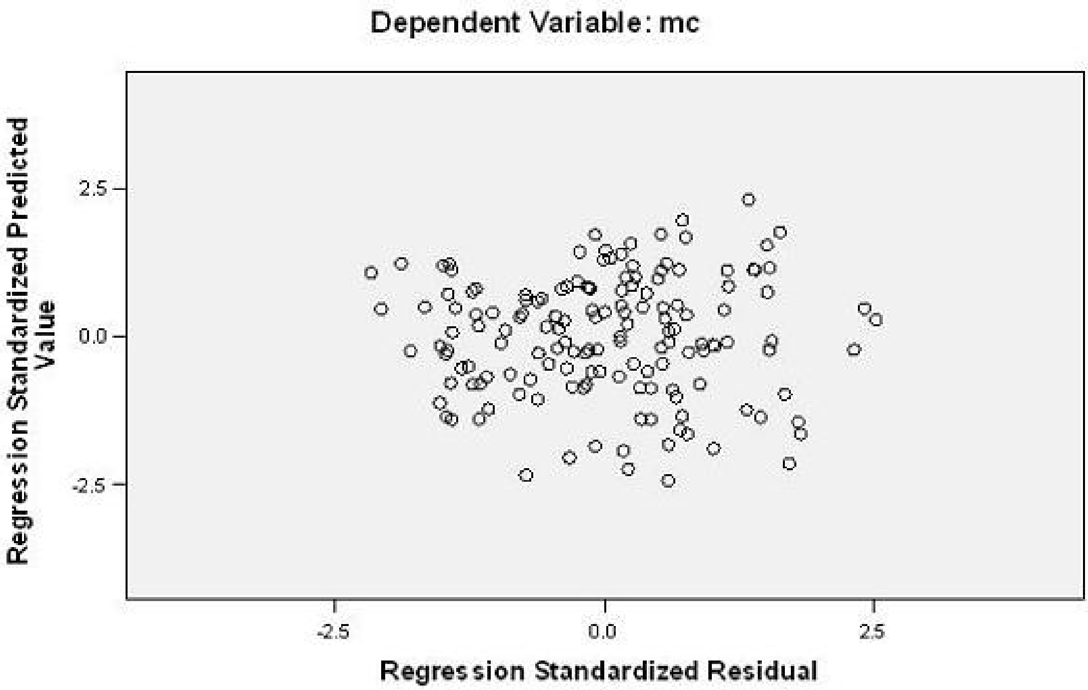

Figure L.34: Step 1-All variables entered.

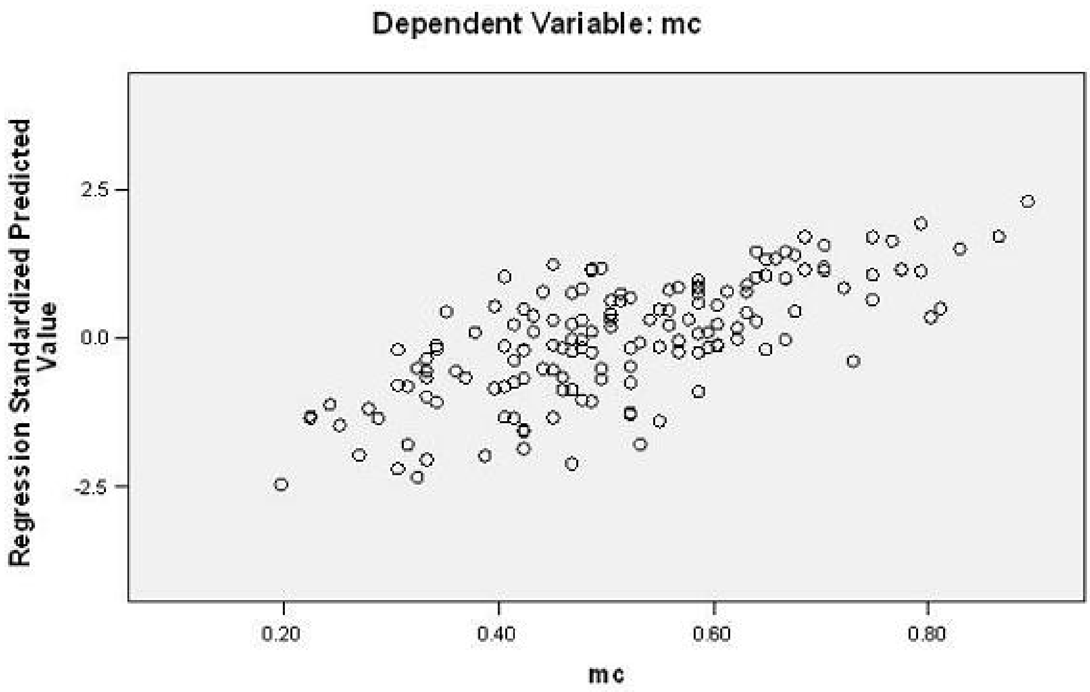

Figure L.35: Step 2-The homework average was removed.

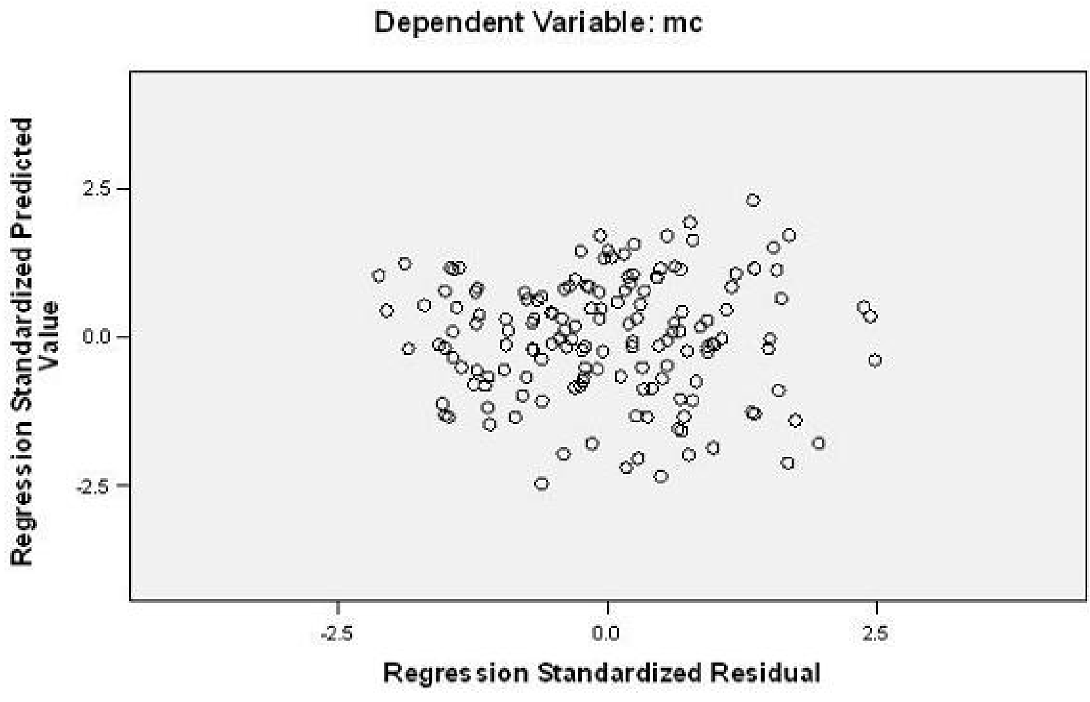

Figure L.36: Step 2-The homework average was removed.

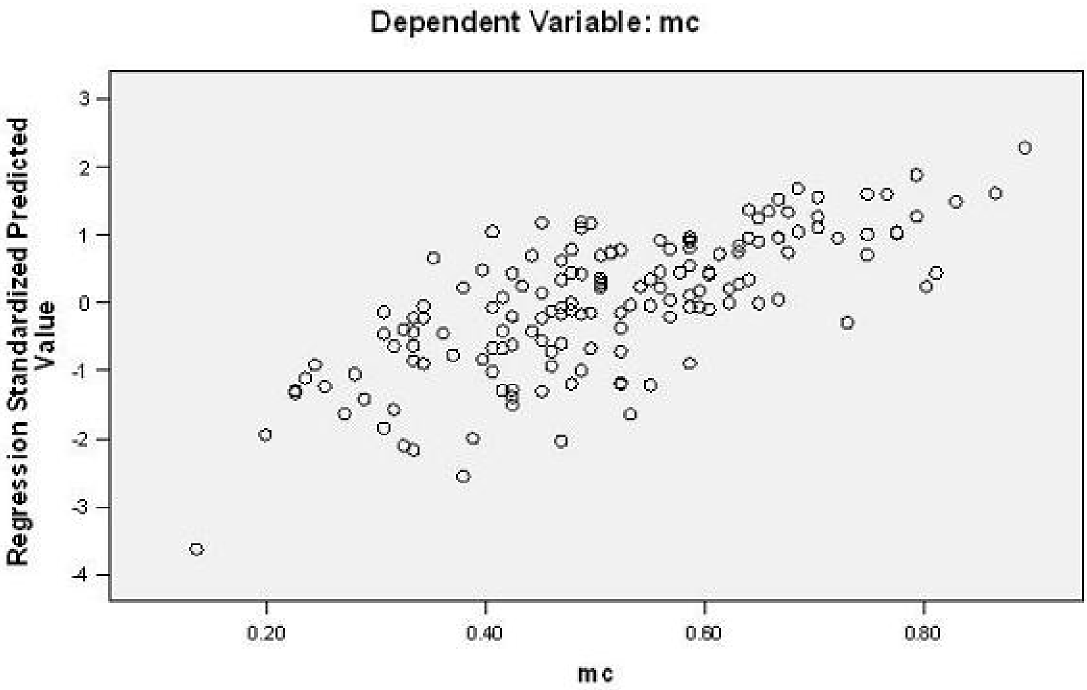

Figure L.37: Step 3-The GPA was removed.

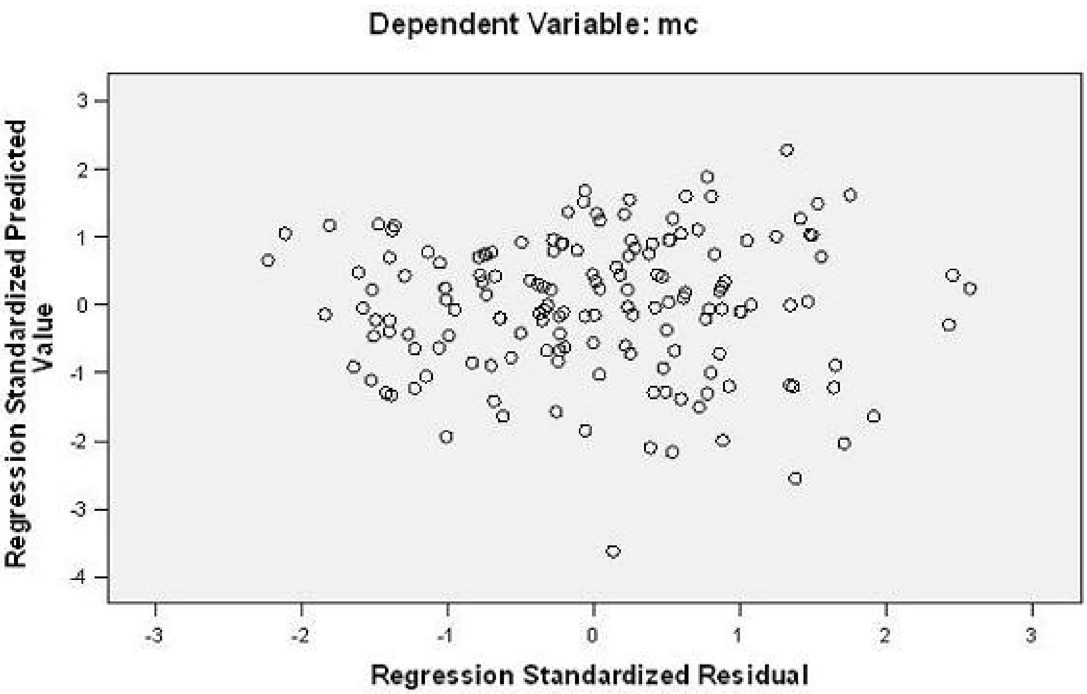

Figure L.38: Step 3-The GPA was removed.

L.5.1 Analysis

With the exception of research question three, the graphs seem to have a nice linear flow to them. Low predicted scores match up with low actual score, and high predicted scores match up with high actual scores. Due to this assumption four is satisfied. The predicted score versus residual seems to have a circular pattern on all of the research questions. Due to this assumption five is satisfied.

L.6 ANOVA Assumptions

There are several assumptions that must be met in order to run a one-way ANOVA. The assumptions for a one-way ANOVA are independence, normality, and homogeneity of variance.

1. The first assumption would be independence. Meeting this assumption is easy. To ensure independence results on the surveys the students are not allowed to discuss the survey with each other while completing the survey. 2. The second assumption is normality. There are several ways to test for normality. In the behavioral sciences if n $\geq$ 12 per group then normality is met. 3. The last assumption is the variances are equal (homogeneity of variance). You can test for this by either using a Levene test or the Hartley F-max test. We hope to fail the null hypothesis that the variances are equal.

L.7 ANOVA Assumptions for Research Question Three

The first two assumptions are easily met. The students did not talk while taking the surveys assuring the data is independent. Every category has at least twelve so normality is met. The focus will be on assumptions three. SPSS tests for homogeneity of variance, so assumption is easy to test. The results are summarized below.

Course Component	Levene Statistic	P-Value
Homework	0.646	0.425
Clicker	0.015	0.904
Quiz	1.233	0.271
Lab	0.136	0.713
Exam	0.107	0.745

Figure L.39: Active/Reflective ANOVA assumption three

Course Component	Levene Statistic	P-Value
Homework	6.291	0.013*
Clicker	5.192	0.024*
HBL	2.615	0.108
Lab	0.076	0.783
Exam	0.546	0.461
Homework Style	4.093	0.045*
Multiple Choice	0.062	0.803
Essay	1.305	0.255

*- Failed homogeneity of variance test

Figure L.40: Active/Reflective ANOVA assumption three

Course Component	Levene Statistic	P-Value
Homework	22.333	<0.001*
Clicker	4.156	0.045*
Quiz	6.827	0.011*
Lab	1.552	0.217
Exam	0.515	0.475

*- Failed homogeneity of variance test

Figure L.41: Global/Sequential ANOVA assumption three

Course Component	Levene Statistic	P-Value
Homework	3.768	0.054
Clicker	5.602	0.019*
HBL	0.196	0.658
Lab	6.461	0.012*
Exam	0.139	0.710
Homework Style	0.310	0.579
Multiple Choice	0.000	0.999
Essay	5.444	0.021*

*- Failed homogeneity of variance test

Figure L.42: Global/Sequential ANOVA assumption three

Course Component	Levene Statistic	P-Value
Homework	5.414	0.023[#]
Clicker	0.944	0.335
Quiz	4.151	0.046[#]
Lab	3.444	0.068
Exam	3.622	0.062

[#]- Failed homogeneity of variance test

Figure L.43: Visual/Verbal ANOVA assumption three

Course Component	Levene Statistic	P-Value
Homework	0.011	0.917
Clicker	0.863	0.354
HBL	0.052	0.819
Lab	2.894	0.091
Exam	0.772	0.381
Homework Style	1.506	0.221
Multiple Choice	0.534	0.466
Essay	1.326	0.251

Figure L.44: Visual/Verbal ANOVA assumption three

The assumption is passed most of the time. Mann-Whitney U replaces ANOVA on the few time the assumption is failed.

APPENDIX M

IRB Approval

Oklahoma State University Institutional Review Board

Date: Monday, August 13, 2007

IRB Application No AS0758

Proposal Title: Evaluating the Effectiveness of Algebra-Based Physics Course Components

Reviewed and Processed as: Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 8/12/2008

Principal Investigator(s

Chris Austin
145 PS II
Stillwater, OK 74078

Bruce J. Ackerson
145 PS II
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

M.2 IRB Modification Approval Letter

Oklahoma State University Institutional Review Board

Date	Monday, December 17, 2007	Protocol Expires:	8/12/2008
IRB Application	AS0758		
Proposal Title:	Evaluating the Effectiveness of Algebra-Based Physics Course Components		

Reviewed and Processed as: Expedited

Modification

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s) :

Chris Austin
145 PS II
Stillwater, OK 74078

Bruce J. Ackerson
145 PS II
Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

Signature :

Sue C. Jacobs, Chair, OSU Institutional Review Board

Monday, December 17, 2007
Date

VITA

Chris Austin

Candidate for the Degree of

Doctor of Philosophy

Dissertation: DETERMINING THE EFFECTIVE PREDICTORS OF PERFORMANCE IN A SECOND SEMESTER ALGEBRA-BASED PHYSICS COURSE.

Major Field: Physics

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, United States on August 23, 1978.

Education:
Received the B.S. degree from Oklahoma Christian University, Edmond, Oklahoma, United States, 2001, in Engineering Physics
Completed the requirements for the degree of Doctor of Philosophy in Physic at Oklahoma State University in December, 2008.

Experience:
PROFESSIONAL ORGANIZATIONS:
American Association of Physics Teachers; Current Member, Society of Physics Students-National and Local Chapter; Current Member,
TEACHING EXPERIENCE:
Instructor for Inquiry Based Physics (Physics 1313)-Fall 2006-Spring 2008
Teaching assistant for first semester algebra-based physics course (Physics 1114) Physics 1313 teaching assistant for four semesters-Fall 2004-Spring 2006
Assisted in the revision of the physics lab manual and introductory PowerPoints for second semester algebra and calculus based physics courses
Teaching assistant for second semester calculus-based physics course (Physics 2114)
Teaching Assistant for OSU Upward Bound

Name: Chris Austin
Date of Degree: December, 2008

Institution: Oklahoma State University
Location: Stillwater, Oklahoma

Title of Study: DETERMINING THE EFFECTIVE PREDICTORS OF PERFORMANCE IN A SECOND SEMESTER ALGEBRA-BASED PHYSICS COURSE.

Pages in Study: 249
Candidate for the Degree of Doctor of Philosophy

Major Field: Physics

Scope and Method of Study: This study investigated the significant predictors of exam performance in a second semester algebra-based Physics course. The predictors included course components, ability variables, and behavioral variables such as learning styles and attitude about Physics. If significant predictor variables are found, then it might be possible to identify students who will struggle in the course.

Findings and Conclusions: The best predictor variable was the first semester Physics grade. Other predictor variables included course components. The course components in this study included: homework average, lab average, HBL average, pre-class quizzes, and attendance. The lab was consistently the best course component predictor variable. This study also investigated ability variables such as GPA, ACT math score, and ACT science score. Surprising the math was not a predictor variable, but the GPA and ACT science score were predictor variables. The role of behavior variables was also determined. Learning styles and Physics attitude were poor predictor of exam performance. Lastly a few other effort variables such as lab attendance, total time in a Physics helproom, and the number of times that a student attends a exam review session were poor predictors of exam performance. These variables may have been poor predictors but they were still useful effort variables. Students who attended at least two help sessions outperformed students who attended fewer than two session. Similar results were found for class attendance. Students with perfect attendance outperformed students who were willing to miss a class. Students who spent at least 7.5 hours in the helproom outperformed students who spent less time. Over the best predictor variables of exam performance was ability or effort variables. Students who are willing to put in the effort will perform well in Physics.

ADVISOR'S APPROVAL: ______________________________