EFFICACY

# The Effect of the Seeds of Science/Roots of Reading Curriculum (Grade 5)

Amplify.

# The Effect of the *Seeds of Science/Roots of Reading* Curriculum

# (*Planets and Moons* Unit)

# for Developing Literacy through Science in Fifth Grade


**Luke Duesbery**

**Jacob Werblow**

**Todd Twyman**


**December 21, 2011**

# Executive Summary

This evaluation examined the *Planets and Moons* (PM) unit as part of the *Seeds of Science/Roots of Reading: Effective Tools for Developing Literacy through Science in the Early Grades (Seeds/Roots)* model of science-literacy integration for Grade 5, developed by the Lawrence Hall of Science (LHS). Specifically, the purpose of this evaluation was to determine the efficacy of the *Seeds/Roots* curriculum—in the areas of science knowledge, nature of science, science vocabulary, attitudes toward science, and reading—on general education students ($N$ = 2,234), as well as a sub-sample of English Language Learners (ELL), $N$ = 769.

Using an experimental pre- post-test design, the 12-week PM unit yielded statistically significant differences in the overall sample in the three areas that could be fully analyzed—science knowledge, nature of science, and science vocabulary (for these students, scores in the two areas of attitudes and reading did not meet statistical assumptions). Although effect sizes were small to medium, students in the treatment (PM) group gained 18% to 34% more in the three areas of science knowledge, nature of science, and science vocabulary. Specific results of the ELL subsample analyses yielded comparable or larger learning gains across science knowledge, vocabulary, and, in this case, also in reading. In these areas effect sizes ranged from $d$ = .40 – .65, indicating that the average ELL student in the treatment group would rank in the top 66$^{th}$ to 75$^{th}$ percentile of their peers in the control group. ELL subsample analyses are reported along with overall Grade 5 results.

## Introduction

This evaluation focuses on the *Seeds of Science/Roots of Reading: Effective Tools for Developing Literacy through Science in the Early Grades (SEEDS/ROOTS)* model of science-literacy integration for Grade 5. This model was developed and implemented by the Lawrence Hall of Science (LHS). This study is a multi-year project funded by the National Science Foundation and builds upon previous *SEEDS/ROOTS* evaluations (Goldschmidt & Jung, 2009; Wang & Herman, 2006). This report provides an overall summative evaluation of the *Planets and Moons* (PM) unit, as well as additional sub-analyses for students who are English language learners (ELL).  Given the experimental design (teachers randomly assigned to treatment or control groups) and the data collected, data were quantitatively analyzed. Because *SEEDS/ROOTS* uses an integrated approach to teaching science and literacy, this evaluation provides evidence for the benefit(s) of utilizing an integrated approach, in comparison to standard instructional practices in a $4^{th}$ and $5^{th}$ grade science unit on planets and moons.

## Background

*SEEDS/ROOTS* is an integrated science-literacy program designed for Grades 2–5, partially based on revisions of units in the Great Explorations in Math and Science (GEMS) Program. *SEEDS/ROOTS* units are designed as “next generation” standards-aligned elementary inquiry science materials that advance student learning in science while meeting the challenges of: an increasingly congested school day, low levels of elementary teacher preparation and efficacy in science, the pressures of large-scale testing, and the growing diversity of our nation’s classrooms. *SEEDS/ROOTS* science-literacy integration is partly based on previous literature on integrated methods. The emphasis is on integrating content-area learning, reading, and writing.

This approach to science-literacy integration ideally fosters a ***synergistic*** relationship (Cervetti, Pearson, Bravo, & Barber, 2006). The *SEEDS/ROOTS* model builds on previous work that has demonstrated positive effects from using an integrated approach (Guthrie & Ozgungor, 2002; Romance & Vitale, 1992). The model is also grounded in Stoddart, Pinal, Latzke, & Canaday's (2002) approach to instructional integration, involving an interdisciplinary approach in which content or processes in one domain are used to support learning in another, or in which emphasis on two or more domains is balanced. Details of the *SEEDS/ROOTS* integrated curriculum and process to achieve balance are discussed in Cervetti, Barber, Dorph, Pearson, and Goldschmidt (2009).

## Purpose

The purpose of this evaluation was to determine the effectiveness of this *Planets and Moons* unit, as representative of the *SEEDS/ROOTS* curriculum. Essentially, we wanted to explore whether students significantly benefited during the 12-week intervention relative to their peers in the control group on the following outcomes: science knowledge, nature of science, science vocabulary, attitudes toward science, and reading. In addition, we wanted to know if the *SEEDS/ROOTS* curriculum demonstrated a differentiated benefit for ELL students relative to their non-ELL peers.

## Methods

### *Sample and Procedure*

Students in ($n$ = 2,234) approximately 100 fifth-grade classrooms from nearly 60 schools were selected in both rural and urban counties in 10 states. States were selected because of the alignment between the state's science standards specific to planets and moons and the integrated science-literacy PM content. This, in turn, created a better content-comparable group between the treatment and the control group. Teachers were randomly assigned to teach either the: (a) integrated science-literacy PM unit (treatment group) or (b) content of their state science standards related to planets and moons, using their typical curriculum materials (control group).

LHS researchers administered pre- and post-tests in science and literacy to students in both the treatment and control classrooms the week before and the week after the 12-week unit. LHS researchers collected information on a number of student and school-level variables, including student performance, student and teacher attitudes, and teacher efficacy. Due to a large amount of missing data in the full dataset, we imputed missing data for 16 variables using the Expectation Maximization (EM) algorithm in SPSS MVA software to reduce sampling bias. See Appendix A for a narrative and imputed results.

A subsample of 769 fifth-grade students was also created from the full dataset of students to run analyses comparing the effect of the treatment on ELL versus non-ELL students. Data on ELL students were collected individually and cross-referenced with teacher, district, and state designations to ensure the most accurate sample possible. Using these methods, 553 students were identified as English only, and 216 as English Language Learners (ELL). Of the ELL students, 96 were in the treatment group, and 120 were assigned to the control group. Considering the scope of the full dataset, student demographics are reported in percentages for ease of interpretation. See Table 1 for all participating student demographics.

**Table 1**

***Sub-Sample Student Demographics (N = 769)***

| | Gender | | Ethnicity* | | | | | Educational Designation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F | M | AA | A | H/L | NA | W | SPED | FLR | ELL |
| Treatment | 50.1% | 49.9% | 23.6% | 1.6% | 10.8% | 3.7% | 58.8% | 9.7% | 54.2% | 24.5% |
| Control | 49.9% | 50.1% | 15.5% | 1.0% | 27.3% | 9.1% | 47.0% | 9.2% | 68.4% | 31.7% |

*Due to substantial missing data, Ethnicity percentages should be viewed with caution.

***Variables***

Students' learning, or achievement gain from pre- to post-test, are the dependent variables used in this study. Specifically, the five outcomes reported here are (a) Science Knowledge, (b) Nature of Science, (c) Science Vocabulary, (d) Attitudes toward Science, and (e) Reading. These variables were computed by subtracting the pre-test score from the post-test score. LHS instrumentation allows for this procedure as scores from pre- and post-tests are linked to the same scale and demonstrate moderate to high reliability (α = .77 - .83). This procedure for constructing gain scores is common in other well-established research (Lee & Smith, 1996; 1997).

***Analyses***

We initially chose to construct Hierarchical Linear Models (HLMs) to analyze the *SEEDS/ROOTS* data because of the nested nature of the dataset (students nested within classrooms); however, the intraclass correlation coefficients (ICCs) of the baseline HLM models were too small ($\leq$ 3%) for HLMs to be appropriate (Stevens & Zvoch, 2006). This was true for the full dataset as well as the ELL subsample. In both cases, nearly all of the variance in the outcomes exists within classrooms (differences in students) not between classrooms, thus nonhierarchical models (such as ANOVAs or Multiple Regressions) would be more appropriate. See Appendix B for detailed analytic procedures.

As HLM was deemed inappropriate, our next step was to consider Multiple Regression models to explore the effectiveness of the *SEEDS/ROOTS* curriculum, as regression modeling is a more robust procedure. However, due to high multicolinearity between the outcomes and some of the control variables (pre-tests) and a the large amount of missing data, we were unable to use the student-level demographic variables required for Multiple Regression. Thus we constructed a one-way analysis of variance (ANOVA) for the full dataset. Because the ELL subsample was more complete and accurate, we conducted repeated Measures ANOVA for the ELL subsample.

## Results

The following results are reported by outcome for the full dataset, followed by the ELL subsample, along with a brief discussion of the magnitude of the treatment (effect sizes). For all analyses, alpha was set at .05, and unless otherwise noted, all statistical assumptions were met. Descriptive statistics are displayed in Tables 2 and 3 and Figures 1 and 2 at the end of this section. Full SPSS Results are presented in tabular form in Appendix C.

Small, but significant effects were found for three of the five tested outcomes—for both the full dataset and the ELL subsample.

***Science Knowledge*.** In *Science Knowledge*, students in the treatment group significantly outgained their peers in the control group, $F$ (1, 2232) = 14.94, $p < .001$, *Cohen's* $d = .17$. For this outcome, students in the treatment group gained, on average, 18% more than the control group. For the ELL subsample, students in the treatment group revealed a statistically significant interaction effect, $F(1,197) = 0.268$, $p = .000$, *Cohen's d* = .65, indicating that the average treatment participant would rank in the 75th percentile of the control group. (Coe, 2002).

***Nature of Science***. In *Nature of Science,* the treatment group also significantly outgained their peers in the control group, $F\ (1, 2232) = 71.30$, $p < .001$, *Cohen's d = .20.* Here, the treatment group outgained the control group by nearly 30%. A repeated ANOVA measure revealed no statistically significant differences between control and treatment groups for ELLs in *Nature of Science*.

***Science Vocabulary*.** Students placed in the treatment group also made significantly greater gains in *science vocabulary* than their peers in the control group, $F\ (1, 2232) = 86.03$, $p < .001$, *Cohen's d =.40.* Demonstrating a medium effect size, the treatment group, on average, made 34% more gain than the control group. ELL subsample analyses also revealed a statistically significant interaction effect $F(1,145) = 12.416$, $p = .001$, *Cohen's d* = .59, indicating that the average treatment participant would rank in approximately the 73rd percentile of the control group.

***Attitudes toward Science and Reading*.** Gain scores for *Attitudes toward Science* and for *Reading* did not pass the Brown-Forsythe Test (assumption: Homogeneity of variance), $p > .05$ for the full dataset. For the ELL subsample analyses, in the area of *attitude*, there were no statistically significant differences, although ELL students in the treatment group *appeared* to have more of a negative effect. In *reading*, for ELL students, analyses yielded a statistically significant interaction effect $F(1,137) = 5.586$, $p = .020$, *Cohen's d* = .40, indicating that the average treatment participant would rank in the 66th percentile of the control group.

**Table 2**

*One Way ANOVA Gain Score Results for Full, Imputed SEEDS/ROOTS Dataset*

| | Treatment | | | Control | | |
|---|---|---|---|---|---|---|
| Gain score | *n=* | *M(SD)* | *SE* | *n=* | *M(SD)* | *SE* |
| Science Knowledge | 1180 | .74(.77) | .02 | 1054 | .61(.79) | .02 |
| Nature of Science | 1180 | 1.13(1.81) | .05 | 1054 | .77(1.84) | .06 |
| Vocabulary | 1180 | .96(.88) | .03 | 1054 | .64(.71) | .02 |
| Attitudes* | 1180 | .67(.99) | .05 | 1054 | .08(1.04) | .03 |
| Reading* | 1180 | .67(1.87) | .87 | 1054 | .56(1.84) | .06 |

* *Note*: These outcomes did not pass the Brown-Forsythe Test for Homogeneity of Variance.

***Figure 1*. Gain score results for full, imputed *SEEDS/ROOTS* dataset.**

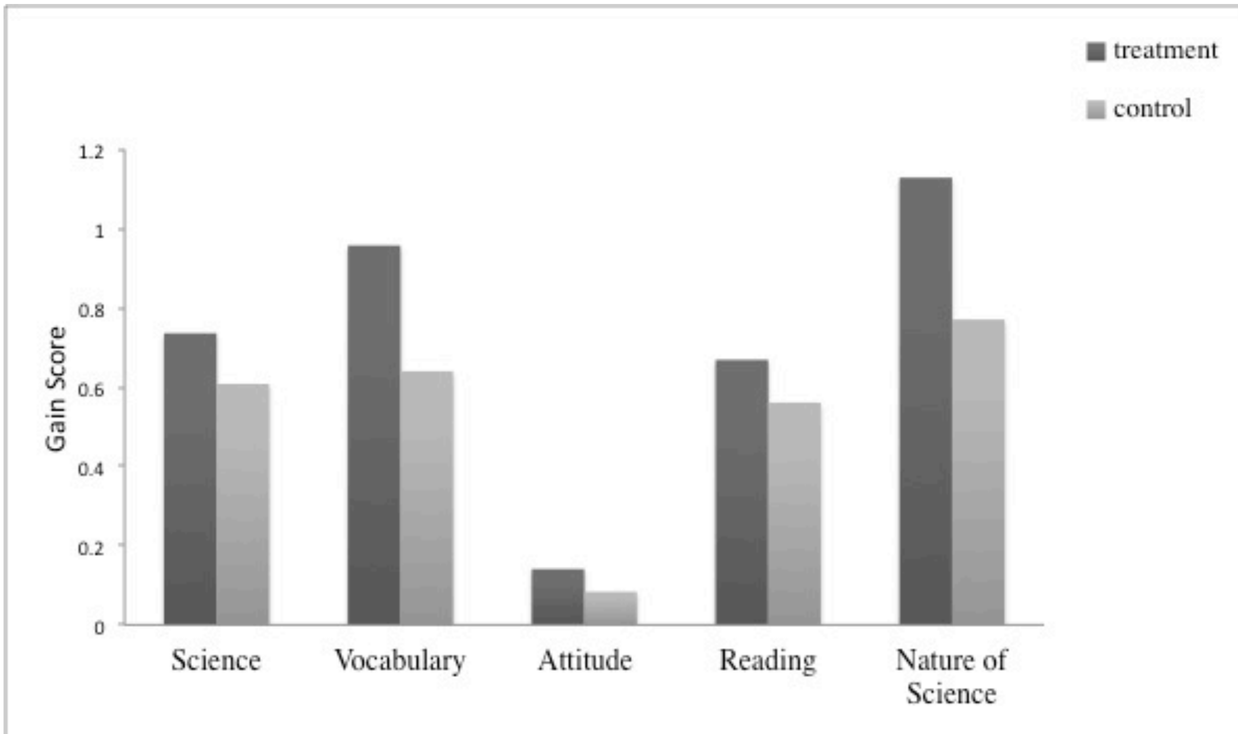
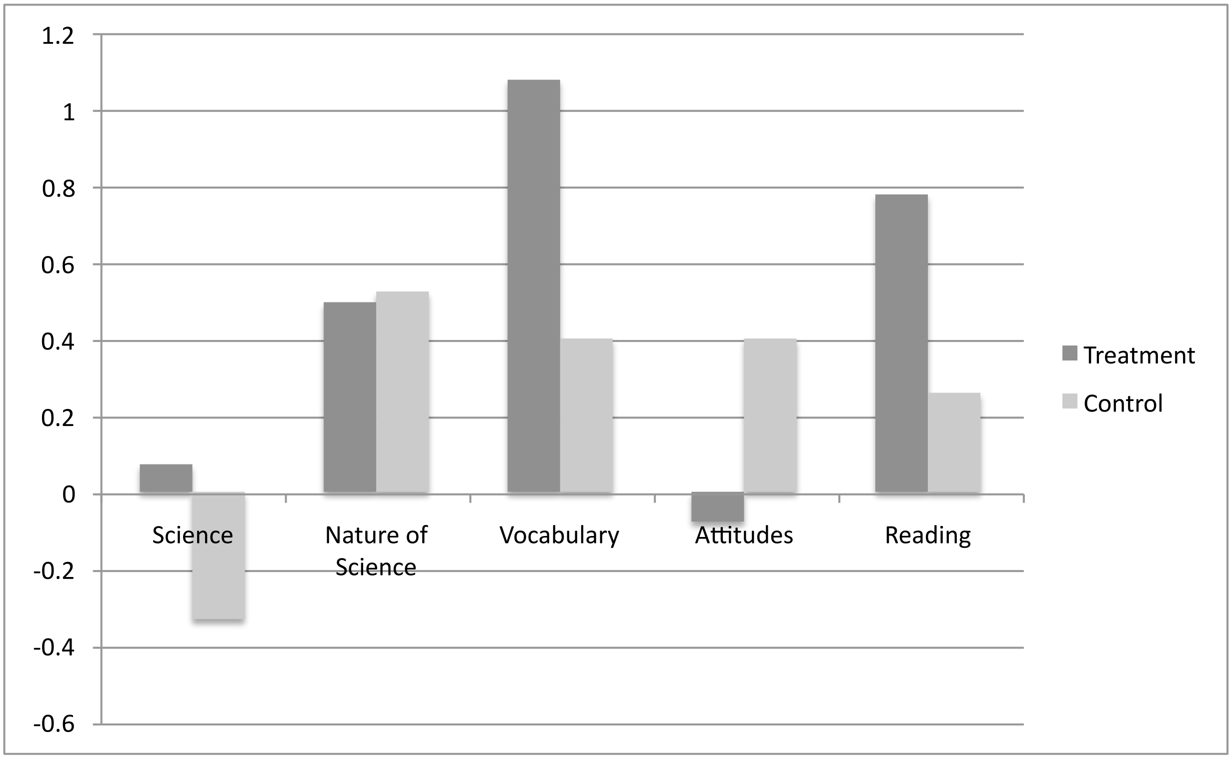


**Table 3**

***Test Score Results for ELL Subsample***

| | Treatment | | Control | |
|---|---|---|---|---|
| Test (PRE/POST) | *M* | *SD* | *M* | *SD* |
| Science Knowledge PRE | -0.261 | 0.449 | 0.031 | 0.611 |
| Science Knowledge POST | -0.189 | 0.610 | -0.302 | 0.563 |
| Nature of Science PRE | 0.982 | 1.199 | 0.986 | 1.302 |
| Nature of Science POST | 1.478 | 1.267 | 1.510 | 1.480 |
| Vocabulary PRE | 0.049 | 0.741 | 0.177 | 0.748 |
| Vocabulary POST | 1.127 | 1.253 | 0.578 | 0.741 |
| Attitudes PRE | -0.702 | 1.799 | -1.140 | 1.472 |
| Attitudes POST | -0.780 | 2.014 | -0.692 | 1.348 |
| Reading PRE | -0.094 | 1.801 | 0.388 | 1.304 |
| Reading POST | 0.684 | 1.547 | 0.647 | 1.203 |

***Figure 2.*** **Gain Score Results for ELL Subsample.**




## Discussion

Students receiving the *SEEDS/ROOTS* curriculum clearly gained more than their peers on science, nature of science, and science vocabulary. In some cases, the treatment group gained over 30% more than the control group. ELL subsample analyses yielded positive findings as well. Perhaps the ELL findings are even more telling with respect to the nature of the intervention. In the areas of *science knowledge*, *vocabulary*, and *reading,* ELL students in the treatment showed positive from pre- to post, while their peers in the control group showed little or a negative trend. For example, in the area of *science knowledge* ELLs in the treatment group grew from - 0.261 to -0.189, but ELLs in the control group fell from 0.031 to -0.302. With respect to discipline-specific *vocabulary,* ELLs in the treatment group grew from 0.049 to 1.127, a growth of more than one standard deviation. In contrast, the ELLs in the control group grew by about ½ of a standard deviation, from 0.177 to 0.578. Finally, in *reading* comprehension ELLs in the treatment group grew from - 0.094 to 0.684, while ELLs in the control group only grew from 0.388 to 0.647. These differences are well illustrated when inspecting effect sizes, as the average ELL student in the treatment group would rank in the top $6^{th}$ to $9^{th}$ percentile of their peers in the control group. It is clear from these results that the *SEEDS/ROOTS* curriculum is significantly more effective in promoting student learning than the traditional science curriculum.

## References

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Wang J., & J. Herman (2006). *Evaluation of Seeds of Science/Roots of reading Project: Shoreline Science and Terrarium Investigations*, CSE Technical Report 676, National Center for Research on Evaluation, Standards, and Student Testing, Center for the Study of Evaluation (CSE) Graduate School of Education & Information Studies, University of California, Los Angeles.

## APPENDIX A

## ACCOUNTING FOR MISSING DATA

Some variables in the *SEEDS/ROOTS* dataset are missing 30–40% of their cases. Because HLM 6.0 (Raudenbush, Bryk, & Congdon, 2004) software cannot run models with datasets that contain missing data, we imputed data to reduce the sampling bias.

Using SPSS MVA software, we conducted missing values analysis to impute 16 variables in the *SEEDS/ROOTS* dataset. The mean relative difference between imputed and unimputed data was small, except for the imputed estimates of the inquiry and attitudes test scores, which were 15% different from the raw scores. This is likely to have occurred because these variables had the largest percentage of missing data (nearly 25%).

The Expectation Maximization (EM) algorithm was used in SPSS 17.0 to impute missing data. This strategy is more reliable than list-wise or pair-wise deletion, as it uses other values in the dataset to construct a missing data estimate. Little's MCAR (chi-square) test was applied and indicated that the data were not completely missing at random at the student level, $\chi^2(120, N = 769) = 362.65, p < .001$. Because of the large proportion of missing cases in this dataset some of these results should be interpreted with caution. For more information see Table 4.

**Table 4**

***Summary of SEEDS/ROOTS Subsample Completion and Coverage Rates, by Instrument***

| Instrument | Selected | Participated | % |
|---|---|---|---|
| Science Pre-test | 769 | 656 | 85.3 |
| Science Post-test | 769 | 645 | 83.9 |
| Nature of Science Pre-test | 769 | 681 | 88.5 |
| Nature of Science Post-test | 769 | 730 | 94.9 |
| Vocabulary Pre-test | 769 | 653 | 84.9 |
| Vocabulary Post-test | 769 | 643 | 83.6 |
| Attitudes Pre-test | 769 | 606 | 78.8 |
| Attitudes Post-test | 769 | 567 | 74.9 |
| Reading Comp. Pre-test | 769 | 730 | 94.9 |
| Reading Comp. Post-test | 769 | 720 | 93.6 |

APPENDIX B

HLM RESULTS OF INTRACLASS CORRELATION COEFFICIENTS

One assumption of HLM is that there must be sufficient variability between each level (at least 10%) to justify conducting a HLM. We found nearly all of the variance in the outcomes to lie *within* classrooms (differences in students) not *between* them (differences in the classroom, teacher, or school). For all unconditional (baseline) HLMs constructed with these outcomes, the intraclass correlation coefficient (ICC) was relatively small. The ICC is the percent of the variance in the outcome (Gain in Vocabulary, Science, etc.) that exists between classrooms. Small ICCs indicate that using HLMs to analyze these outcomes is not an appropriate analysis for this subsample. Results of the ICCs are presented in Table 5.

**Table 5**

***Interclass Correlation Coefficient (ICC) Results of the Unconditional HLM Models for Imputed SEEDS/ROOTS***

| | ICC | |
|---|---|---|
| Gain Score | *Subsample (n = 767)* | *Full Sample (n =* 2,234*)* |
| Vocabulary | **3%** | 1.5% |
| Science | 2.2% | 1.1% |
| Reading | .9% | 2.3% |
| Attitudes | .9% | .2% |
| Nature of Science | .7% | .6% |

# APPENDIX C

## SPSS RESULTS OF ONE-WAY ANOVAS

**Notes**

| | | |
|---|---|---|
| Output Created | | 11-Jan-2011 11:03:51 |
| Comments | | |
| Input | Data | F:\SEEDSFull_imputed.sav |
| | Active Dataset | DataSet2 |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 2234 |
| Missing Value Handling | Definition of Missing | User-defined missing values for dependent variables are treated as missing. |
| | Cases Used | Statistics are based on cases with no missing values for any dependent variable or factor used. |
| Syntax | | EXAMINE VARIABLES=SGain VGain AGain RGain NoSGain<br>/PLOT BOXPLOT STEMLEAF NPPLOT<br>/COMPARE GROUP<br>/STATISTICS DESCRIPTIVES<br>/CINTERVAL 95<br>/MISSING LISTWISE<br>/NOTOTAL. |
| Resources | Processor Time | 00:00:20.453 |
| | Elapsed Time | 00:00:18.013 |

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| SGain | 2234 | 100.0% | 0 | .0% | 2234 | 100.0% |
| VGain | 2234 | 100.0% | 0 | .0% | 2234 | 100.0% |
| AGain | 2234 | 100.0% | 0 | .0% | 2234 | 100.0% |
| RGain | 2234 | 100.0% | 0 | .0% | 2234 | 100.0% |
| NoSGain | 2234 | 100.0% | 0 | .0% | 2234 | 100.0% |

**Descriptives**

| | | | Statistic | Std. Error |
|---|---|---|---|---|
| SGain | Mean | | .6755 | .01659 |
| | 95% Confidence Interval for Mean | Lower Bound | .6429 | |
| | | Upper Bound | .7080 | |
| | 5% Trimmed Mean | | .6788 | |
| | Median | | .6726 | |
| | Variance | | .615 | |
| | Std. Deviation | | .78411 | |
| | Minimum | | -6.39 | |
| | Maximum | | 4.49 | |
| | Range | | 10.88 | |
| | Interquartile Range | | .78 | |
| | Skewness | | -.638 | .052 |
| | Kurtosis | | 6.961 | .104 |
| VGain | Mean | | .8076 | .01741 |
| | 95% Confidence Interval for Mean | Lower Bound | .7734 | |
| | | Upper Bound | .8417 | |
| | 5% Trimmed Mean | | .7815 | |

| | | | | |
|---|---|---|---|---|
| | Median | | .7810 | |
| | Variance | | .677 | |
| | Std. Deviation | | .82270 | |
| | Minimum | | -2.25 | |
| | Maximum | | 5.37 | |
| | Range | | 7.62 | |
| | Interquartile Range | | .79 | |
| | Skewness | | .687 | .052 |
| | Kurtosis | | 3.006 | .104 |
| AGain | Mean | | .1138 | .02154 |
| | 95% Confidence Interval for Mean | Lower Bound | .0716 | |
| | | Upper Bound | .1560 | |
| | 5% Trimmed Mean | | .1170 | |
| | Median | | .1137 | |
| | Variance | | 1.036 | |
| | Std. Deviation | | 1.01800 | |
| | Minimum | | -5.81 | |
| | Maximum | | 7.69 | |
| | Range | | 13.50 | |
| | Interquartile Range | | .77 | |
| | Skewness | | .025 | .052 |
| | Kurtosis | | 5.938 | .104 |
| RGain | Mean | | .6179 | .03936 |
| | 95% Confidence Interval for Mean | Lower Bound | .5407 | |
| | | Upper Bound | .6951 | |
| | 5% Trimmed Mean | | .6206 | |
| | Median | | .6179 | |
| | Variance | | 3.461 | |
| | Std. Deviation | | 1.86038 | |
| | Minimum | | -9.00 | |
| | Maximum | | 10.00 | |
| | Range | | 19.00 | |

| | | | | |
|---|---|---|---|---|
| | Interquartile Range | | 2.30 | |
| | Skewness | | .014 | .052 |
| | Kurtosis | | 1.455 | .104 |
| NoSGain | Mean | | .9597 | .03890 |
| | 95% Confidence Interval for Mean | Lower Bound | .8834 | |
| | | Upper Bound | 1.0360 | |
| | 5% Trimmed Mean | | .9620 | |
| | Median | | 1.0000 | |
| | Variance | | 3.380 | |
| | Std. Deviation | | 1.83855 | |
| | Minimum | | -9.00 | |
| | Maximum | | 10.00 | |
| | Range | | 19.00 | |
| | Interquartile Range | | 2.00 | |
| | Skewness | | -.049 | .052 |
| | Kurtosis | | 2.755 | .104 |

**Tests of Normality**

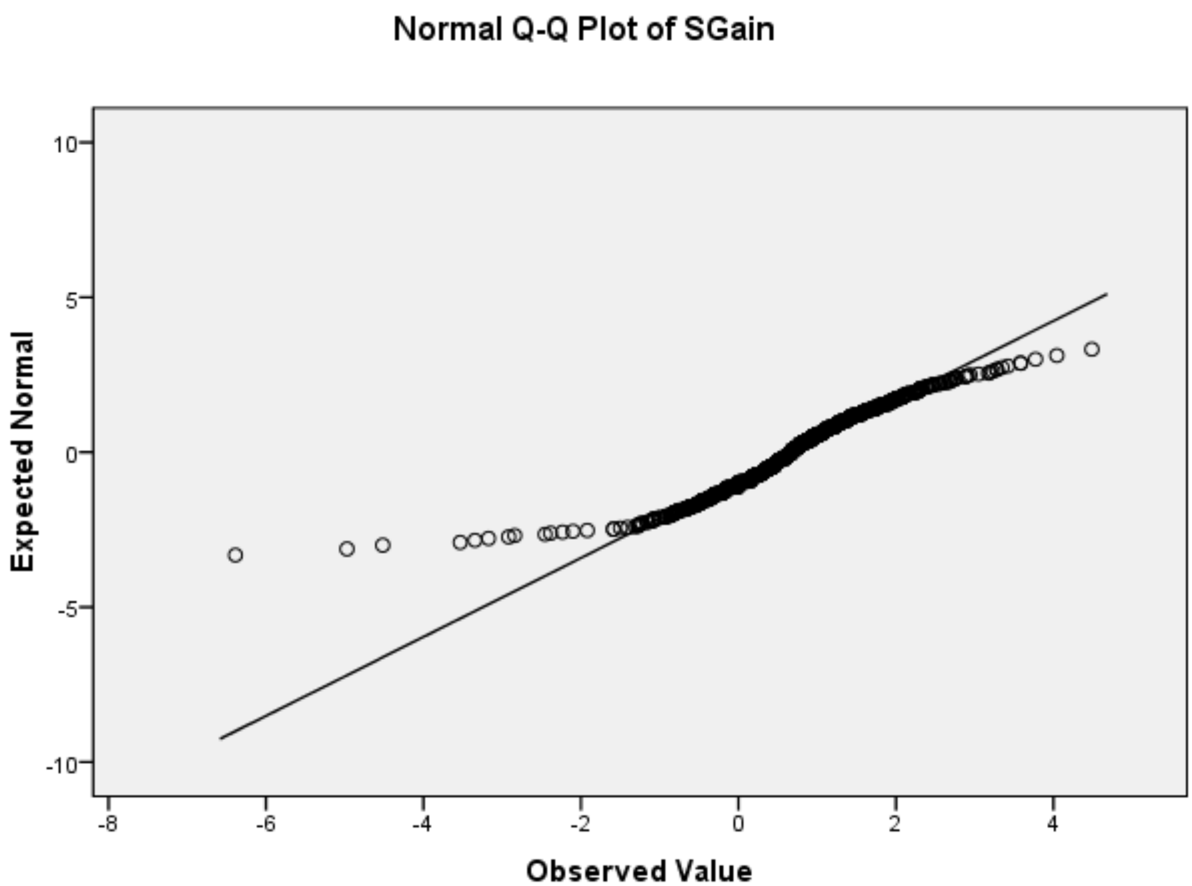
| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| SGain | .071 | 2234 | .000 | .941 | 2234 | .000 |
| VGain | .095 | 2234 | .000 | .950 | 2234 | .000 |
| AGain | .115 | 2234 | .000 | .905 | 2234 | .000 |
| RGain | .104 | 2234 | .000 | .974 | 2234 | .000 |
| NoSGain | .108 | 2234 | .000 | .953 | 2234 | .000 |

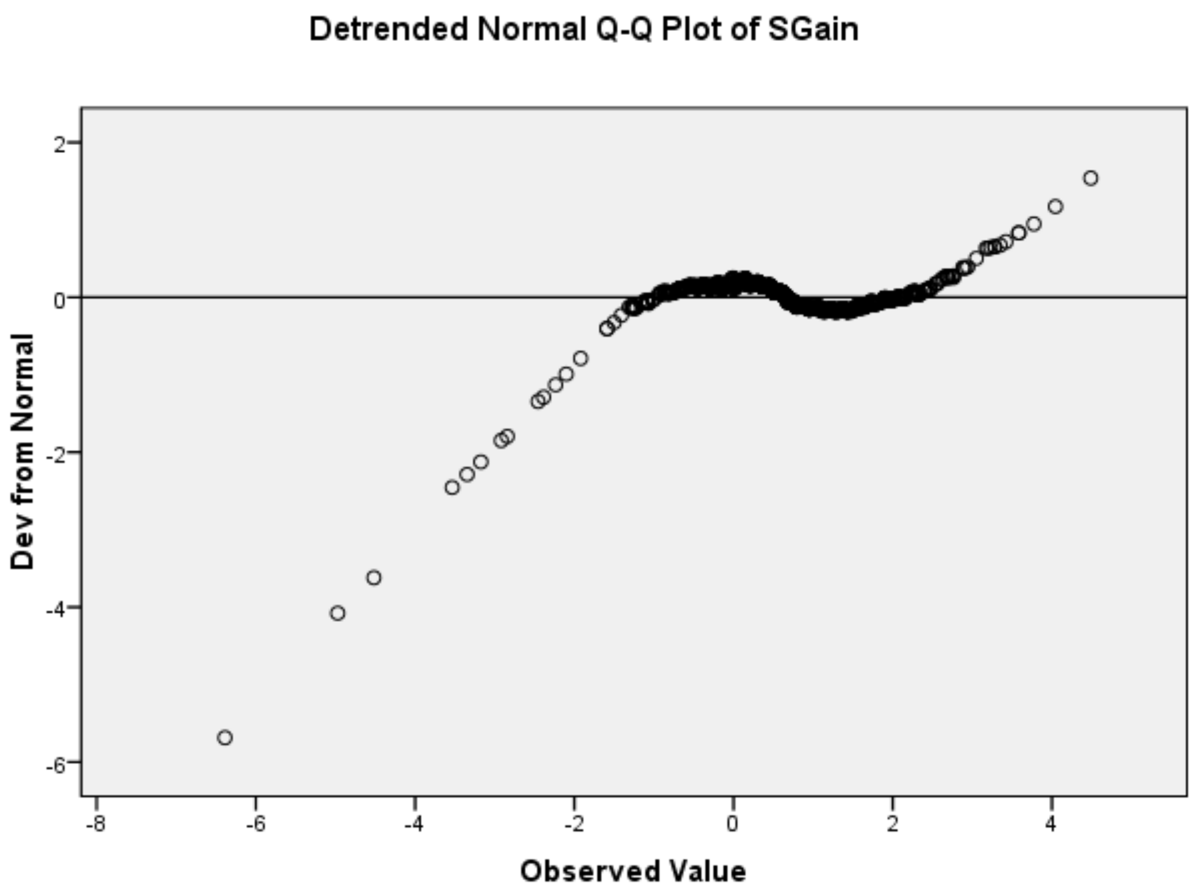
a. Lilliefors Significance Correction

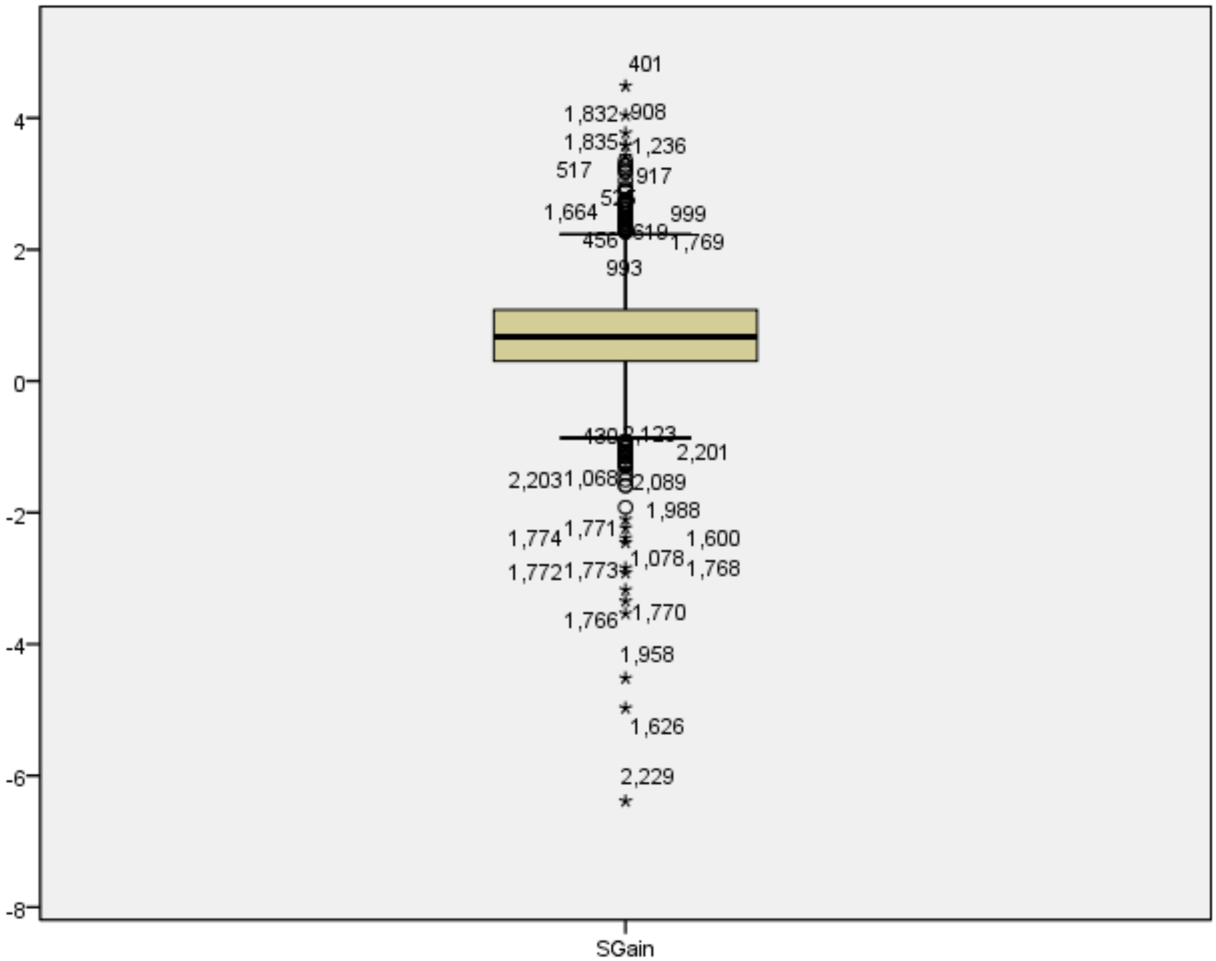
## SGain

SGain Stem-and-Leaf Plot

```
 Frequency    Stem &  Leaf

    44.00 Extremes    (=<-.9)
    14.00       -0 .  888
    31.00       -0 .  6666777
    54.00       -0 .  4444444455555
    74.00       -0 .  222223333333333333
    78.00       -0 .  0001111111111111111
   202.00        0 .  00000000000000000000000111111111111111111111111111
   193.00        0 .  222222222222223333333333333333333333333333333333
   279.00        0 .  4444444444444444444444444444444444444444555555555555555555555555555555
   398.00        0 .
666666666666666666666666666666666666666666666666666666667777777777777777777777777777777777777777777
   226.00        0 .  88888888888888888888888899999999999999999999999999999999
   188.00        1 .  00000000000000000000000000011111111111111111111
   145.00        1 .  222222222222222222222333333333333333
    95.00        1 .  444444444444444555555555
    66.00        1 .  66666667777777777
    54.00        1 .  88889999999999
    30.00        2 .  0000111
     6.00        2 .  2
    57.00 Extremes    (>=2.3)

 Stem width:      1.00
 Each leaf:       4 case(s)
```


Normal Q-Q Plot of SGain
Expected Normal
10
5
0
-5
-10
-8
-6
-4
-2
0
2
4
Observed Value

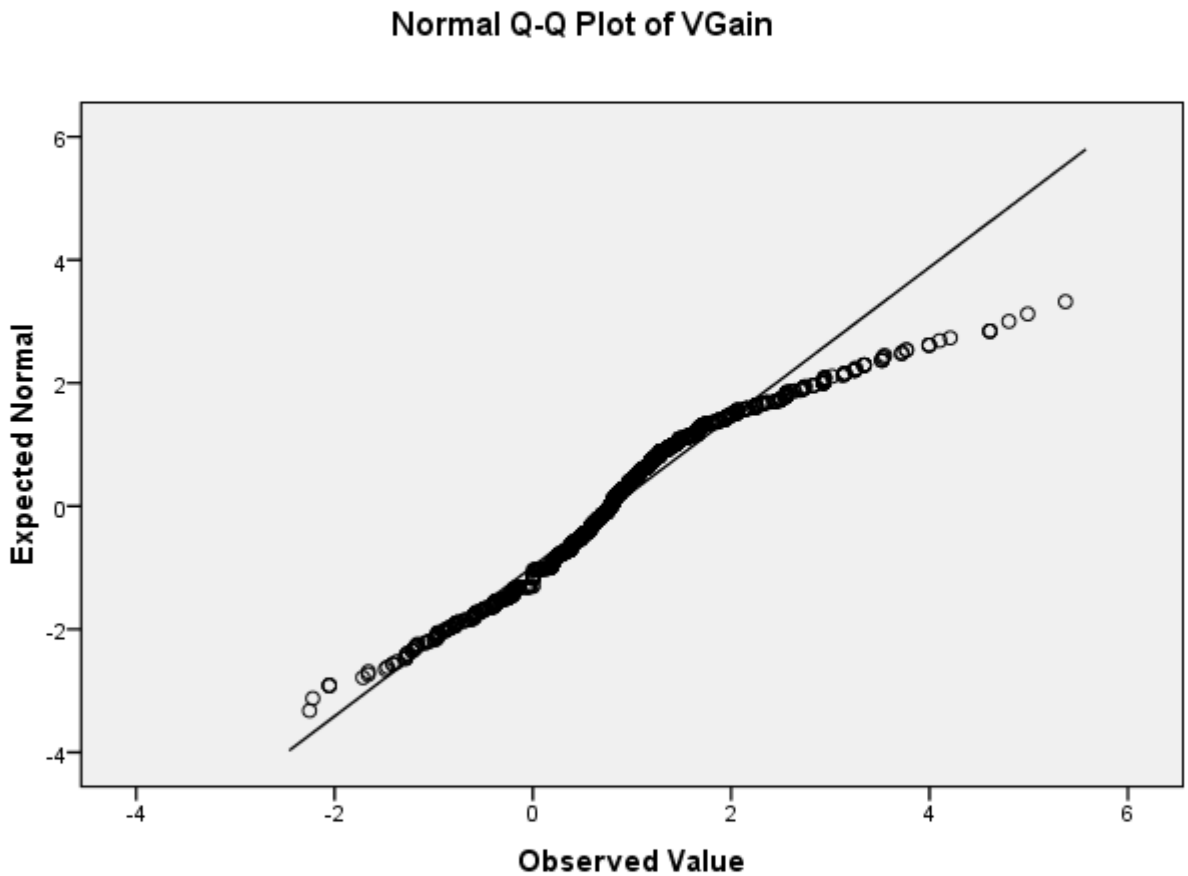

Detrended Normal Q-Q Plot of SGain
Dev from Normal
2
0
-2
-4
-6
-8
-6
-4
-2
0
2
4
Observed Value

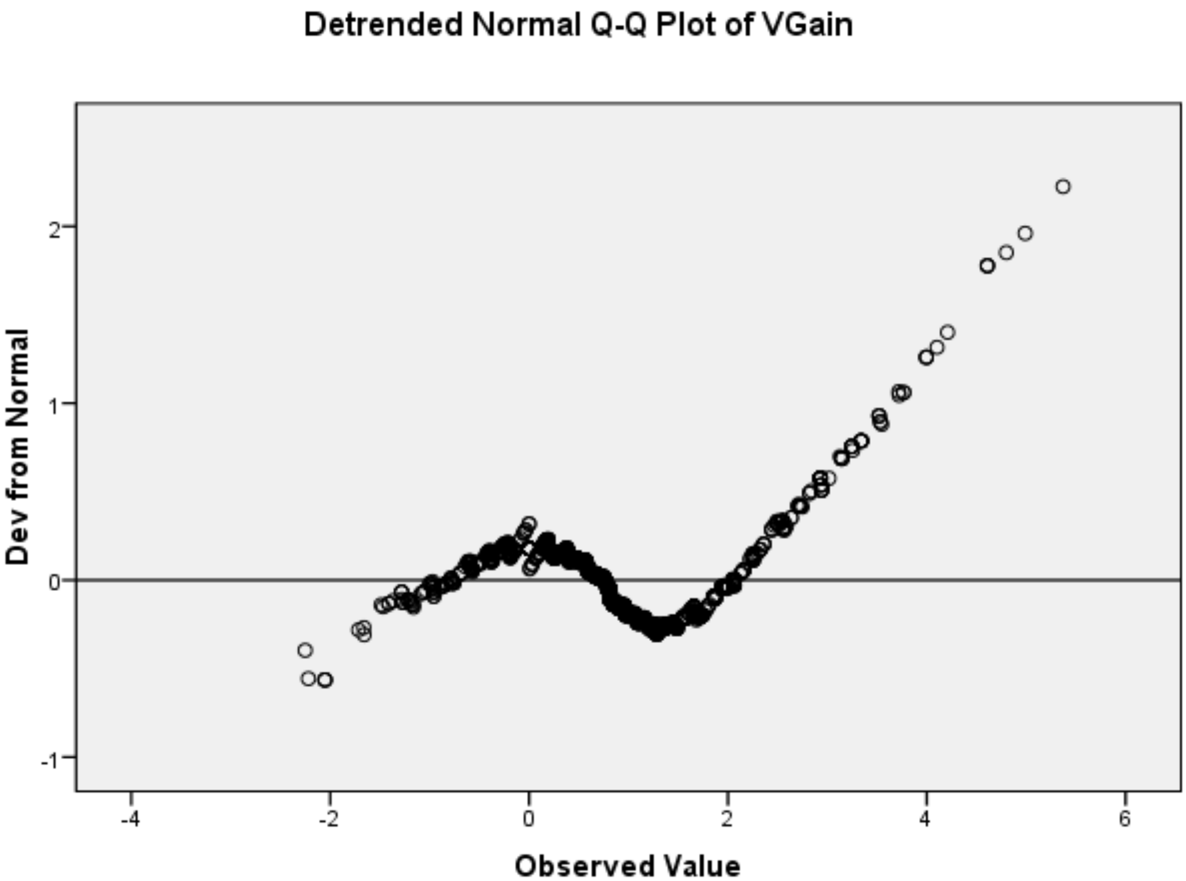

401
1,832
908
1,835
1,236
517
917
1,664
999
456
1,769
993
2,123
2,201
2,203
1,068
2,089
1,988
1,774
1,771
1,600
1,078
1,772
1,773
1,768
1,766
1,770
1,958
1,626
2,229
4
2
0
-2
-4
-6
-8
SGain

## VGain

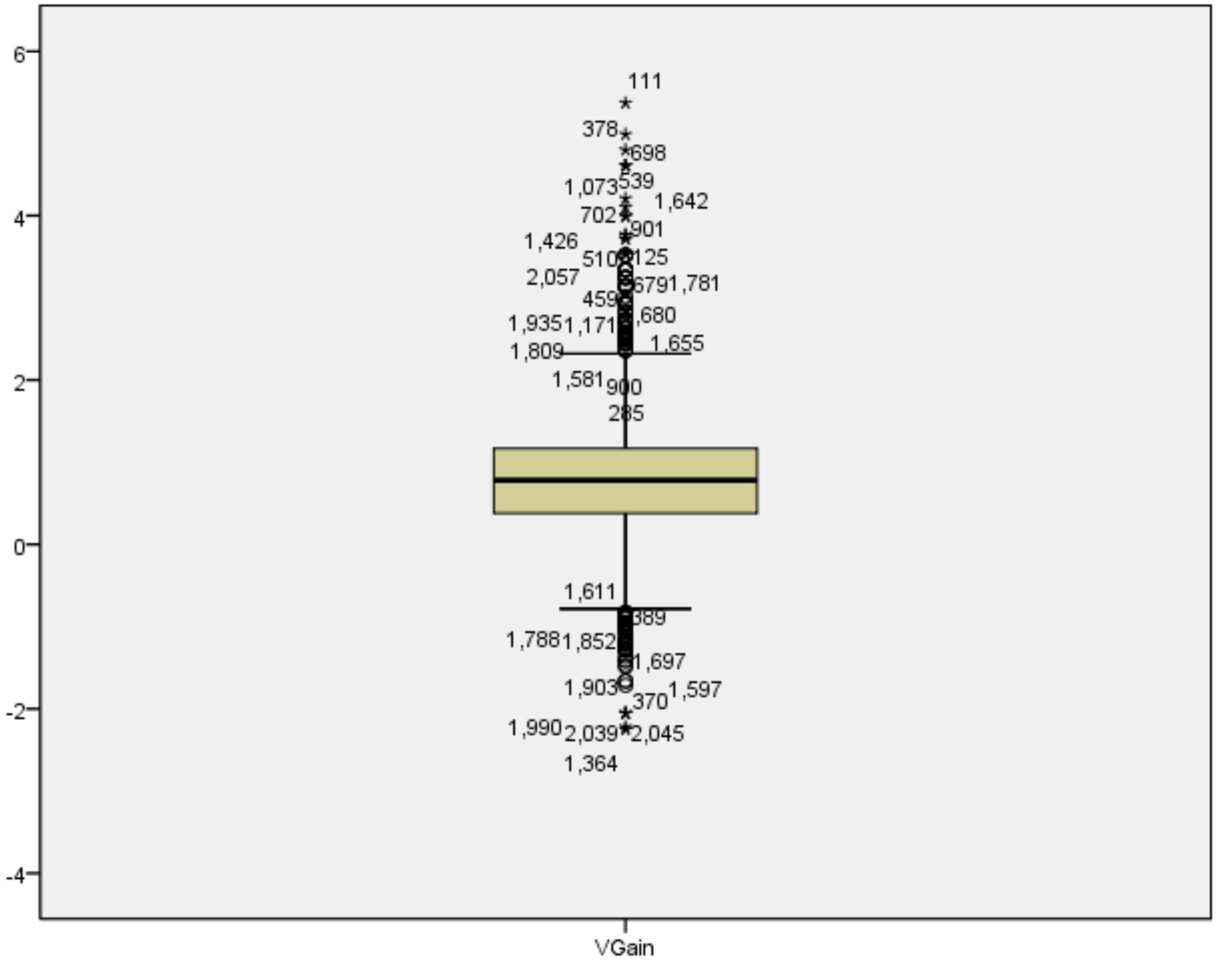
VGain Stem-and-Leaf Plot

```
 Frequency    Stem &  Leaf

    56.00 Extremes    (=<-.8)
    21.00       -0 .  66777
    37.00       -0 .  444555555
    58.00       -0 .  22222233333333
    45.00       -0 .  00111111111
   182.00        0 .  000000000000000000000000000000001111111111111
   215.00        0 .  222222222222222222222222333333333333333333333333333333
   238.00        0 .  44444444444444444444444455555555555555555555555555555555555
   295.00        0 .  66666666666666666666666666666666666777777777777777777777777777777777777777
   343.00        0 .  8888888888888888888888888888888888888888888888888888889999999999999999999999999999999999
   233.00        1 .  0000000000000000000000000000000011111111111111111111111111
   143.00        1 .  22222222222222222222222233333333333
    89.00        1 .  4444444444444444455555
    84.00        1 .  666666666666666777777
    43.00        1 .  88889999999
    29.00        2 .  0000011
    19.00        2 .  22223
   104.00 Extremes    (>=2.4)

 Stem width:      1.00
 Each leaf:       4 case(s)
```


Normal Q-Q Plot of VGain
Expected Normal
Observed Value
6
4
2
0
-2
-4
-4
-2
0
2
4
6



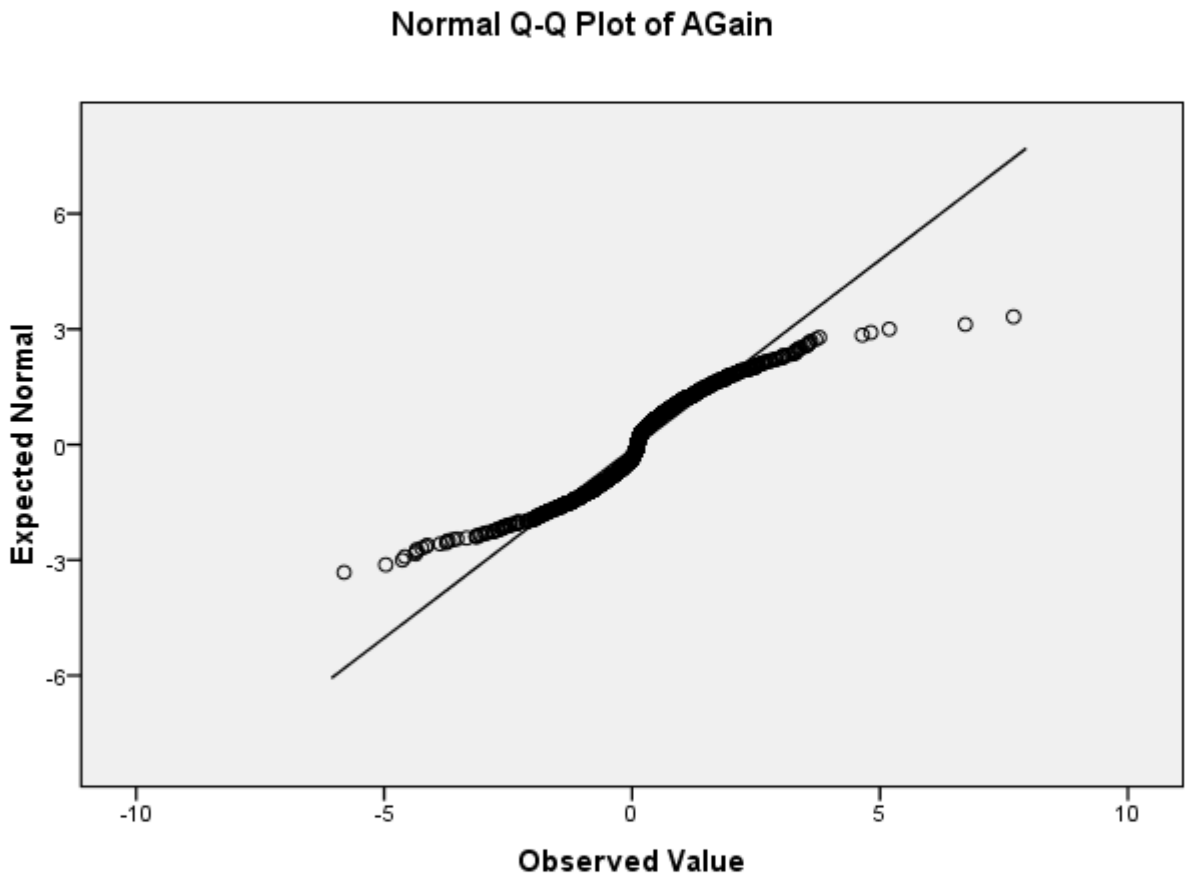
Detrended Normal Q-Q Plot of VGain
Dev from Normal
Observed Value
2
1
0
-1
-4
-2
0
2
4
6

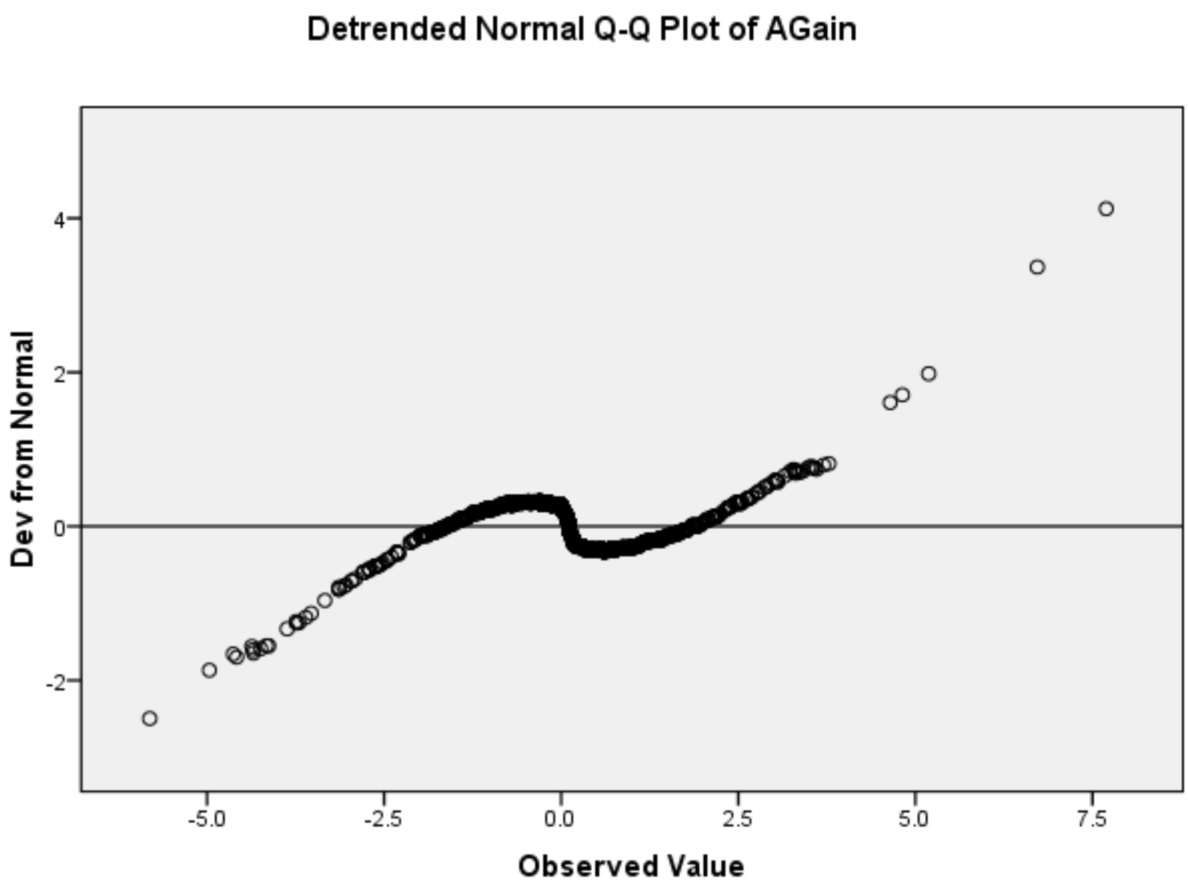

6
4
2
0
-2
-4
111
378
698
1,073
539
1,642
702
901
1,426
510
125
2,057
1,781
459
1,935
1,171
680
1,809
1,655
1,581
900
285
1,611
389
1,788
1,852
1,697
1,903
370
1,597
1,990
2,039
2,045
1,364
VGain

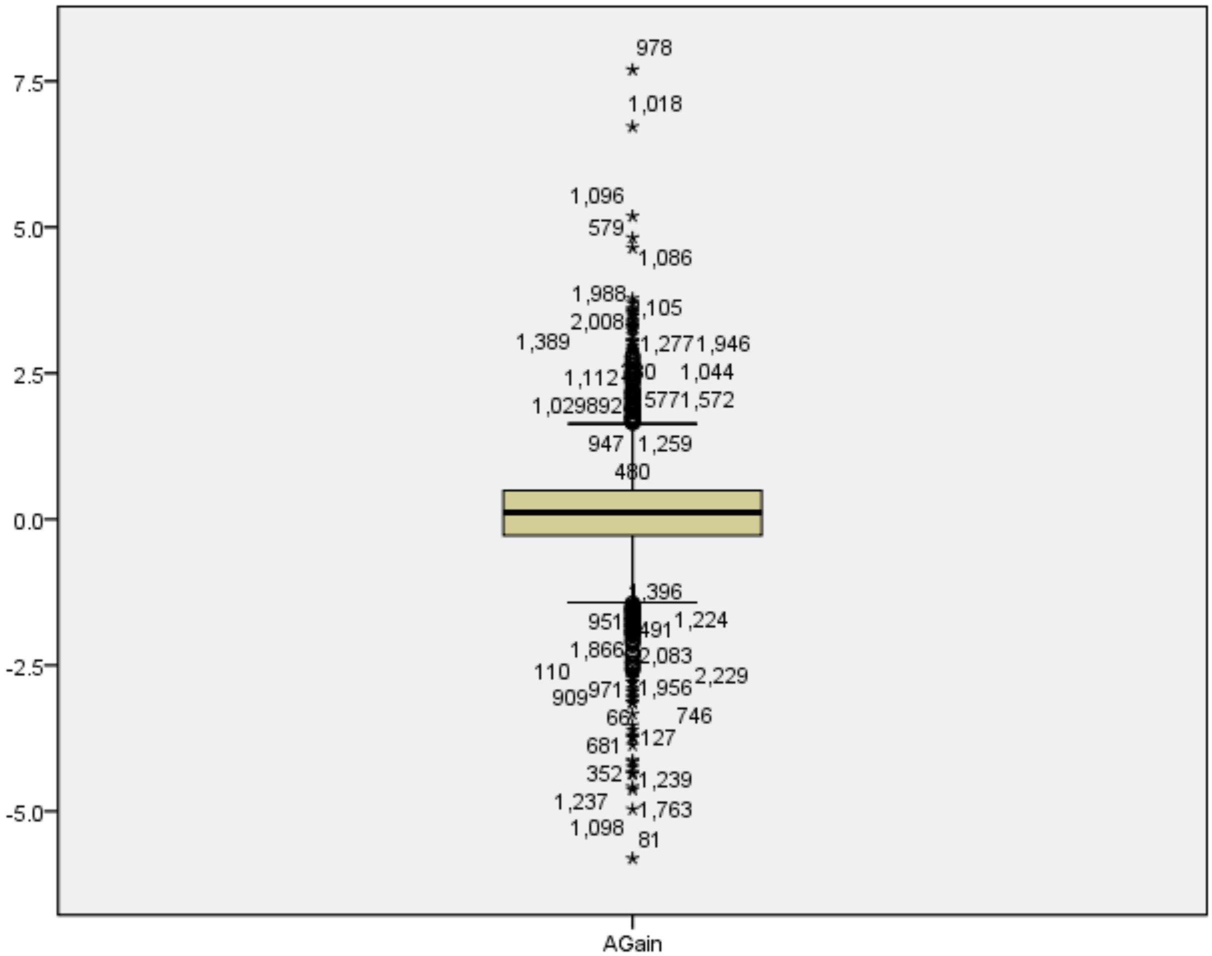
## AGain

AGain Stem-and-Leaf Plot

```
 Frequency    Stem &  Leaf

   118.00 Extremes    (=<-1.4)
    12.00       -1 .  44
    32.00       -1 .  22233
    46.00       -1 .  0000111
    60.00       -0 .  88889999
    76.00       -0 .  66666777777
   117.00       -0 .  44444444555555555
   137.00       -0 .  2222222222233333333
   194.00       -0 .  0000000000000011111111111111
   613.00        0 .  0000000000000000000000000000000000000011111111111111111111111111111111111111111111111111
   201.00        0 .  22222222222222233333333333333
   155.00        0 .  4444444444455555555555
    98.00        0 .  66666667777777
    92.00        0 .  8888888999999
    55.00        1 .  00000111
    58.00        1 .  22223333
    38.00        1 .  44455
     9.00        1 .  6
   123.00 Extremes    (>=1.7)

 Stem width:      1.00
 Each leaf:       7 case(s)
```


Normal Q-Q Plot of AGain
Expected Normal
6
3
0
-3
-6
-10
-5
0
5
10
Observed Value

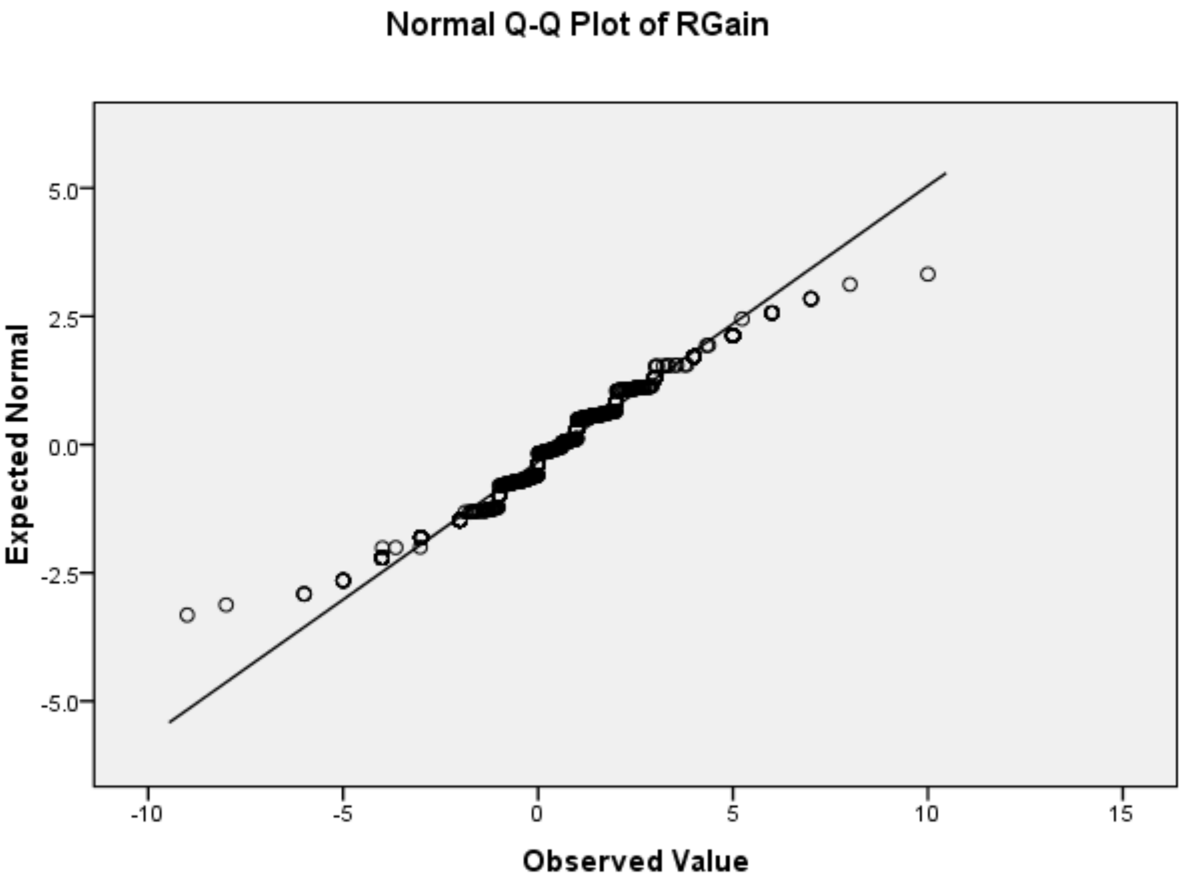

Detrended Normal Q-Q Plot of AGain
Dev from Normal
4
2
0
-2
-5.0
-2.5
0.0
2.5
5.0
7.5
Observed Value

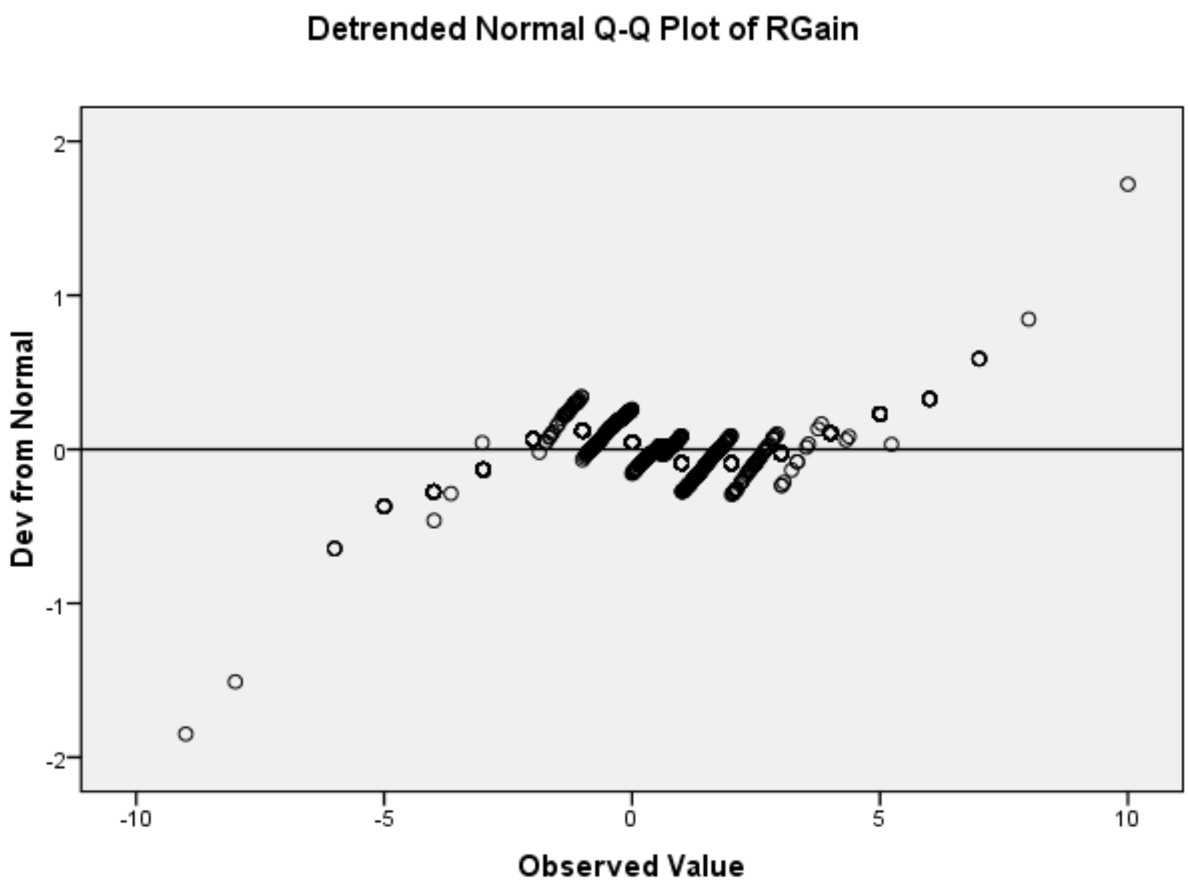

7.5
5.0
2.5
0.0
-2.5
-5.0
AGain
978
1,018
1,096
579
1,086
1,988
2,008
1,389
1,044
1,259
947
480
1,396
951
1,224
2,083
110
2,229
909
746
681
352
1,239
1,237
1,763
1,098
81

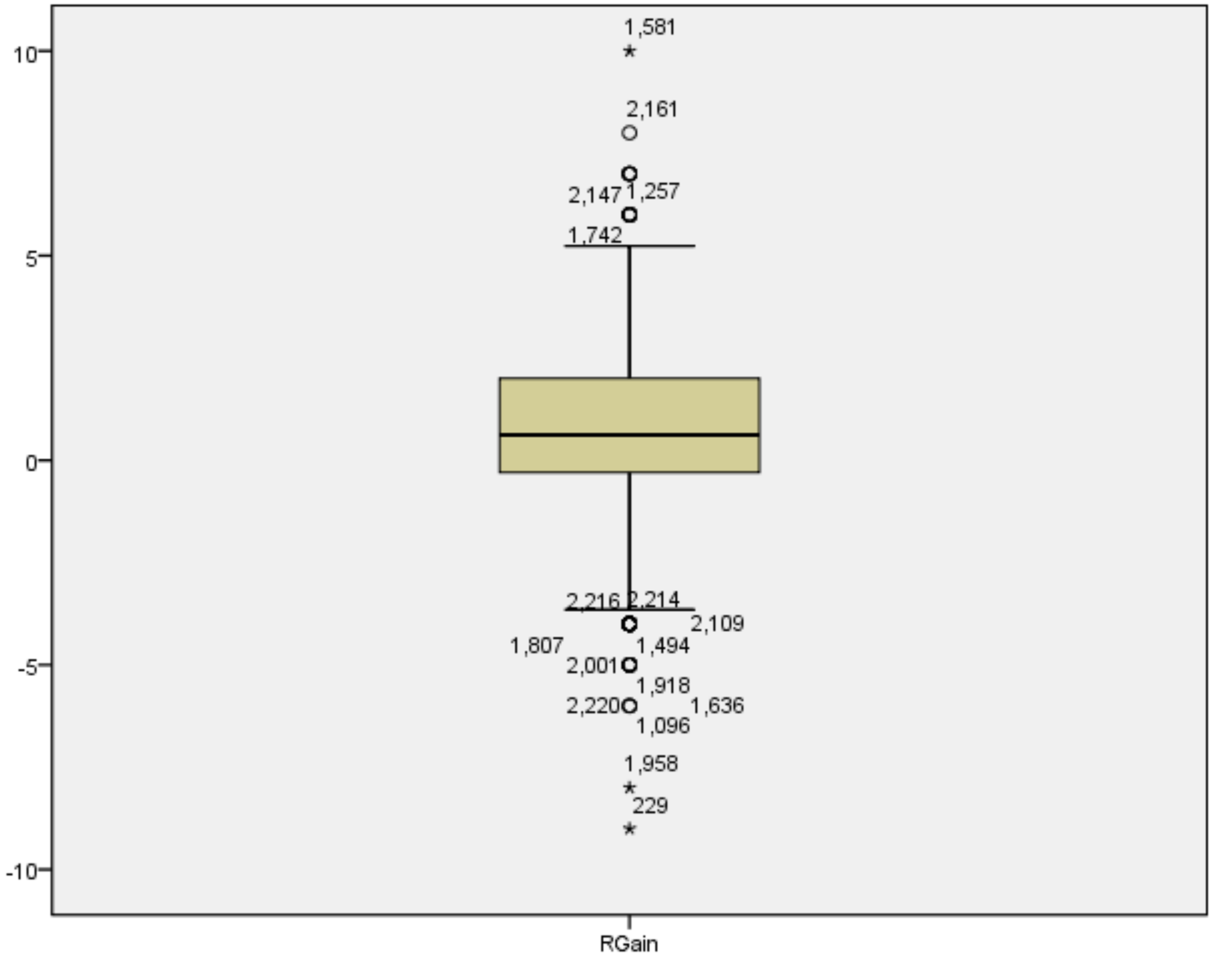
## RGain

RGain Stem-and-Leaf Plot

```
 Frequency    Stem &  Leaf

    49.00 Extremes    (=<-4.0)
     1.00       -3 .  &
    54.00       -3 .  00000000000
      .00       -2 .
   105.00       -2 .  000000000000000000000
     8.00       -1 .  6&
   255.00       -1 .  000000000000000000000000000000000000000000000011233&
    57.00       -0 .  55667778889
    89.00       -0 .  000011112222333444
   443.00        0 .  0000000000000000000000000000000000000000000000000000000000000000000000001112222333344444
   161.00        0 .  5555556666666666666667778888899
   376.00        1 .  000000000000000000000000000000000000000000000000000000000000000001112233344
    63.00        1 .  556667778899
   270.00        2 .  0000000000000000000000000000000000000000000000000012344
    19.00        2 .  568&
   147.00        3 .  00000000000000000000000000000&
     4.00        3 .  &
    75.00        4 .  000000000000000&
      .00        4 .
    43.00        5 .  00000000&
    15.00 Extremes    (>=6.0)

 Stem width:      1.00
 Each leaf:       5 case(s)


 & denotes fractional leaves.
```


Normal Q-Q Plot of RGain
5.0
2.5
0.0
-2.5
-5.0
Expected Normal
-10
-5
0
5
10
15
Observed Value

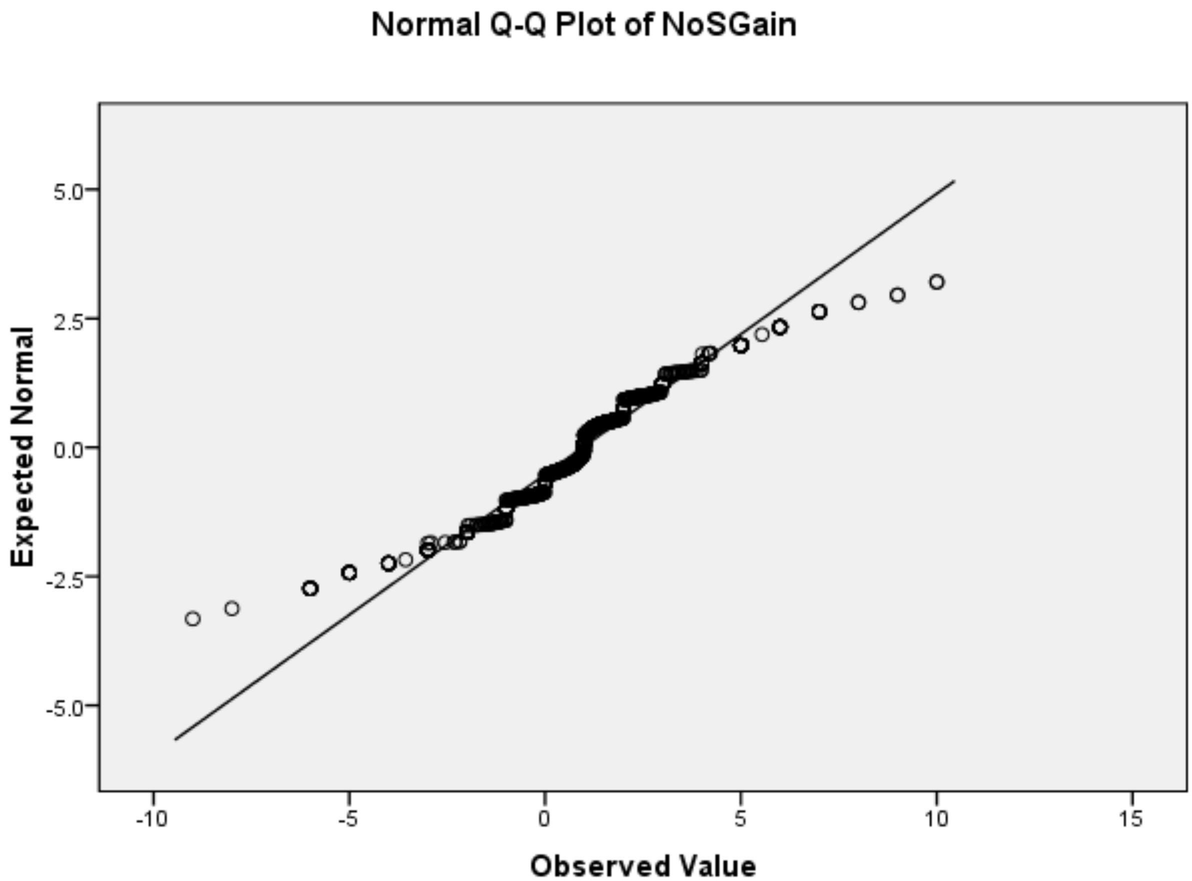

Detrended Normal Q-Q Plot of RGain
Dev from Normal
Observed Value
2
1
0
-1
-2
-10
-5
0
5
10

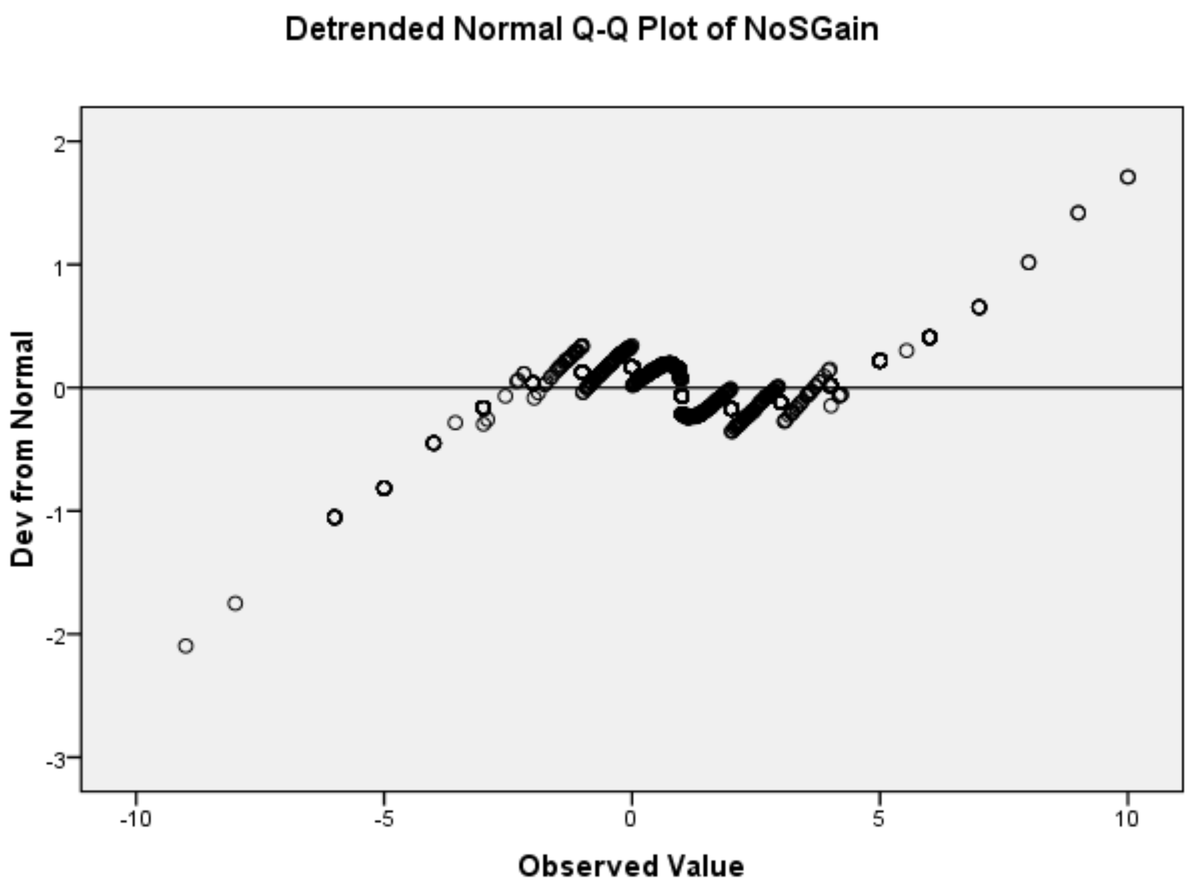

1,581
2,161
2,147
1,257
1,742
2,216
2,214
2,109
1,807
1,494
2,001
1,918
2,220
1,636
1,096
1,958
229
10
5
0
-5
-10
RGain

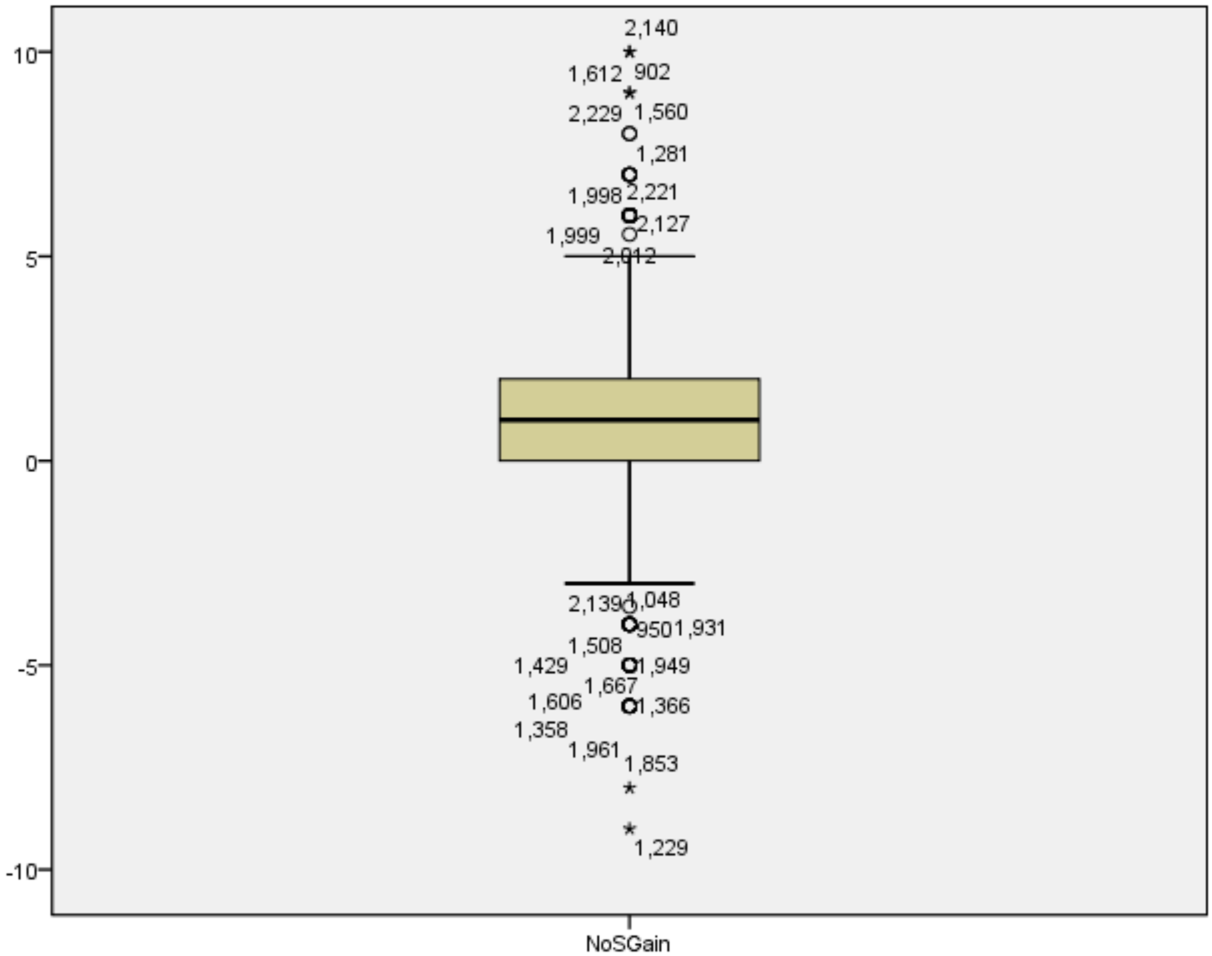
## NoSGain

NoSGain Stem-and-Leaf Plot

```
 Frequency    Stem &  Leaf

    33.00 Extremes    (=<-3.6)
    37.00       -3 .  0000000
     3.00       -2 .  &
    72.00       -2 .  00000000000000&
     8.00       -1 .  &&
   188.00       -1 .  0000000000000000000000000000000001234
    33.00       -0 .  55667889
    58.00       -0 .  000111222344
   331.00        0 .  000000000000000000000000000000000000000000000000111122222333344444
   308.00        0 .  5555566666667777777778888888888888899999999999999999999999999
   451.00        1 .  00000000000000000000000000000000000000000000000000000000000000000111111112222222233333344
    78.00        1 .  5555667777888999
   280.00        2 .  00000000000000000000000000000000000000000000000011123344
    39.00        2 .  56777889
   153.00        3 .  000000000000000000000000000023&
    13.00        3 .  567&
    75.00        4 .  00000000000000&
      .00        4 .
    42.00        5 .  00000000
    32.00 Extremes    (>=5.5)

 Stem width:      1.00
 Each leaf:       5 case(s)


 & denotes fractional leaves.
```


Normal Q-Q Plot of NoSGain
Expected Normal
5.0
2.5
0.0
-2.5
-5.0
-10
-5
0
5
10
15
Observed Value


Detrended Normal Q-Q Plot of NoSGain
Dev from Normal
2
1
0
-1
-2
-3
-10
-5
0
5
10
Observed Value


10
5
0
-5
-10
2,140
1,612
902
2,229
1,560
1,281
1,998
2,221
2,127
1,999
2,012
2,139
1,048
950
1,931
1,508
1,429
1,949
1,667
1,606
1,366
1,358
1,961
1,853
1,229
NoSGain

```
GLM MV_MLE_PRE MV_MLE_POST
  /WSFACTOR=time 2 Polynomial
  /MEASURE=vocabulary
  /METHOD=SSTYPE(3)
  /PLOT=PROFILE(time)
  /EMMEANS=TABLES(time) COMPARE ADJ(BONFERRONI)
  /PRINT=DESCRIPTIVE ETASQ
  /CRITERIA=ALPHA(.05)
  /WSDESIGN=time.
ONEWAY SGain VGain AGain RGain NoSGain BY Treatment_Final
  /STATISTICS DESCRIPTIVES HOMOGENEITY BROWNFORSYTHE
  /MISSING ANALYSIS.
```

## Oneway

**Notes**

| | | |
|---|---|---|
| Output Created | | 11-Jan-2011 11:58:58 |
| Comments | | |
| Input | Data | F:\SEEDSFull_imputed.sav |
| | Active Dataset | DataSet2 |
| | Filter | <none> |
| | Weight | <none> |
| | Split File | <none> |
| | N of Rows in Working Data File | 2234 |
| Missing Value Handling | Definition of Missing | User-defined missing values are treated as missing. |
| | Cases Used | Statistics for each analysis are based on cases with no missing data for any variable in the analysis. |
| Syntax | | ONEWAY SGain VGain AGain RGain NoSGain BY Treatment_Final /STATISTICS DESCRIPTIVES HOMOGENEITY BROWNFORSYTHE /MISSING ANALYSIS. |
| Resources | Processor Time | 00:00:00.219 |
| | Elapsed Time | 00:00:00.141 |

[DataSet2] F:\SEEDSFull_imputed.sav

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| SGain | Treatment | 1180 | .7359 | .77176 | .02247 | .6918 | .7800 | -6.39 | 4.04 |
| | Control | 1054 | .6078 | .79262 | .02441 | .5599 | .6557 | -4.52 | 4.49 |
| | Total | 2234 | .6755 | .78411 | .01659 | .6429 | .7080 | -6.39 | 4.49 |
| VGain | Treatment | 1180 | .9573 | .88378 | .02573 | .9069 | 1.0078 | -2.05 | 5.37 |
| | Control | 1054 | .6399 | .71239 | .02194 | .5969 | .6830 | -2.25 | 3.99 |
| | Total | 2234 | .8076 | .82270 | .01741 | .7734 | .8417 | -2.25 | 5.37 |
| AGain | Treatment | 1180 | .1409 | .99281 | .02890 | .0842 | .1976 | -5.81 | 6.72 |
| | Control | 1054 | .0835 | 1.04512 | .03219 | .0203 | .1467 | -4.97 | 7.69 |
| | Total | 2234 | .1138 | 1.01800 | .02154 | .0716 | .1560 | -5.81 | 7.69 |
| RGain | Treatment | 1180 | .6689 | 1.87481 | .05458 | .5618 | .7760 | -6.00 | 10.00 |
| | Control | 1054 | .5608 | 1.84330 | .05678 | .4494 | .6722 | -9.00 | 7.00 |
| | Total | 2234 | .6179 | 1.86038 | .03936 | .5407 | .6951 | -9.00 | 10.00 |
| NoSGain | Treatment | 1180 | 1.1285 | 1.81491 | .05283 | 1.0249 | 1.2322 | -8.00 | 10.00 |
| | Control | 1054 | .7706 | 1.84729 | .05690 | .6590 | .8823 | -9.00 | 9.00 |
| | Total | 2234 | .9597 | 1.83855 | .03890 | .8834 | 1.0360 | -9.00 | 10.00 |

**Test of Homogeneity of Variances**

| | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|
| SGain | .496 | 1 | 2232 | .481 |
| VGain | 13.821 | 1 | 2232 | .000 |
| AGain | .184 | 1 | 2232 | .668 |
| RGain | .003 | 1 | 2232 | .957 |
| NoSGain | .690 | 1 | 2232 | .406 |

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| SGain | Between Groups | 9.129 | 1 | 9.129 | 14.941 | .000 |
| | Within Groups | 1363.769 | 2232 | .611 | | |
| | Total | 1372.898 | 2233 | | | |
| VGain | Between Groups | 56.090 | 1 | 56.090 | 86.027 | .000 |
| | Within Groups | 1455.281 | 2232 | .652 | | |
| | Total | 1511.371 | 2233 | | | |
| AGain | Between Groups | 1.832 | 1 | 1.832 | 1.769 | .184 |
| | Within Groups | 2312.289 | 2232 | 1.036 | | |
| | Total | 2314.121 | 2233 | | | |
| RGain | Between Groups | 6.509 | 1 | 6.509 | 1.881 | .170 |
| | Within Groups | 7721.936 | 2232 | 3.460 | | |
| | Total | 7728.445 | 2233 | | | |
| NoSGain | Between Groups | 71.306 | 1 | 71.306 | 21.286 | .000 |
| | Within Groups | 7476.830 | 2232 | 3.350 | | |
| | Total | 7548.136 | 2233 | | | |

**Robust Tests of Equality of Means**

| | | Statistic[a] | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| SGain | Brown-Forsythe | 14.897 | 1 | 2189.320 | .000 |
| VGain | Brown-Forsythe | 88.113 | 1 | 2209.238 | .000 |
| AGain | Brown-Forsythe | 1.758 | 1 | 2173.466 | .185 |
| RGain | Brown-Forsythe | 1.885 | 1 | 2211.577 | .170 |
| NoSGain | Brown-Forsythe | 21.244 | 1 | 2194.530 | .000 |

a. Asymptotically F distributed.