



K-12 Research Idaho

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## Biology and Chemistry Achievement In Idaho High Schools, 2015 to 2017

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The State Department of Education (SDE) prepared end-of-course biology and chemistry tests for statewide use in Idaho high schools. The SDE collects and stores student-level scale scores from these science end-of-course tests. The first administration of both tests was in 2015.

### METHODOLOGY

Learning Point Associates (2009) suggested three measures of student achievement to analyze accountability and program evaluation data. These measures were once in widespread use but today are often ignored. They provide more useful information about student performance than the percentage of students in an achievement level. The three measures are the average (mean), percentiles, and the effect size.

#### **Average/Mean**

The difference between two averages (means) can be described in terms of *statistical significance* or *practical significance* or both.

The *Student t-test* is a commonly used to indicate *statistical significance*. A free online, unpaired *student t-test* calculates the level of statistical significance the difference between two averages scores (means). The online calculator computes the *Student t* using the number of students, the average score, and the standard deviation from both test administrations. (GraphPadSoftware, 2017).

*Effect size* is a commonly used indicator of *practical significance* that describes the *magnitude* of the difference between two averages scores (means). A simple effect size is calculated from the means and standard deviations. The effect size

from one test should not be compared with the effect from a different test. The meaning of effect size emerges in a trend view of magnitude values of a single test over time. No statistical analysis of effect sizes were performed for this paper. From one year to the next, the anticipated result is a magnitude of zero or higher is the anticipated result (i.e., not a negative magnitude).

## Percentile

Percentiles. The average (mean) can hide a lot of change that may occur in the student distribution. Percentiles, on the other hand, enable us to identify changes at five points across the distribution: High student (90th percentile), High Average student (75th percentile), Average student (50th percentile), Low Average student (25th percentile), and Low student (10th percentile). From assessment to assessment, the High student can be compared with the High student, the Average student with the Average student, etc.

Percentiles are calculated from the mean and standard deviation. They may be displayed as either as a boxplot (when an overall impression is desired) or a line graph (when detail is desired). No statistical analyses of percentiles were performed for this paper. The expectation, however, for a percentile change from one year to the next is either zero or higher, never a negative.

## TEST DATA FROM 2015 to 2017

The State Department of Education provided the number of students taking the biology and chemistry tests from 2015 to 2017, their average scores (means), and their standard deviations that are displayed in Figure 1. Raw data from the biology test should not be compared to raw data from the chemistry test because each test was developed with a unique scale.

	Biology			Chemistry		
School Year Ending	2,015	2,016	2017	2015	2016	2017
Number of Students	18,855	20,159	20,927	1,783	2,738	3,757
Average Scale Score	207	206	205	215	210	209
Standard Deviation	19.191	16.241	19.013	19.100	14.634	21.193

Figure 1. Number of students, averages, and standard deviations from the Idaho science end-of-course tests of biology and chemistry from 2015 to 2017

## RESULTS: BIOLOGY

### Biology Average/Mean (Statistical Significance)

- The biology achievement scores of Idaho high school students had a statistically significant drop from 2015 to 2016, and again from 2016 to 2017.
- Biology students scored significantly lower in 2016 than their counterparts scored in 2015. The unpaired two-tailed *t-test* for biology:  $t=3.137$ ,  $df=40,042$ , and  $p=0.0017$ ; which is a highly statistically significant result.
- Biology students scored significantly lower in 2017 than their counterparts scored in 2016. The unpaired two-tailed *t-test* for biology:  $t=5.7226$ ,  $df=41,084$ , and  $p=0.0001$ ; which is an extremely statistically significant result.

### Biology Average/Mean (Practical Significance) = Effect Size

Figure 2 displays the effect size (growth or magnitude of change) for the Idaho biology end-of-course test from 2015 to 2017: a steady decline in scores.

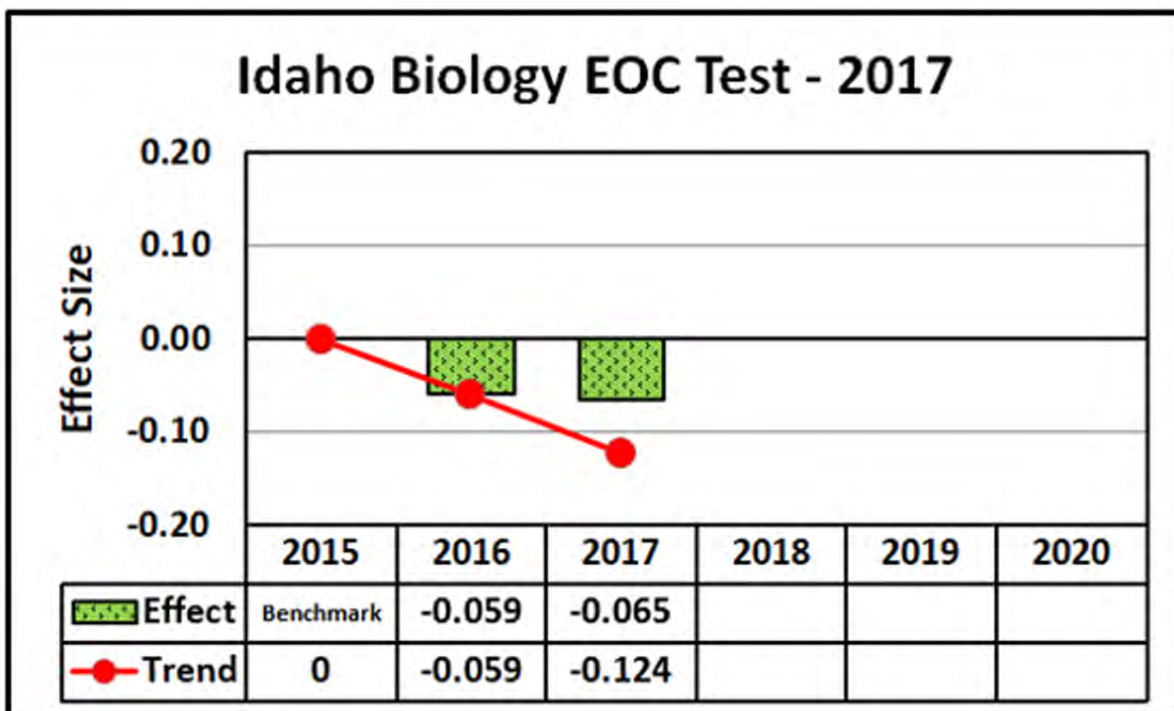


Figure 1. Effect sizes (growth) on Idaho biology end-of-course test from 2015 to 2017

## Biology Percentiles

Percentile findings for the high school biology end-of-course test:

- The **High student** (90th percentile) dropped eleven (-11) points in 2016, but gained two (+2) points in 2017
- The **High Average student** (75th percentile) dropped eight (-8) points in 2016, but gained one (+1) point in 2017
- The **Average student** (50th percentile) scored five (-5) points lower in 2016, and dropped one (-1) point in 2017
- The **Low Average student** (25th percentile) scored two (-3) points lower in 2016, and dropped four (-4) points in 2017
- The **Low student** (10th percentile) score remained constant from 2015 to 2016, but dropped five (-5) points in 2017

## Biology Percentile Boxplot and Line Graphs

Figure 4 is a boxplot displaying percentile results from the Idaho biology end-of-course test for 2015 to 2017.

Figure 5 is a line graph displaying percentile results from the Idaho biology end-of-course test for 2015 to 2017.

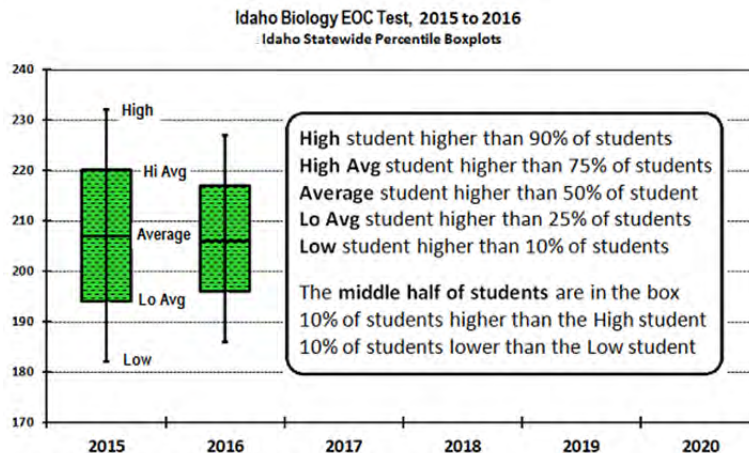


Figure 3. Reading the biology percentile boxplot

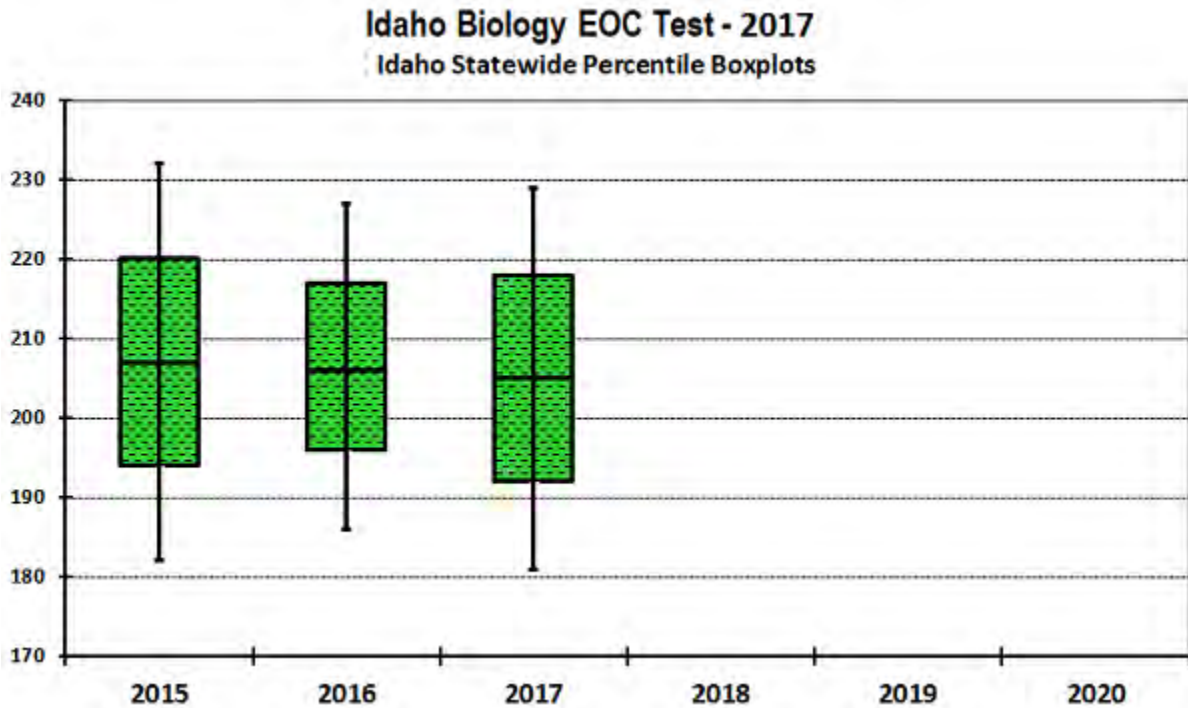


Figure 4. Boxplot of percentile results from the Idaho biology end-of-course test for 2015 to 2017

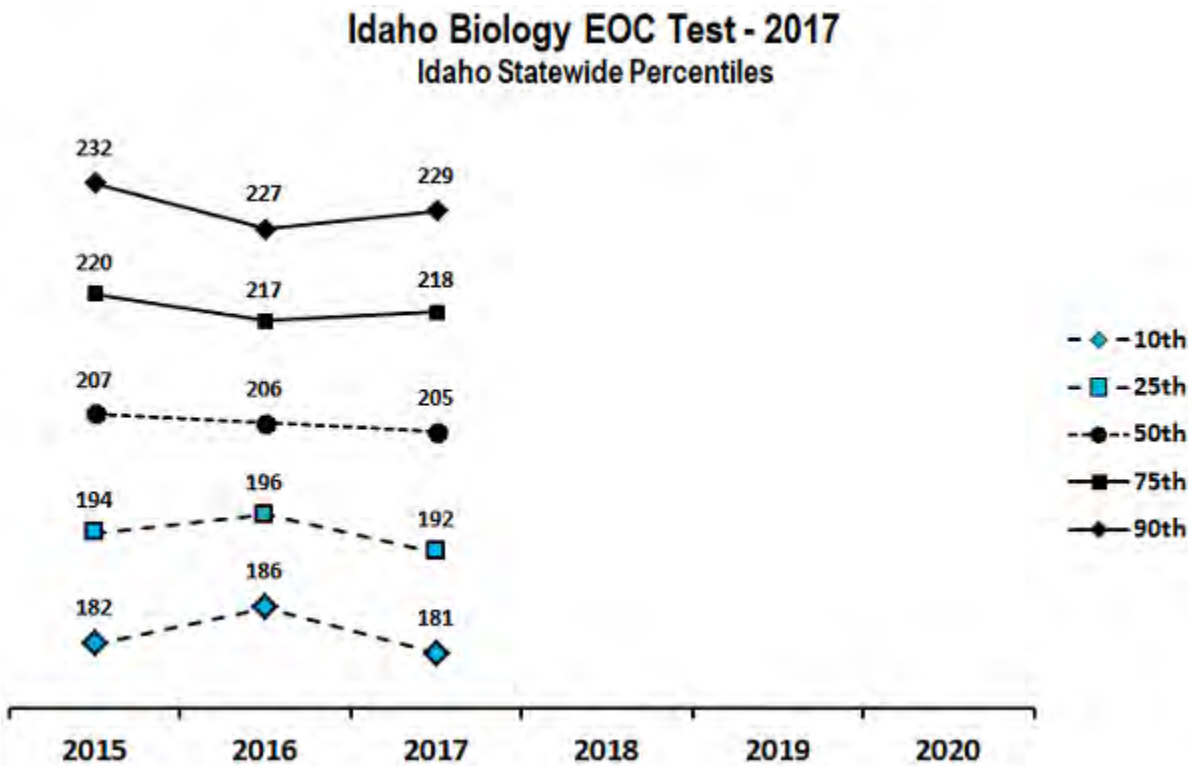


Figure 5. Line graph of percentile results from the Idaho biology end-of-course test for 2015 to 2017

## RESULTS: CHEMISTRY

### Chemistry Average/Mean (Statistical Significance)

- The chemistry achievement scores of Idaho high school students had a statistically significant drop from 2015 to 2016, and again from 2016 to 2017.
- Chemistry students scored significantly lower in 2016 than their counterparts scored in 2015. For chemistry, the unpaired two-tailed *t*-test:  $t=10.8613$ ,  $df=4,517$ , and  $p=0.0001$ ; which is a highly statistically significant result.
- Chemistry students scored significantly lower in 2017 than their counterparts scored in 2016. For chemistry, the unpaired two-tailed *t*-test:  $t=2.127$ ,  $df=6,493$ , and  $p=0.0335$ ; which is a statistically significant result.

### Chemistry Average/Mean (Practical Significance) = Effect Size

Figure 6 displays the effect size (growth or magnitude of change) for the Idaho chemistry end-of-course test from 2015 to 2017: a slowing decline in scores.

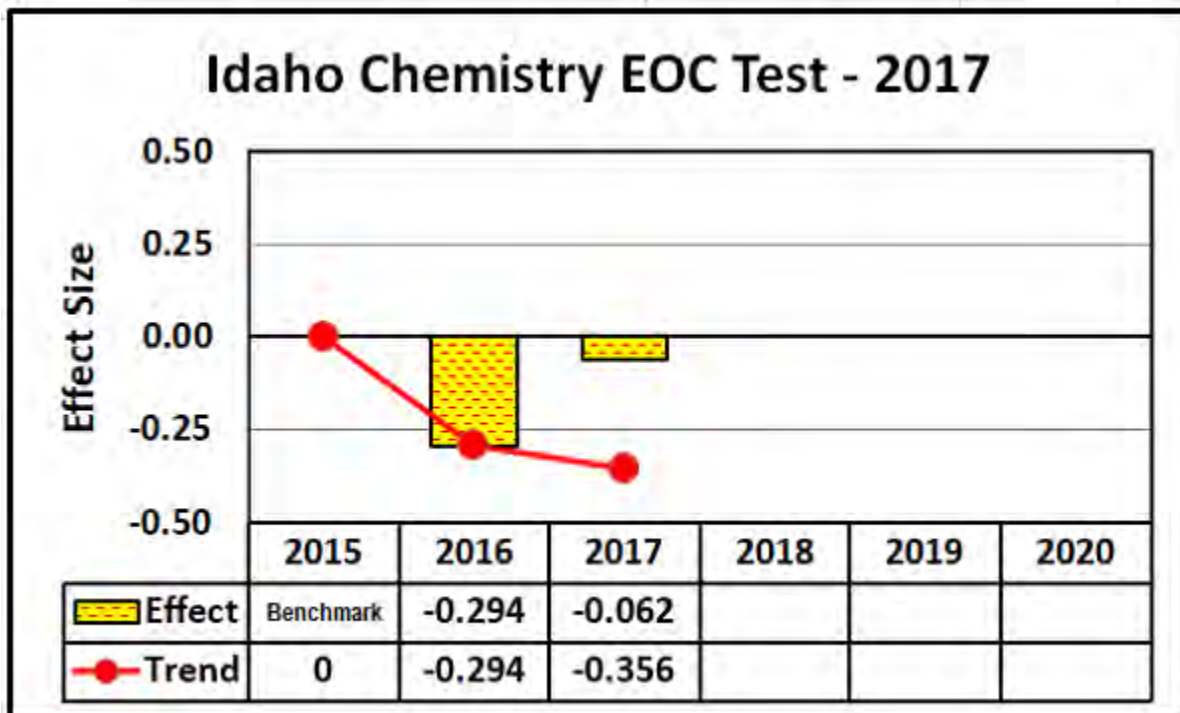


Figure 6. Effect size (growth) on Idaho chemistry end-of-course test from 2015 to 2017

## Chemistry Percentiles

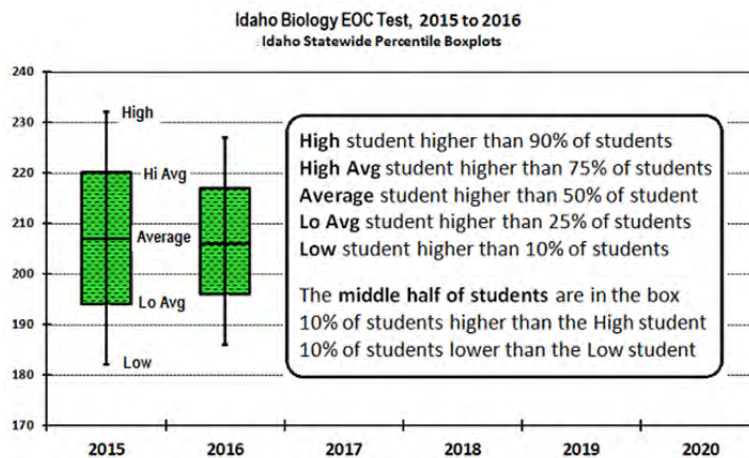
Percentile findings from the Idaho high school chemistry end-of-course test:

- The **High student** (90th percentile) dropped eleven (-11) points in 2016, but gained seven (+7) points in 2017.
- The **High Average student** (75th percentile) dropped eight (-8) points in 2016, but gained three (+3) points in 2017.
- The **Average student** (50th percentile) scored five (-5) points lower, and dropped one (-1) point in 2017
- The **Low Average student** (25th percentile) scored two (-3) points lower in 2016, and dropped five (-5) points in 2017
- The **Low student** (10th percentile) score remained constant from 2015 to 2016, but dropped nine (-9) points in 2017

## Chemistry Percentile Boxplots and Line Graphs

Figure 8 is a boxplot displaying percentile results from the Idaho chemistry end-of-course test for 2015 and 2016.

Figure 9 is a line graph displaying percentile results from the Idaho chemistry end-of-course test for 2015 and 2016.



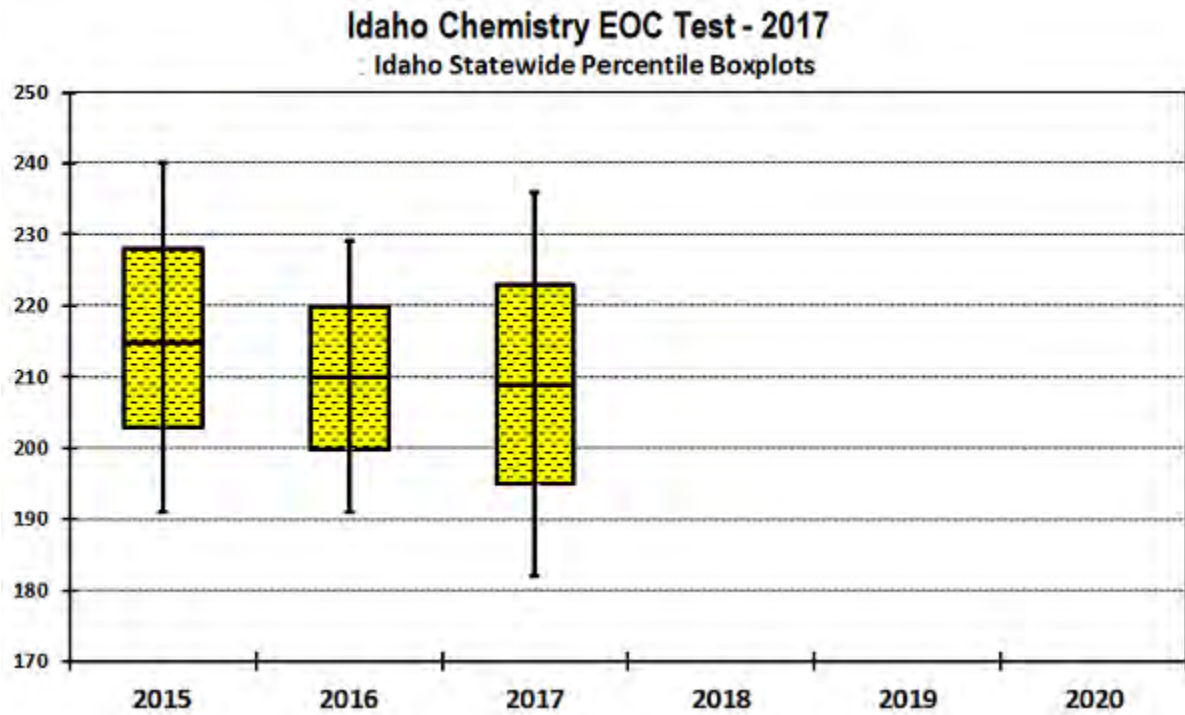


Figure 8. Boxplot of percentile results from the Idaho chemistry end-of-course test from 2015 to 2017

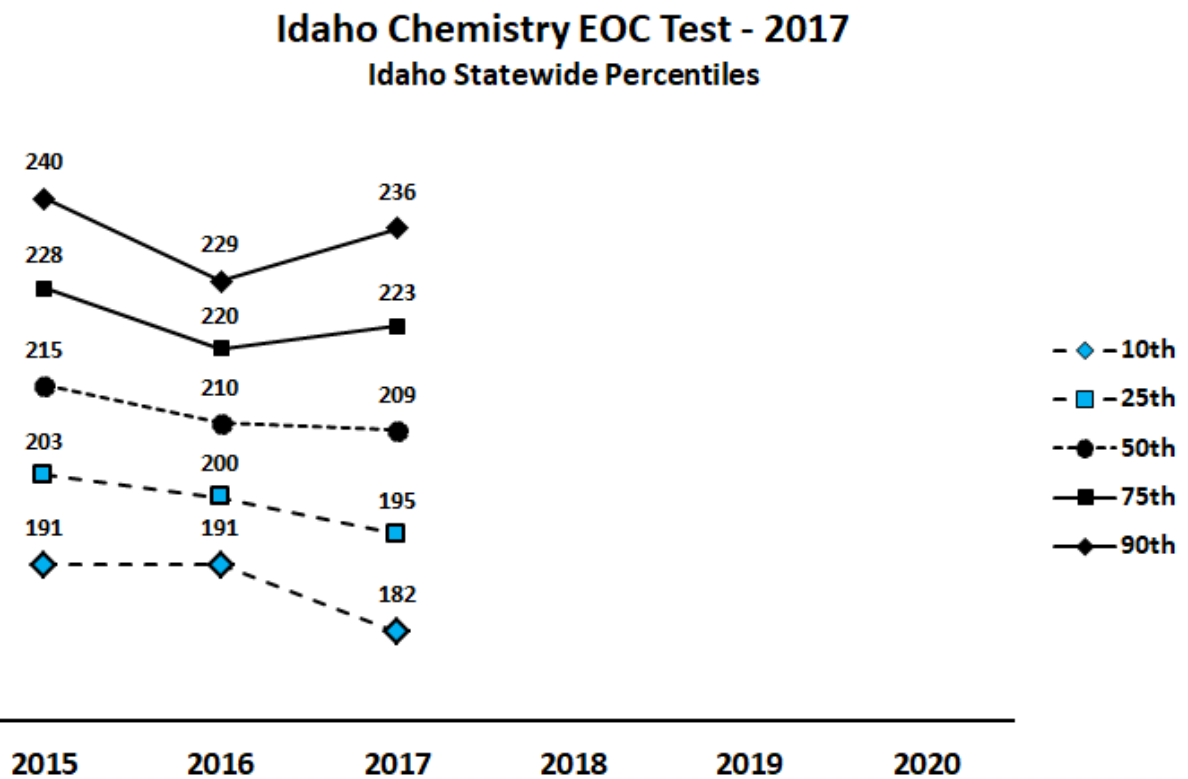


Figure 9. Line graph of percentile results from the Idaho chemistry end-of-course test from 2015 to 2017.



## REFERENCES

GraphPadSoftware. (2017). *t test calculator*. Retrieved February 5, 2017, from <http://www.graphpad.com/quickcalcs/ttest1.cfm?Format=SD>

Learning Point Associates. (2009, August). *Connecting Research to Practice: Knowing Who Is Proficient Isn't Always Sufficient*. Retrieved February 5, 2017, from <http://files.eric.ed.gov/fulltext/ED509965.pdf>

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