K-12 Research Idaho

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Biology and Chemistry Achievement in Idaho High Schools, 2015 and 2016

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The State Department of Education (SDE) has 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 the science end-of-course tests. The first student data collected from these tests was in the 2014-15 school year.

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 measures are the average (mean), percentiles, and the effect size. The number of students taking the test, the average (mean), and the standard deviation are used to calculate these time-tested measures of student achievement. Figure 1 displays the biology and chemistry scores from 2015 and 2016 that the SDE provided.

Biology	2015	2016
Number of Students	18,855	20,159
Average/Mean	206.969	206.413
Standard Deviaion	19.191	16.241

Chemistry	2015	2016
Number of Students	1,783	2,738
Average/Mean	215.331	209.846
Standard Deviaion	19.100	14.634

Figure 1. Numbers of students, average, and standard deviations from the Idaho science end-of-course tests of biology and chemistry for 2015 and 2016.

AVERAGE

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* was used to calculate the level of statistical

significance between the 2015 and 2016 averages (means) for both end-of-course tests, biology and chemistry (GraphPadSoftware, 2017).

Effect size is a commonly used indicator of *practical significance* that describes the *magnitude* of the difference between the 2015 and 2016 averages (means) for the end-of-course tests, biology and chemistry. 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. No statistical analysis of effect sizes were performed for this paper. The meaning of effect size emerges in a trend view of magnitude values of a single test over time. From one year to the next, any magnitude zero or higher is the anticipated result.

PERCENTILES

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 for percentile comparisons from one year to the next is zero or higher.

RESULTS

Average: statistical significance.

- **Biology** students scored significantly lower in 2016 than their counterparts scored in 2015. For biology, the unpaired two-tailed *t-test*: t=3.137, df=40,042, and p=0.0017; which is a highly statistically significant result.
- 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.

Average: practical significance.

Figure 2 displays the effect size (growth or magnitude of change) for the Idaho biology end-of-course test from 2015 to 2016.

Figure 3 displays the effect size (growth or magnitude of change) for the Idaho chemistry end-of-course test from 2015 to 2016.

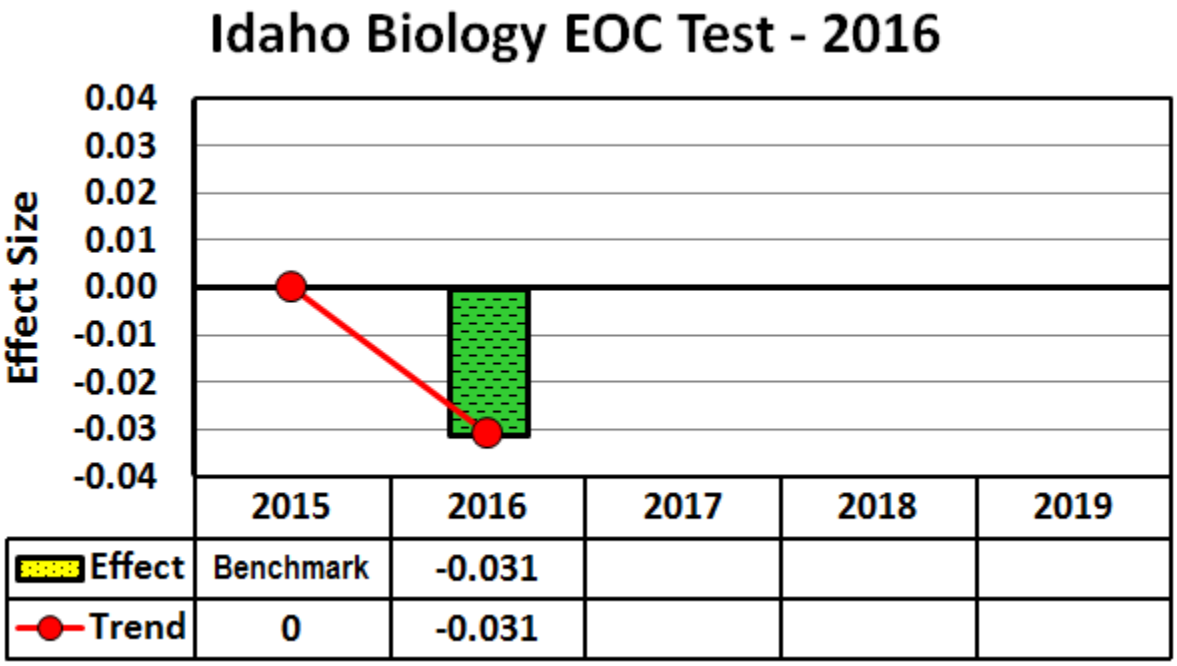

Figure 2. Effect size (growth) for Idaho biology end-of-course test from 2015 to 2016.

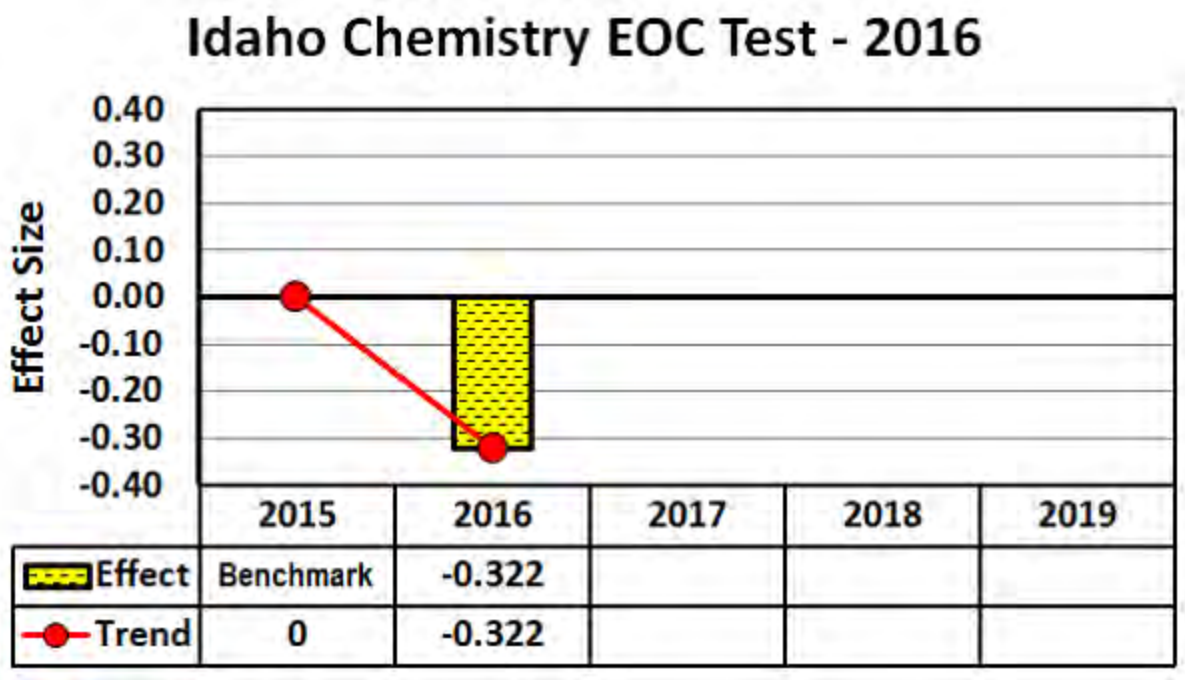

Figure 3. Effect size (growth) for Idaho chemistry end-of-course test from 2015 to 2016.

Percentiles

Figure 4 is a **boxplot** displaying percentile results from the Idaho **biology** end-of-course test from 2015 and 2016.

Figure 5 is a **line graph** displaying percentile results from the Idaho **biology** end-of-course test from 2015 and 2016.

Figure 6 is a **boxplot** displaying percentile results from the Idaho **chemistry** end-of-course test from 2015 and 2016.

Figure 7 is a **line graph** displaying percentile results from the Idaho **chemistry** end-of-course test from 2015 and 2016.

Findings.

On the Idaho high school biology end-of-course test:

- In Idaho high schools, the biology performance of Average, High Average and High students was lower in 2016 than in 2015, but the performance of Low Average and Low students improved.

- The High student in 2016 scored five (-5) points lower on the biology scale that his counterpart scored in 2015, the High Average student scored three (-3) points lower, and the Average student scored one (-1) point lower. In contrast, the Low Average students in 2016 scored two (+2) points higher than is counterpart scored in 2015, and the Low student scored four (+4) higher.

On the Idaho high school chemistry end-of-course test:

- In Idaho high schools, the chemistry performance of Average, High Average and High and Low Average students was lower in 2016 than in 2015, the performance of Low students was constant from 2015 to 2016.

- The High student in 2016 scored eleven (-11) points lower on the chemistry scale that his counterpart scored in 2015, the High Average student scored eight (-8) points lower, and the Average student scored five (-5) points lower, and the Low Average students scored two (-3) points lower. In contrast, the Low student's score remained constant from 2015 to 2016.

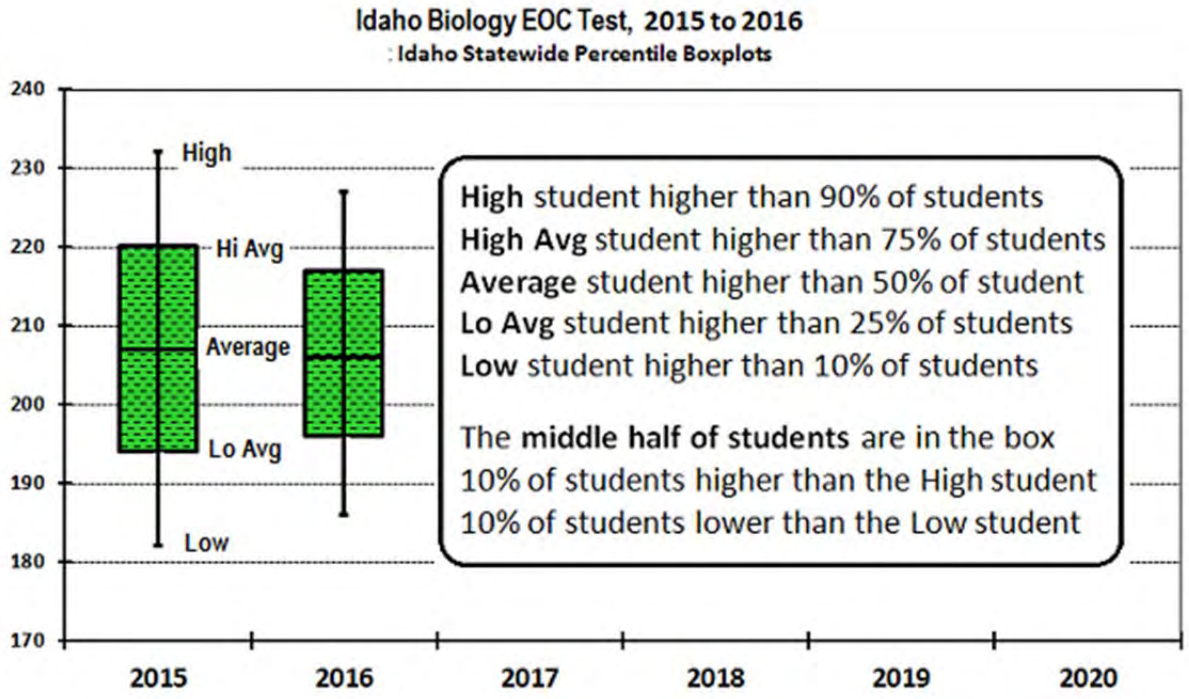

Figure 4. Boxplot displaying percentile results from the Idaho biology end-of-course test from 2015 and 2016.

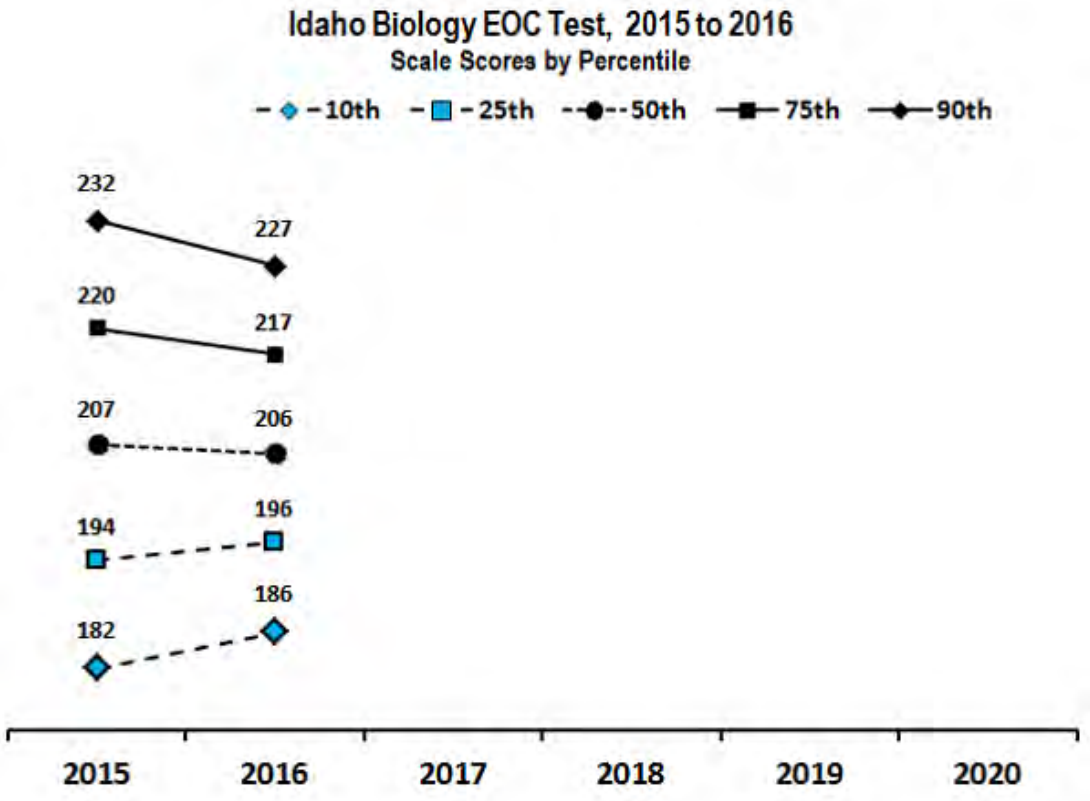

Figure 5. Line graph displaying percentile results from the Idaho biology end-of-course test from 2015 and 2016.

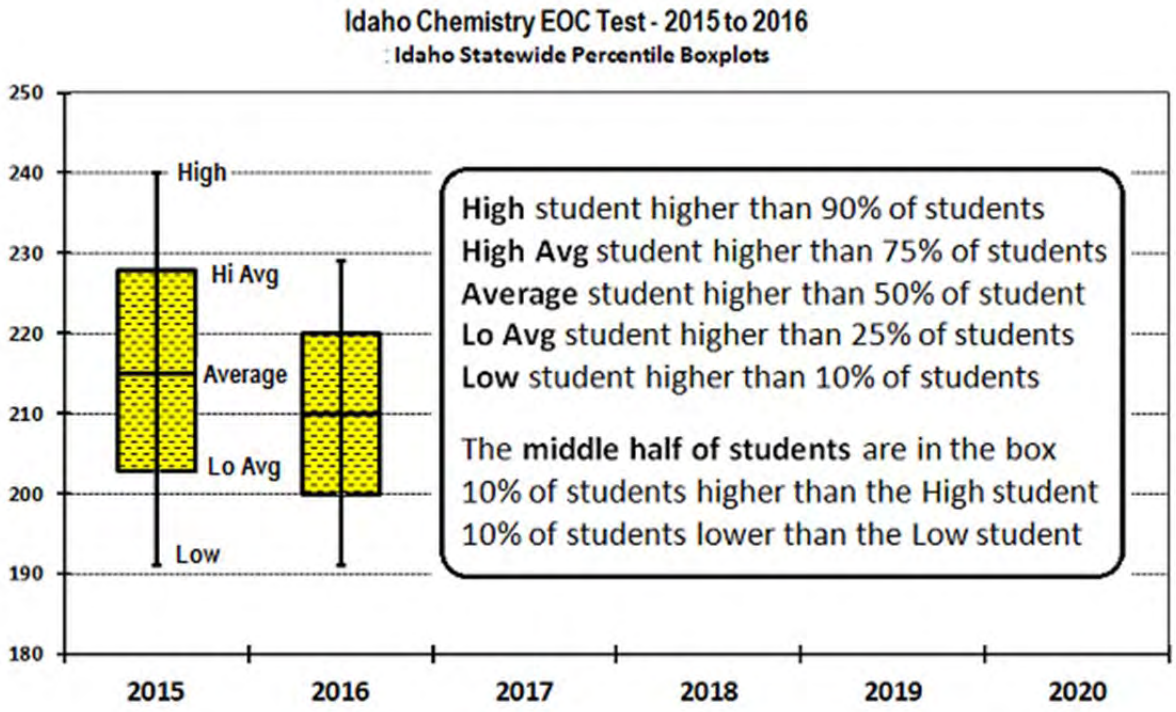

Figure 6. Boxplot displaying percentile results from the Idaho chemistry end-of-course test from 2015 and 2016.

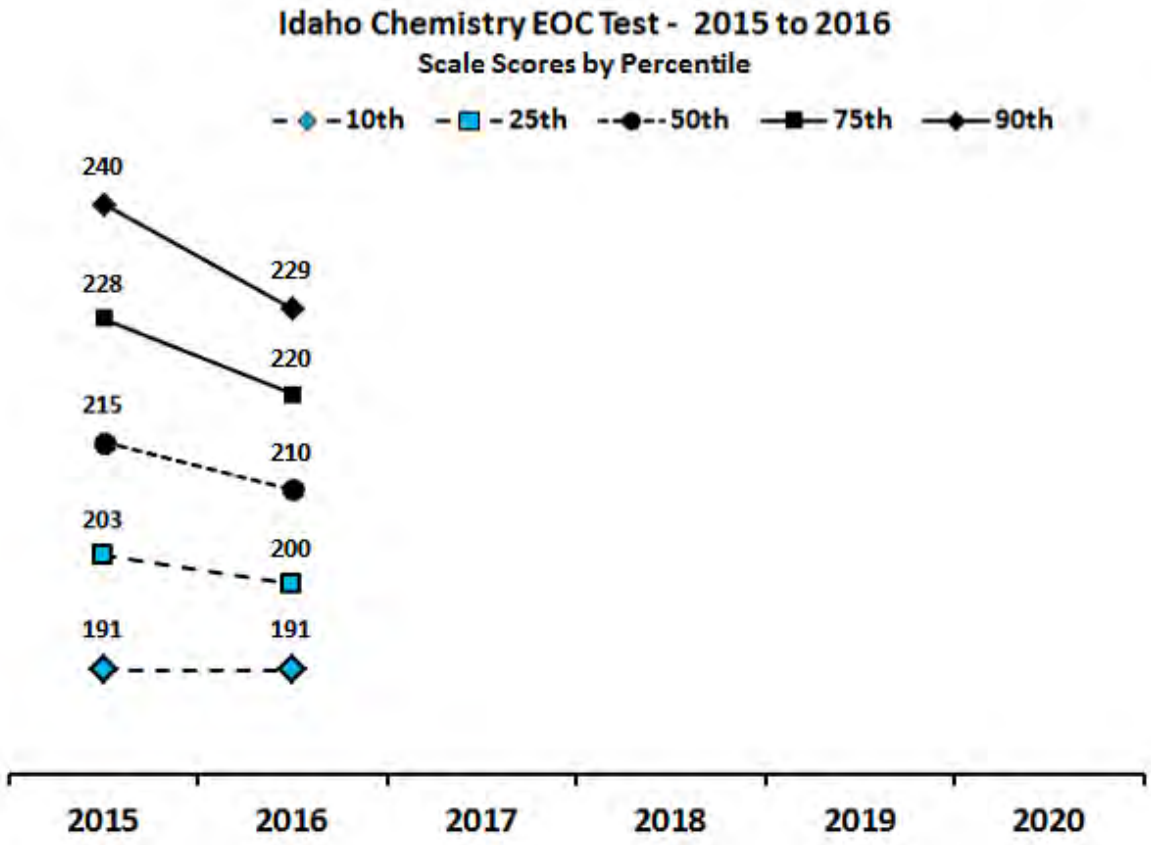

Figure 7. Line graph displaying percentile results from the Idaho chemistry end-of-course test from 2015 and 2016.

DISCUSSION

The 2016 results from the Idaho high school end-of-course tests of biology and chemistry are surprising. Science educators should take time to identify the "factors" that contributed to these results (one of which may be the increase in number of students tested, particularly for chemistry). This will be a useful exercise and may help to improve science education in Idaho, but it is not the main reason behind this paper.

Two other recent papers shared the same reason:

- *Idaho percentile results for the 2015 and 2016 ISAT (SBAC) English Language Arts and Mathematics tests in grades 3-8 and 10* (Stoneberg, 2016)

- *The IRI and the Idaho Reading Initiative, Fall 2016 (Stoneberg, 2016, Dec. 23)*

If the Idaho accountability plan now on the table survives, state education officials likely will not report out average or percentile results for statewide mandated tests for accountability, program evaluations, or educational research. The accountability plan is focused on achievement level percentages (i.e., percent proficient). State officials seem unconcerned that achievement level percentages have not yet been demonstrated to be "reasonable, valid, and informative to the public" (Pellegrino et al, 1999). They may not even know the difference between "proficient" and "proficiency" (Stoneberg, 2013). No test developer has spent more money than NAEP trying to make achievement level percentages "work." Visit the National Center for Education Statistics' website to see the status of NAEP's achievement levels (NCES, 2017).

Learning Point Associates (2009) published a readable and usable 18-page paper entitled *Connecting Research to Practice: Knowing Who Is Proficient Isn't Always Sufficient* that discusses achievement levels, statistical and practical (effect size) differences between means, and percentiles. It is a good starting place for anyone who wants to know more about using student achievement data to understand what is going on with achievement in our public schools.

The State Board of Education and the State Department should together engage one FTE person who has considerable knowledge, skills and experience in educational measurement (i.e., Psychometrics, Logistics, and Data Analysis & Reporting). That person's assignment to is marshal state resources so that Idaho does not just administer mandated statewide testing, but that Idaho collects and uses all student achievement scores fully to inform accountability, program evaluation and educational research for the benefit of Idaho educators, students, parents and taxpayers.

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