



The Effect of NGSS-Aligned Instruction on Student Learning in High School Science



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Background

The Next Generation Science Standards (NGSS) have been adopted in my state of California. These differ from the old California State Science Standards by moving from a content-based approach to more complex performance expectations combining knowledge with practice. The NGSS recommend a three-dimensional approach to the performance expectations combining all three aspects of the standards – disciplinary core ideas (DCI), science and engineering practices (SEP), and crosscutting concepts (CCC). The NGSS propose that content is best learned by engaging in the science and engineering practices, while the practices are best learned in the context of specific disciplinary content.

My action research is focused on student learning when instruction and curriculum have been aligned with the NGSS three dimensional learning model. If this model works, my students will have improved learning opportunities for both disciplinary content and the science and engineering practices, as well as an opportunity to learn at deeper levels of understanding. Consequently, I will attempt to measure learning of the disciplinary content and the scientific practices at both acquisition and application levels of understanding.

Treatments

The treatment plan involves alternating instructional units that have been revised for NGSS alignment with instructional units, from prior years, that have not been revised. All units are designed to move students through a learning cycle of acquisition, meaning making and transfer. All use both teacher-centered and student-centered instruction, including some type of laboratory experience in each. There are two aligned units and two non-aligned units.

Treatment/Non-Treatment	Topic
NGSS Revised Instruction (Treatment 1)	Photosynthesis + Cell Respiration
2014-15 Instruction (Non-Treatment 1)	Agriculture + Food Resources
2014-15 Instruction (Non-Treatment 2)	Energy Basics – Forms and Transformations
NGSS Revised Instruction (Treatment 2)	Energy Resources

Instruments

I need instruments to measure that NGSS alignment as part of unit planning. I also need instruments to measure student learning and perception as a result of that instruction.

Instrument	Purpose
Instructional Alignment Review	Evaluates instructional activities for alignment to DCI, SEP and CCC.
Assessment Alignment Review	Evaluates each assessment item for alignment to NGSS, as well as conceptual level and difficulty level.
Pre- and Post-Tests	Mix of multiple choice and open-ended questions, measures learning – both acquisition and application – of DCI.
Laboratory Reports	Experimental design analysis, data analysis and conclusions measure application of both DCI and SEP.
Student Questionnaire	Student perception of assessment difficulty level and alignment between assessment and instruction.
Student Interviews	In depth probe on student perceptions of instruction and assessment, from all learning levels.

Research Questions

Primary Question

What is the impact on student learning of revising curriculum and instructional activities to align with the NGSS model of three-dimensional learning?

Secondary Questions

- What is the impact of NGSS-aligned revisions on student learning, as measured by acquisition and application of the disciplinary core ideas?
- What is the impact of these NGSS-aligned revisions on student learning, as measured by application of the science and engineering practices?

Student Population

This research was done with two sections of Integrated Science Honors. This is a required 10th grade course that integrates the California standards in Earth Science and Biology.

The two classes have a total of 54 students, 28 males and 26 females. Reflecting the overall population of Redwood High School, there is very little diversity. There is one student of Asian descent and no Latinos or African-Americans. There are five students for whom English is a second language and all are designated proficient in English. One student has an IEP plan, one has section 504 accommodations and two have general education accommodations.

Redwood High School has an enrollment of 1661 students: 83% are white; 11% Hispanic; 5% Asian; 2% African-American. Additionally, 1% are designated ELL and 5% are low-SES.

Interpretation

- Increased learning occurred in treatment units compared to non-treatment units for *all* measured categories – DCI acquisition, DCI application, SEP application.
 - Acquisition level learning of DCI showed greater normalized gains, pre- v. post-assessments, in treatment units. Differences were statistically significant ($p=0.001$).
 - Application level learning of DCI showed greater normalized gains in treatment units, but differences were not statistically significant ($p=0.171$).
 - Application level learning of SEP showed improved learning, on rubric-scored lab reports, in treatment units. Differences were not statistically significant ($p=0.322$).
- In *each* category, the largest difference between treatment and non-treatment units occurred in the lowest performing students.
- Treatment unit revisions included changing depth of instruction based on the ‘assessment boundary’ from NGSS and aligning with new practices (ie. modeling). This may explain significant gains shown at the acquisition level and by lower-performing students.
- Practices of AQ/CE/AE had the largest difference in treatment v. non-treatment units. These were not common in prior instruction and received increased focus in revised units.
- Practices of PE/AD/MT had highest overall scores with little difference between treatment and non-treatment. These have been well-represented in prior instruction.
- Students reported the treatment unit assessments as more difficult than the non-treatment, even though performance was better on the treatment units. Had the tests been more equal in difficulty level, the differences between treatment and non-treatment may have been more significant.
- Student perception of instructional value was low for labs and high for direct instruction. This was counter to instructor’s preconception and suggests re-examining lab instruction.
- Overall, this first round of data collection shows promise for the NGSS three-dimensional model. Future work would include a greater focus on the cross-cutting concepts dimension to better link SEP to DCI and improve the perceived value of lab instruction.

Data – Treatment v. Non-Treatment

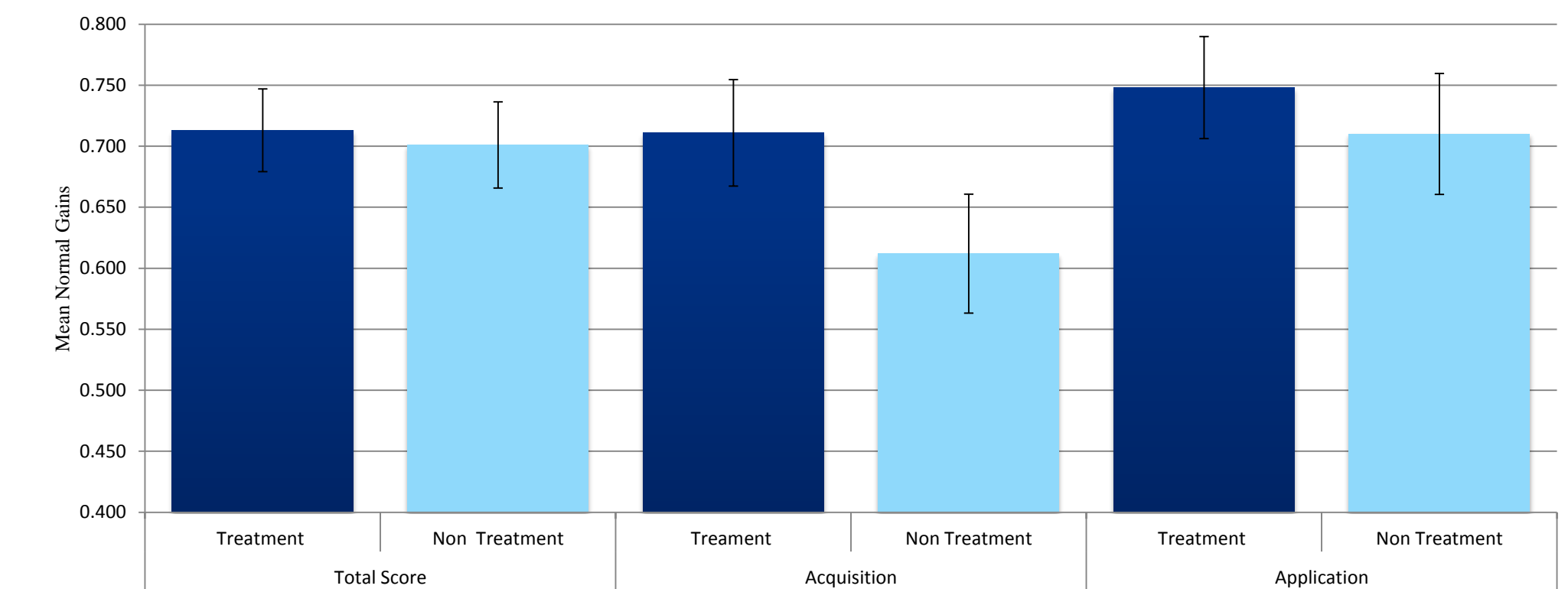


Chart 1. Pre/Post Test Normalized Gains – by Conceptual Level (N=54)
Note: Error bars indicate 95% confidence intervals.

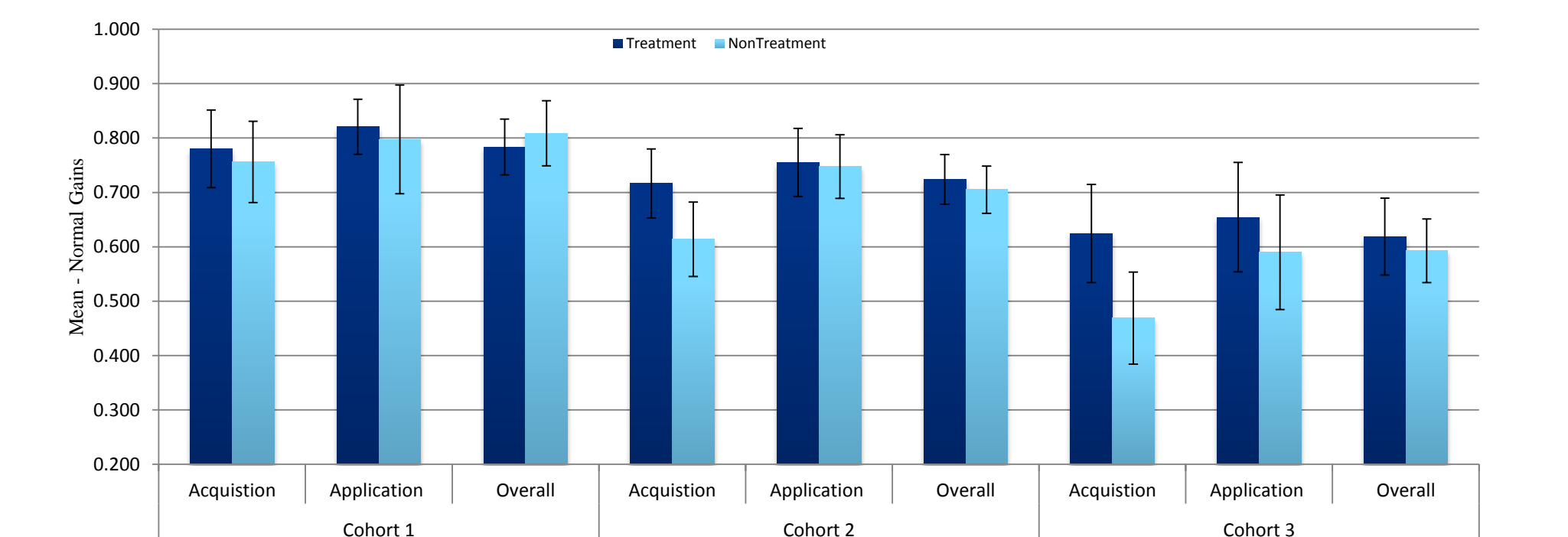


Chart 2. Pre/Post Test Normalized Gains – by Learning Level and Student Performance Level
Note: Cohort 1 = top 1/3 (N=36); Cohort 2 = middle 1/3 (N=36); Cohort 3 = bottom 1/3 (N= 32)

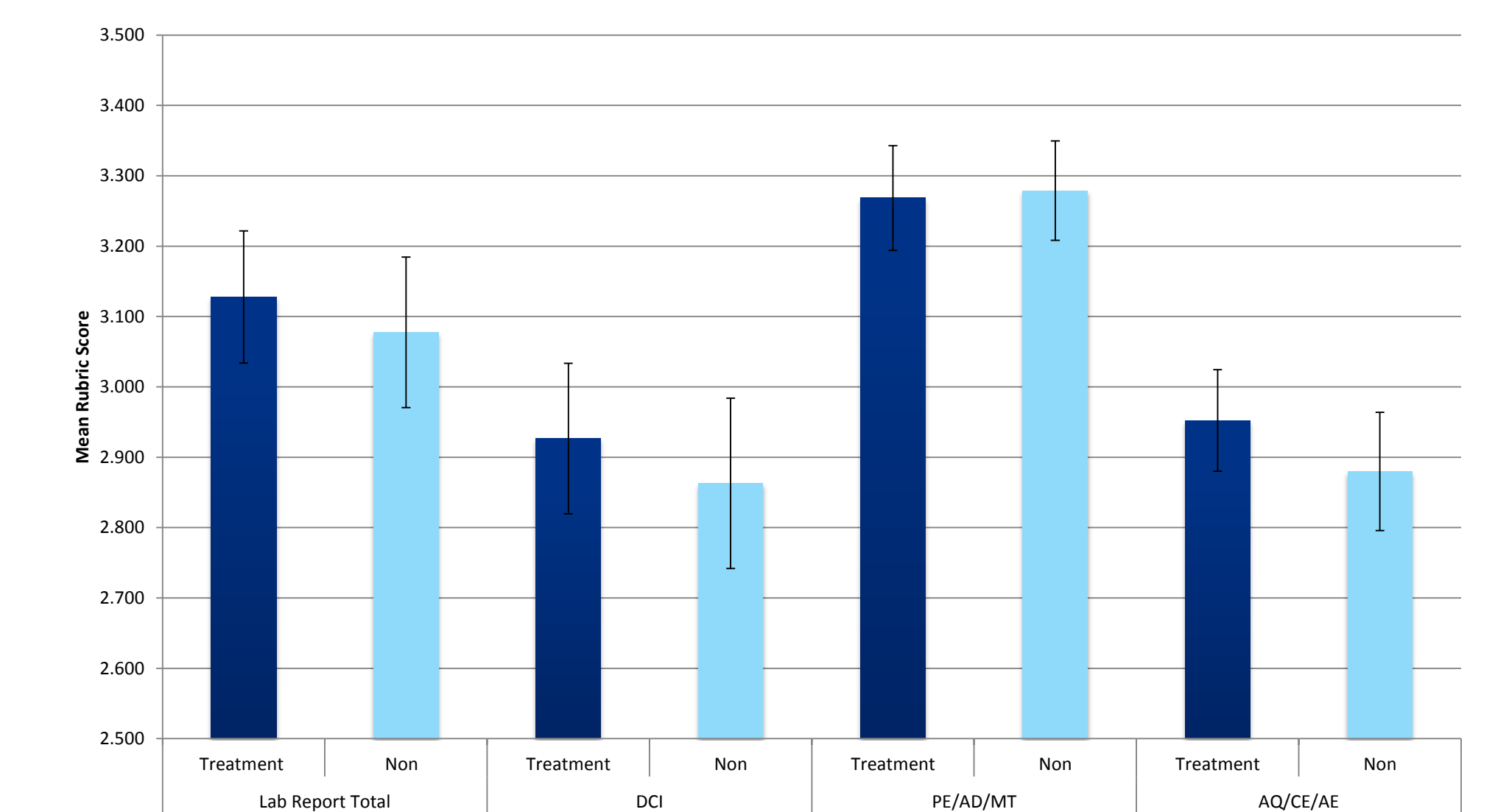


Chart 3. Mean Lab Report Rubric Scores – Total and by Question Type
Note: Total N=108; DCI N=216; PE/AD/MT N= 432; AQ/CE/AE N= 432
PE= Plan Experiments; AD = Analyze Data; MT = Mathematical Thinking
AQ= Ask Questions; CE= Construct Explanations; AE= Argue from Evidence

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References

1. California Department of Education (13 March, 2015). *Enrollment by Ethnicity 2014-15*. Retrieved April 17, 2016 from <http://ftp.cde.ca.gov/ftp/enrollment/2014-15/ethnicity/2014-15-ethnicity-by-district-and-county.pdf>