Increasing Student Confidence-Based and Understanding with the Implementation of Inquiry-Based Modeling in a High School Chemistry Classroom
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Background
With the release of the Next Generation Science Standards (NGSS), modeling was an important concept in the new standards being released (NGSS Lead States, 2013). Also, with the release of revised Advanced Placement (AP) Chemistry standards in 2014, there was a shift in focus from recall to enduring conceptual understanding (The College Board, 2014). Chemistry requires students to understand concepts on atomic, subatomic, and molecular levels. This means that students need to grasp abstract and microscopic ideas, which can be difficult to visualize and转入到最终的现实理解。物理和空间模型化是构建一个虚拟环境的创新方法。在改进理解 (Vakman-Guzl & Adanah, 2012).

Because of this shift in education, I chose to implement student-based modeling in my AP Chemistry class. I engaged my students in creating physical models using a variety of mediums and monitored their attitudes and understanding throughout the process.

Research Questions
Table 1

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<th>Data Triangulation Matrix</th>
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<td>Data Source 1</td>
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<td>Modeling in Chemistry Survey</td>
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Sub-Question 1: What is the effect of inquiry-based modeling on student achievement in chemistry?

Sub-Question 2: What is the effect of inquiry-based modeling on student attitudes about chemistry?

Methodology
The treatment of this study included intentional use of models for students throughout two units in the AP Chemistry curriculum. The student population consisted of two classes, totaling 53 students, of 11th and 12th grade AP Chemistry students at Artesia High School in Lakewood, CA. For every topic covered within the two units, modeling was prompted by the teacher and completed by the students in the classroom. This treatment occurred from February 2017 to April 2017. These models were based off of concepts in the NGSS and College Board’s Course and Exam Description and were inquiry-based models.

Students took concept-based pre-tests and post-tests for both units of treatment. These results were compared for normalized gains. The post-test data was also collected between the 2015-2016 school year and 2016-2017 school year, and was analyzed and reported in box and whisker plots. A Likert-style survey, Modeling in Chemistry Survey, was administered pre-treatment and post-treatment to monitor student attitudes during the modeling treatment.

Results
The results of the Modeling in Chemistry Survey indicated that students responded positively towards modeling in the chemistry classroom and that they used modeling more after the treatment than before. One student stated, “I wish we had included more models in the beginning of the year because it would have been more beneficial.” When asked if students better understand chemistry concepts when creating models, 37.7% of students responded strongly agree, pre-treatment while 49% of students had the same response post-treatment. A student stated, “Modeling affected my learning in chemistry in the sense that I am better able to conceptually understand what is going on because it is easy to do the math portion but if I cannot conceptually understand it then what is the point?” An increase from 15.1% to 37.7% of students responded strongly agree when asked if they enjoy making models of chemical concepts. One student stated, “I enjoy making models after learning the chemical concepts because it helps me understand what we just learned about and put an image in my head of what is actually happening in chemistry.” Students who strongly agree that making models helped them better understand chemistry increased from 45.3% of students pre-treatment to 66% post-treatment. One student stated, “Before I would just be memorizing and regurgitating. Modeling forced me to make the concept for myself rather than following a set concept that would not contribute to my personal learning of the subject.” Post-treatment, 19% of students responded strongly disagree when asked if making models helped them better understand chemistry. One student stated, “I need people to explain to me what is going on in order for me to understand a concept; I can’t just normatively figure out what is happening on my own. It confuses me more.”

When comparing the pre-test and post-test scores, the average student average on both the Chapter 6 Test and the Chapter 17 Test increased by 43.4% for both tests (Figure 4). The results of the Chapter 6 and Chapter 17 post-tests from the treatment group of students (N=53) was compared to the scores from my students the year prior, who did not receive any treatment (N=76). The treatment group’s average score was 2.9% higher for the treatment group compared to the non-treatment group on the Chapter 6 Test. For the Chapter 17 Test, the treatment group had an average score of 3.5% higher than the non-treatment group (Figure 5). One student stated, “At first I did not have a conceptual understanding which prohibited me from creating a proper model and understanding the subject. However, as time progressed and more model making assignments and projects were introduced I was able to understand the concept and properly model what was going on.”

Conclusions
This study provided evidence that incorporating modeling into my classroom curriculum positively affected student achievement and attitudes in chemistry. According to the data, students were impacted by the implementation of modeling in the chemistry classroom. Student achievement in chemistry deviated only slightly from the previous year, which received no treatment, during the first chapter of treatment. It is evident, however, that there is a larger increase in achievement during the second chapter. When implementing modeling, I noticed that my students were not familiar with creating visuals and hadn’t been challenged to contemplate conceptual concepts prior to the treatment. Because of this, I think the students took more time than I had expected to get comfortable with thinking conceptually, making mental models, and creating visual representations of their understandings of chemistry concepts. By the time Chapter 17 was started, which was the second chapter in the treatment plan, students were beginning to be more comfortable with modeling and I noticed that students began making better models. As the data shows, the students have a slightly larger normalization gain in the second chapter compared to the first of the treatment. When comparing the scores on the same exams of my students from the previous year, who did not receive treatment, the group of students who received treatment showed higher scores comparatively as the treatment progressed. The achievement of my students who received treatment increased as they had more exposure and practice with creating their own models.