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Closing the Science and Achievement Gap: Overlap of the Next Generation Science Standards and Culturally Relevant Pedagogy

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Abstract

The United States is experiencing both a science gap and an achievement gap within science education. To shrink the science gap and prepare American students for the innovative and rigorous STEM career fields ahead, the Next Generation Science Standards (NGSS) were implemented in science education. Additionally, culturally relevant pedagogy was implemented in general education to alleviate the achievement gap. To ensure that all students are prepared to succeed in the competitive global world they are going to be a part of, science education needs to incorporate both NGSS and culturally relevant pedagogy. To examine the overlap of both pedagogies working in a science classroom, eight chemistry lessons from the National Science Teachers Association's journal *The Science Teacher* were analyzed for the key aspects of culturally relevant pedagogy. Analysis of the NGSS chemistry lessons reveal that both pedagogies overlap and the lessons that are created with NGSS in mind only require slight adjustments to meet the requirements of culturally relevant pedagogy.

Keywords: culturally relevant pedagogy, Next Generation Science Standards, achievement gap

The Science Gap

The strength of the United States' education program has been in question for several decades, specifically the strength of its math and science education programs. For example, in 2009, thirty-three Organization for Economic Cooperation and Development (OCED) countries participated in a Programme for International Student Assessment (PISA) study. Twelve countries scored higher in science than the United States and seventeen countries scored higher in math than the United States (Committee on STEM Education National Science and Technology Council, 2013). Additionally, the United States participated in the latest Trends in International Mathematics and Science Study (TIMSS). The United States was ranked 11th out of the 37 countries that participated in grade 8 science and was ranked 10th out of the 37 countries that participated in grade 8 math (National Center for Education Statistics, 2015). These statistics show that the United States is falling behind other countries in academic achievement, specifically in math and science.

In addition to falling behind in test scores, the United States is lagging behind their global counterparts in the STEM career fields. The National Science Teachers Association (NSTA) reports that "U.S. high-tech manufacturing industries continue to have a larger share of global output than any other economy, but the U.S. global share fell from 34% in 1998 to 28% in 2010" (NSTA, 2012). Additionally, the NSTA reports that "the U.S. share of global high tech exports dropped from 19% to 15% in 2010; at the same time China's share of global high tech goods exports more than tripled, from 6% in 1995 to 22% in 2010, making it the single largest exporting country for high tech products" (NSTA, 2012). The decline in both high tech output and exports highlights the fact that the United States is falling behind in STEM career fields and in STEM education. Because U.S students are not prepared for the innovative and rigorous

STEM career fields as their global counterparts, the U.S is failing to create cutting edge high tech goods. To become a global competitor again, the United States needs to better prepare its students for the STEM world.

The Next Generation Science Standards

To prepare students for the innovative and rigorous STEM career fields, science educators called for a redesign of science education that would better prepare American students for STEM careers. A Carnegie Corporation of New York/Institute for Advanced Study Commission of Researchers and Public and Private Leaders stated that “the nation’s capacity to innovate for economic growth and the ability of American workers to thrive in the modern workforce depend on a broad foundation of math and science learning” (NSTA, 2012). In response to this finding, the Next Generation Science Standards were developed in a two-step process. A partnership between the National Research Council (NRC), National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and Achieve was created and was put in charge of the creation of the Next Generation Science Standards (NGSS) (NSTA, 2012). The first step in creating the NGSS was the development of *A Framework for K-12 Science Education* by the National Academies of Science. *A Framework for K-12 Science Education* “identified broad ideas and practices in STEM that all students should be familiar with by the time they graduate from high school” (NSTA, 2012). The second step was creating the NGSS based on *A Framework for K-12 Science Education.* The standards were released in April of 2013 and have been adopted by thirteen states and the District of Columbia (NSTA, 2012). These standards require the use of *three-dimensional learning*, that is, learning experiences that engage students in *science and* *engineering practices*, *cross cutting concepts*, and *disciplinary core ideas* (NGSS Lead States, 2013).

The first dimension of *A Framework for K-12 Science Education* and NGSS is *science and engineering practices*. This dimension is defined as “behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems” (NGSS Lead States, 2013). There are eight science and engineering practices: asking questions (for science) and defining problems (for engineering); developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations (for science) and designing solutions (for engineering); engaging in argument from evidence; and obtaining, evaluating, and communicating information (NRC, 2012). For example, students can explore the variables that could possibly effect a simple pendulum’s period by collecting and analyzing data. Through the collection and analysis of the data, students can discover the relationship between each variable and the simple pendulum’s period.

The second dimension of *A Framework for K-12 Science Education* and NGSS is *cross cutting concepts*. This dimension is defined as “a way of linking the different domains of science” (NGSS Lead States, 2013). There are seven cross cutting concepts: patterns; cause and effect: mechanism and explanation; scale, proportion, and quantity; system and system models; energy and matter: flows, cycles, and conservation; structure and function; and stability and change (NRC, 2012). An example of a cross cutting concept in a classroom, is students analyzing chemical compounds names. Rather than just memorizing the rules of naming chemical compounds, students can explore the pattern of naming chemical compounds.

The third dimension of *A Framework for K-12 Science Education* and NGSS is *disciplinary core ideas*. This dimension is defined as content that "focus[es] K-12 science curriculum, instruction, and assessments on the most important aspects of science" (NGSS Lead States, 2013). There are four categories of disciplinary core ideas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science. In addition, the disciplinary core ideas need to meet at least two of the following criteria: "have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline," "provide a key tool for understanding or investigating more complex ideas and solving problems," "relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge," or "be teachable and learnable over multiple grades at increasing levels of depth and sophistication" (NRC, 2012, p. 31). An example of a disciplinary core idea is "matter and its interactions," which is a physical science disciplinary core idea. The two criteria it meets is that it is a key concept of chemistry and it can be taught over multiple grades.

The overall intent of the Next Generation Science Standards is to create student-centered learning that emphasizes learning science through engagement with scientific and engineering practices where students will practice critical thinking skills. This will reduce the focus on memorizing and using procedures in science and instead focuses on strengthening students' ability to critically engage in a problem and construct in-depth explanations about both the problem and the solution to the problem. This in turn prepares students for the intellectual demands of current STEM fields and can help the United States become a STEM leader again.

The Achievement Gap

In addition to the international science gap, the United States is experiencing another gap in education: the achievement gap. The achievement gap is the gap between the academic success and the test scores of white students and students of color. In a recent study on an international assessment of 8^{th} grade mathematics and science, white students' scores were only surpassed by three countries, while Hispanic students and African American students were in the bottom third of the forty-five countries who participated in the assessment (Committee on STEM Education National Science and Technology Council, 2013). In addition to the international assessment, the achievement gap can be seen in the results from the National Assessment of Education Progress (NAEP) between 2009 and 2011 for Grade 8 science. On the test, there was a 36 point gap between White students' scores and Black students' scores in 2009 and a 35 point gap in 2011 (Rodriguez, 2015). There is a similar trend between White students' scores and Hispanic students' scores with a 30 point gap in 2009 and a 27 point gap in 2011 (Rodriguez, 2015).

For students of color, experiencing less success in STEM high school classes makes it difficult for these students to pursue a STEM undergraduate degree and a STEM career. This is problematic because the percentage of people of color is growing in the United States. The Center for American Progress predicted that the majority of the U.S population will be people of color by 2044 (Progress 2050, 2015). If there is growing population of people of color, there should be a growing population of students of color pursuing an undergraduate STEM degree. Only 2.2 % of Hispanics and Latinos, 2.7 % of African Americans, and 3.3 % of Native Americans and Alaska Natives complete a STEM degree by the age of twenty-four (Committee on STEM Education National Science and Technology Council, 2013). In addition, there is an underrepresentation of people of color who are in the STEM workforce. Only 6.4% of the STEM workforce is African American, 0.4% is American Indian or Alaska Native, and 6.5% is Hispanic or Latino, which is substantially lower than the 70.8% of Whites who make up the STEM workforce (U.S Census Bureau, 16, 2013). This underrepresentation is clear in comparison to the 2010 Census data of the breakdown of the population of 15-24 year olds by race, 20.3 % of Hispanics and Latinos, 14.9 % of African Americans, and 0.87% of Native Americans and Alaska Natives (Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2015). There is a discrepancy between the percent of Hispanics and Latinos, African Americans, and Native Americans and Alaska Natives in the general population and the percentage of these students perusing a STEM degree and holding a STEM career.

Culturally Relevant Pedagogy

Educational researchers who focus on the achievement gap recommend the use of *culturally relevant pedagogy*[1]. Culturally relevant pedagogy (CRP) focuses on the academic and social empowerment of students, especially students of color, and was first described by Gloria Ladson-Billings, who researched how teachers can help their African American students succeed in the classroom. Ladson-Billings defined CRP as “a pedagogy of opposition” with three key parts (Ladson-Billings, 1995, p. 160). First, teachers need to have a strong conception of self and others. Second, teachers need to have strong social relations with both their students and the community they are a part of. Finally, teachers must have a strong conception that knowledge is a continuous process (Ladson-Billings, 1994).

To begin to develop one’s conception of self and others, teachers need to be aware of their own race and ethnicity. By being aware of their own race and ethnicity, teachers can reflect on their own privilege they carry throughout their everyday lives and their education. They will also be able to reflect on their mindset to determine if they have a deficit mindset surrounding students of color. A deficit mindset is defined as a mindset where "educators […] tend to focus on what students do not bring to the classroom; that is, they may focus on students' deficits rather than their many assets" (Milner, 2010, p. 15). To fix the deficit mindset, teachers need to look for and build on students' assets, which can be experiences, social capital, or attitude. In addition to being aware of their own identity, teachers need to be aware of their students' race and ethnicity (Ladson-Billings, 1994). This awareness helps teachers create a space that honors students' experiences. In addition, teachers need to be able to "mine" ideas out of their students. This mining refers to information a student may have on the content, but also the ideas and questions students generate during the learning process (Ladson-Billings, 1994). Students feel valued and important when their ideas and questions are included in the class and this feeling of being valued will lead to students achieving in the classroom.

In addition to having a strong conception of self and others, teachers need to create strong social relations within their classroom and the larger community. When a teacher creates these strong relations, this leads the classroom to become a community of learners that learn collaboratively (Ladson-Billings, 1994). There are several ways where a teacher can create strong relationships in the classroom and within the community. To create community in the classroom, the teacher needs to connect the learning to all students' communities and identities. Additionally, the teacher should also extend the student relationship into the community, which could be attending a student's musical performance or sporting event (Ladson-Billings, 1994). Teachers can create a classroom environment that allows students to express their initial ideas of the content in their home language and then translate the final product into "standard English"

(Ladson-Billings, 1995). In addition, the teacher could create a classroom residency program with students' parents, in which parents come into the classroom and teach or discuss how they use concepts from class in their daily or work lives (Ladson-Billings, 1995). Additionally, students can be involved in a project-based collaboration with a local community member or business that addresses a local issue that students find interesting or important (Rittenburg et al., 2015). By creating a community of learners that work collaboratively, students will feel that they are part of a community that cares about them. This helps motivate students who have felt previously left out in their classroom and experience success in the classroom.

The final key aspect to culturally relevant pedagogy is a classroom that has a culture that sees knowledge as a continuous process. This pairs well with teachers "mining" ideas out of their students. The main role a teacher has is to help students develop necessary skills related to the content but let students discover the concept as much on their own as possible (Ladson-Billings, 1994). In addition, teachers and students need to approach learning with the understanding that '[k]nowledge is continuously recreated, recycled, and shared by teachers and students, [and] it is not static or unchanging" (Ladson-Billings, 1994, p. 81). This means that students will learn from their teachers and their classmates and, importantly, know that learning is not simply an accumulation of facts from an authoritative teacher or textbook, but a construction of knowledge and skills through shared experiences and problem-solving. This again allows students to feel welcomed and appreciated in their classroom, which leads to student achievement.

Can the Next Generation Science Standards and Culturally Relevant Pedagogy be combined?

While Next Generation Science Standards and culturally relevant pedagogy address different weaknesses in educational experiences, in reality, there are enormous overlaps between the recommendations of both theories and their practice. Instead of viewing each set of recommendations as its own separate practice, science teachers can view the practices each as a different lens through which to envision teaching in a more student-centered way. For example, one of the science and engineering practices is asking questions and defining problems (NRC, 2012). This practice pairs nicely with the part of culturally relevant pedagogy that calls for students to be involved in the community through the lessons. Students could ask questions regarding their community and conduct an experiment to answer their question. Both NGSS and CRP calls for teachers to mine knowledge from their students and ask teachers to have their students learn collaboratively. Combining these two practices is not an overwhelming undertaking; instead, it involves making slight changes to lesson plans that have a focus on one practice or the other to fill the gaps.

Evaluation of Next Generation Science Standard Lesson Plans

To assess the overlap of the Next Generation Science Standards and culturally relevant pedagogy, all chemistry lessons were evaluated from the National Science Teachers Association publication *The Science Teacher* from the years 2015 and 2016. There were a total of eight chemistry lessons that were written to meet Next Generation Science Standards These eight lessons were evaluated for their “cultural relevancy.” They will be evaluated by the following criteria: teachers mine knowledge from students, teachers encourage students to learn collaboratively, and teachers involve students in the community.

The first chemistry lesson came from the article “Does it Mix” (Tillman Kennon et al, 2016). This lesson’s goal is to have students learn about solubility and partition coefficients. The lesson call for students to mix various amounts of Gatorade powder in water and oil. Students then use a voltmeter to measure the conductivity of the solution. Finally, they mix together oil, water, and Gatorade together and use the voltmeter to identify the layers of the mixture (Tillman Kennon et al, 2016). Within the lesson, several Framework dimensions and their corresponding NGSS are addressed. The scientific and engineering practice that is focused on is *developing and using models*. The cross cutting concept that is addressed is *structure and function* and the disciplinary core ideas that are focused on are *motion and stability* and *force and interactions* (Tillman Kennon et al, 2016).

This lesson meets two requirements of culturally relevant pedagogy: students learning collaboratively and connecting students to the community. This lesson does not mine knowledge from students because the teacher talked about separation of the liquids before the students do their experiments. This lesson does have students learn collaboratively because they work in groups. Finally, it does have students learn within a part of the community since some students are athletes and drink Gatorade. To make the lesson more culturally relevant, a teacher could have students do the experiment before the teacher talks about the reasoning for the separation of the liquids.

The second chemistry lesson came from the article “Separating a Mixture” (Lotter and Taylor, 2016). The goal of the lesson is to have students explain how ionic substances interact in solutions by developing and revising explanatory models. Students first watch a demonstration of a “poly-density bottle,” in which there are two sets of colored beads in a one liter plastic bottle filled with salt, water, and alcohol. Then, the teacher shakes the bottle and the two different sets of beads move to opposite ends of the bottle and then to the middle of the bottle. Students then write and draw what they saw in the demonstration and share it with the class. Then, students create their own model with a water bottle, table salt, 70 % isopropyl alcohol, and green food coloring. They first pour out half of the water bottle, pour in alcohol up to about a centimeter from the top, add one drop of food coloring, and then experiment with adding salt until they get the liquids to separate. After this, they revise their models with sticky notes. They write new information on yellow sticky notes, write information that changes on blue sticky notes, and write questions down on purple sticky notes (Lotter and Taylor, 2016). The scientific and engineering practices that are addressed are *developing and using models* and *constructing explanations and designing solutions*. This lesson's cross cutting concept is *patterns* and its disciplinary core ideas are *structure and properties of matter* and *types of interactions* (Lotter and Taylor, 2016).

This lesson meets one requirement of culturally relevant pedagogy: mining information and ideas from students. This lesson does mine knowledge from students because it has students write descriptions and explanations of what they see in the demonstration and their own experiment. Students in addition are tracking their changes in thinking surrounding the demonstration. While this lesson mines knowledge from students, it does not have students learn collaboratively or involve the larger community. To make the lesson more collaborative, the teacher can have students work together in groups and discuss their observations and ideas in small groups. To make it more relevant to the community, the teacher could have students read information about a local water issue and brainstorm how building these models could help solve the local water issue. This would allow students to see how the can use their new knowledge to help their community.

The third chemistry lesson came from the article "Chemical Solitaire" (Philippoff et al., 2015). The goal of this lesson is to have students understand the periodic table and the trends that are present on it. There are three sets of elements that students will work with. The first set is the original twenty-seven elements that were known to Antoine-Lauren Lavoisier when he made his periodic table. The second set is the additional elements known at the time that Mendeleev constructed his first periodic table. The third set is the additional elements known when Harry Mosely rearranged the periodic table based off of atomic number. On each card is the chemical name, symbol, elemental weight, state at room temperature and valence --which is the most common number of chemical bonds an atom can form-- and reactivity. Students work together with the first set for ten minutes and organize the cards. Then, they get the second set and rearrange their cards in to new groups. The same process occurs with the third set (Philippoff et al., 2015). The scientific and engineering practices that are addressed are *developing and using models* and *obtaining, evaluating, and communicating information.* The cross cutting concept is *patterns* and disciplinary core idea is *matter and its interactions* (Philippoff et al, 2015).

This lesson meets two requirements of culturally relevant pedagogy: mining information and ideas from students and having students work collaboratively. This lesson does mine information from the students because the lesson has students use their critical thinking skills to sort the cards and solve the problem of creating the periodic table while learning the content surrounding the periodic table. This lesson is collaborative because the students are working together in groups and sharing their ideas with the class. This lesson is not part of the larger community though. While the periodic table itself is removed from everyday life, the lesson could be connected better to students' own lives by a warm up activity that relates sorting everyday things (types of music, types of food, etc.) into categories.

The fourth chemistry lesson came from the article "Connecting the Visible World with the Invisible: Particulate Diagrams Deepen Student Understanding of Chemistry" (Pentecost et al., 2016). The goal of this lesson is to have students grasp the particulate representation of an element, a mixture, and a compound. To do this, the lesson calls for students to draw a particulate diagram of an element, a mixture, and a compound at the beginning of class. Then, students work as a whole class to identify the particulate models as having undergone a physical or chemical change and then create a particulate diagram for various solutes in a solution. It is during this time that the class determines the relationship between the freezing point of a solution and the particulate models. After these activities, the students complete the same question from the beginning of class and draw a particulate model of an element, a mixture, and a compound. Within this lesson, the science and engineering practice *developing and using models* is addressed. The cross cutting concept that is covered is *patterns* and the disciplinary core idea that is addressed is *structure and properties of matter* (Pentecost et al, 2016).

This lesson is slightly culturally relevant because it only meets one requirement of a culturally relevant classroom: mining information and ideas from students. During the lesson, the teacher mines information and questions from students but does not have students learn collaboratively or connect the material to the larger community. To remedy this, the teacher can have students work in small groups when students draw the particulate models. In addition, the teacher can have students do a gallery walk of their classmates work and find patterns across all of their work. To connect the lesson to the school or larger community, the teacher could show particulate models of common solutions that students would see. This could be a common drink that students drink or a common mixture in the community that many students could identify.

The fifth chemistry lesson came from the article "Shedding Light on the 'Science of Small': Exploring Nanoparticles and Energy Conversion" (Goldston et al., 2016). The goal of this lesson is to have students "explore titanium oxide nanoparticles as photo catalysts activated by the energy of ultraviolet radiation" (Goldston et al, 2016, p. 29). During this lesson, students expose a silver nitrate solution to ultraviolet light. Some solutions contain titanium oxide nanoparticles while other solutions did not contain nanoparticles. After analyzing their results, students discover that the well plates that contain the solution with nanoparticles present had a color change while the other solutions did not change colors. The students talk about nanoparticle reactivity and how this could be helpful in everyday life. Then, they repeat the experiment but instead, expose the solutions to either red, green, or blue lasers and record the observed color changes. After they repeat the experiment, they address an application problem where they had to give advice to a construction worker who couldn't tell which side of the window they were installing was the side that was coated in titanium oxide nanoparticles. In this lesson, the science and engineering practices that are addressed are *constructing explanations and designing solutions*, and *obtaining, evaluating, and communicating information*. The cross cutting concept that is addressed is *cause and effect* and the disciplinary core ideas that are addressed are *chemical reactions*, *conservations of energy and energy transfers*, and *electromagnetic radiation*.

This lesson meets two requirements of culturally relevant pedagogy: mining information and ideas from students and having students learn collaboratively. This lesson didn't connect to the school or larger community but the lack of connection to community can be easily remedied. To have the lesson connect to the larger community, the window installer could be installing a window in a real local building or in a new construction zone within the community.

The sixth chemistry lesson came from the article "Settling the Score: Exploring the Historic Debate over Atomic Bonding" (Askew and Gray, 2016). The goal of this lesson is highlight the nature of science through historical case studies. In this lesson, students are evaluating John Dalton and Joseph Louis Gay-Lussac's hypothesis for the chemical formula of water. During the first day of this lesson, students write the formula of water and justify their answer. Students look at both Dalton's and Gay Lussac's hypotheses and create a poster to showcase each scientist's argument. On the second day of the lesson, students add in both scientists' arguments surrounding the density of oxygen gas, hydrogen gas, and water vapor. During this time, students find that neither scientist's argument worked and that another scientist, Avogadro, had the correct hypothesis. At the end of the second day, students talk about how ideas in science change and what this means for science. This lesson addresses *engaging in argument from evidence and constructing explanations* as the science and engineering practice. The cross cutting concepts that are addressed are *patterns* and *system and system models* and the disciplinary core idea that is addressed is *chemical reactions* (Askew and Gray, 2016).

This lesson plan meets two requirements of culturally relevant pedagogy: mining information and ideas from students and having students learn collaboratively. This lesson does not pull in from the larger community nor the school community. During this lesson, students could discuss what it means to have the community disagree on a solution to a question and what issues could arise from this. In addition, the students could research common debated topics in their everyday life or school life and what tension has arisen from this disagreement.

The seventh chemistry lesson came from the article "Finding Patterns" (Mulvey, 2016). The goal of this lesson plan is to have students discover the patterns to naming chemical compounds. This lesson plan stretches over five days and had students first do a card sort that contains binary compounds. There are three types of binary compound cards, Type I, Type II, and Type III. Students categorize the cards into groups and they must identify several different methods of sorting the cards. Once students sort the cards, the teacher asks students where on the periodic table the elements come from. The hope is for students to see the pattern that Type I compounds have an alkali metal or alkali earth metal and a non-metal that Type II compounds have a transition metal and a non-metal, and that Type III compounds have two non-metals. After students see the pattern, the teacher clarifies the naming rules and reminds students that they found these patterns on their own. Within this lesson, the science and engineering practice that is addressed is *engaging in argument in evidence*. The cross cutting concept that is covered is *patterns* and the disciplinary core idea that is addressed is *structure and properties of matter* (Mulvey, 2016).

This lesson meets two requirements of culturally relevant pedagogy: mining information and ideas from students and have students learn collaboratively. This lesson mines information and ideas from students and also has students learn collaboratively. The lesson does not connect compound naming with the school or larger community. To connect naming patterns to students' lives, the lesson could have students look at a street map and identify the patterns they see with street names when they focus on the second part of the street name. This slight change will make the lesson culturally relevant.

The final chemistry lesson came from the article "Making Molecular Movies" (O'Brien, 2015). The goal of the lesson is to have students understand the implications of chemistry. Students read a chapter on cellulose from Napoleon's Buttons, which is a book about how seventeen molecules affected human history, health, economics, and geopolitics. Students focus on "how slight differences in its structure results in cellulose polymers having different functions and how cellulose affected the industrial revolution" (O'Brien, 2015, 30). After reading the chapter, students work in pairs or small groups to develop a two to three minute movie about a perspective from the reading. This perspective must address the historical background, the chemistry of the molecule, and the importance to history. For example, a group could focus on "the moisture-wicking property of cotton […] as a reason for the popularity of cotton, which fueled the growth of slavery to provide a workforce to harvest the labor intensive commodity" (O'Brien, 2015, 31). The scientific and engineering practice that is addressed is *obtaining, evaluating, and communicating information.* The cross cutting concepts that is addressed is *patterns* and the disciplinary core ideas that is addressed is *matter and its interactions*.

This lesson meets all the requirements of culturally relevant pedagogy. This lesson is culturally relevant. First, this lesson mines knowledge from the students. Though students were reading material to learn concepts, they were not simply reporting out on the events of the reading but they were mining the story and their understanding of a particular idea within the story. Students then develop the idea and use their own ideas of how to make the story meaningful and understandable to their classmates. In addition, students are learning collaboratively. They work together in groups for their project and they are learning about the other properties from their classmates. Finally, the lesson allows students to connect their learning to their community. For example, students were able to discuss how the macromolecule, cotton, effected the larger community. To ensure that all groups connected their macromolecule to the larger community, the teacher could make that a requirement of the project.

The case study of eight chemistry lessons featured in *The Science Teacher* from 2015-2016 show that lessons created with the Next Generation Science Standards in mind have the ability to meet the requirements or parts of the requirements of culturally relevant pedagogy. While only one lesson meet all the requirements of culturally relevant pedagogy, it is clear that most of these Next Generation Science Standards lessons only need to make small adjustments in order to make them exemplars of culturally relevant pedagogy. Most of the lessons need to connect the lesson to the community while only a few needed to have students learn collaboratively.

Implementation and Support

For teachers who are already implementing Next Generation Science Standards into their classroom, implementing culturally relevant pedagogy will be fairly simple. As demonstrated by the case study of eight NGSS chemistry lessons, lessons that are created with the NGSS in mind only require a small change to meet the requirements of CRP. Teachers should look at their Next Generation Science Standards lessons and think about what requirements each lesson meets. Once they determine which requirements the lesson meets, they must make small adjustments to the lesson to make sure that it meets all the requirements of culturally relevant pedagogy.

For teachers who do not currently implement Next Generation Science Standards in their classroom, the implementation of both Next Generation Science Standards and culturally relevant pedagogy might seem to be a daunting task. Currently, there are a number of resources for science teachers to create science lessons that meet Next Generation Science Standards. These resources can be found on National Science Teachers Association's (NSTA) website. They range from online copies of the NSTA journals, NSTA recommended books, and NSTA e-newsletters. With these resources, teachers can analyze the lessons they find from these resources and make the small changes to meet all culturally relevant pedagogy requirements. If implementing both Next Generation Science Standards and culturally relevant pedagogy is overwhelming at the beginning, a teacher can implement Next Generation Science Standards first. As the case study highlighted, Next Generation Science Standards meet at least one requirement of culturally relevant pedagogy. Meeting one requirement is better than not meeting a single requirement. Once the teacher is more comfortable with lessons that meet the Next Generation Science Standards, they can begin making the small changes that are needed to make sure the lesson meets all the requirements of culturally relevant pedagogy. It is important to start implementing both Next Generation Science Standards and culturally relevant pedagogy as soon as possible so that the United States can start the process of preparing students for the innovative and rigorous STEM career fields ahead.

The requirement that the case study lessons fell short on the most was connecting the lesson to the community. It is important to remember that there are various communities students are a part of. These communities include but not limited to the classroom community, the school community, the local community, and the global community. To help connect lessons to community, teachers need to build a strong base knowledge about their students, and to build this knowledge, teachers need to do research about their students. One way to do this research is having students complete a survey at the beginning of the school year. This survey will ask students about their interests, career goals, family background, and extracurricular activities. By doing this survey, teachers will know some of their students' interests and be able to connect to students' lives in their lessons. In addition to having students answer a survey, teachers need to research into the community that the school is a part of. Teachers should look into local events, local issues, and large local clubs. This will give the teacher insight into the community that students interact with on a regular basis. Finally, teachers should look into social justice issues that are not just affecting the local community but also the global community. Students may feel strongly about some of these issues and will be engrossed in the lesson when these issues become part of the lesson. To learn about the community, it can be very overwhelming. To ease the research burden, teachers should ask other teachers what they know about the community, ask local officials or local community members.

To support and remind teachers to make the changes needed to make the NGSS lesson meet the requirements of CRP, the Next Generation Science Standards and Frameworks should be amended by adding an addition dimension that reflects the key aspects of culturally relevant pedagogy: mining information, learning collaboratively, and being involved in the community. By amending NGSS, science teachers will be able to design their lessons using one resource, which streamlines the planning process and makes the endeavor less overwhelming.

Conclusion

To prepare future students for the competitive STEM world they will be a part of after graduation, science teachers need to implement both the Next Generation Science Standards and culturally relevant pedagogy into their classroom. Through this implementation, students of color and their white classmates will both be able to succeed in the classroom, which is turn helps prepare them for the competitive STEM world they will be working in. By having prepared students, the United States of America will grow and be recognized as a STEM leader in the world again.

References

Askew, J., & Gray, R. (2016, November). Settling the score: Exploring the historic debate over atomic bonding. *The Science Teacher,* 49-54.

Committee on STEM Education National Science and Technology Council. (2013). *Federal science, technology, engineering, and mathematics (stem) education 5-year strategic plan.* Washington D.C: The White House.

Department of Education. (2016). *Giving every child a fair shot: Progress under the Obama administration's education agenda.*

Goldston, M. J. "., Pan, S., Boykin, K., Allison, E., & Wehby, S. (2016, February). Shedding light on the "science of small". *The Science Teacher,* 29-34.

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of african american chilren* (1st ed.). San Francisco, CA: Jossey-Bass Inc.

Ladson-Billings, G. (1995). But that's just good teaching! The case for culturally relevant pedagogy. *Theory into Practice, 34*(3), 159-165. Retrieved from http://www.jstor.org/stable/1476635

Loetter, C., & Taylor, L. (2016, September). Separating a mixture: Student build models to explain ionic interactions. *The Science Teacher,* 61-68.

Milner, H. R. (2010). *Start where you are, but don't stay there: Understanding diversity, opportunity gaps, and teaching in today's classroom*. Cambridge, MA: Harvard Education Press.

Mulvey, B. (2016, February). Finding patterns: A lesson on naming chemical compounds. *The Science Teacher*, 44-49.

National Center for Education Statistics. (2015). Trends in international mathematics and science study (TIMSS). Retrieved from https://nces.ed.gov/timss/timss2015/

National Research Council, Division of Behavioral and Social Sciences and Education, & Committee on Conceptual Framework for the New K-12 Science Education Standards. (2012). *Framework for K-12 science education* National Academy Press. Retrieved from http://lib.myilibrary.com?ID=365317

NGSS Lead States. (2013). Retrieved from http://www.nextgenscience.org/three-dimensions

NSTA. (2012). Why K-12 science standards matter- and why the time is right to develop next generation standards. Retrieved from http://ngss.nsta.org/why-standards-matter.aspx

O'Brien, W. (2015, April/May,). Making molecular movies. *The Science Teacher*, 29-34.

Pentecost, T., Weber, S., & Herrington, D. (2016, Summer). Connecting the visible world with the invisible: Particulate diagrams deepen student understanding of chemistry. *The Science Teacher*, 53-58.

Philppoff, J., Duncan Seraphin, K., Seki, J., & Kaupp, L. (2015, October). Chemical solitaire: Arranging cards to build an organizational model of the elements. *The Science Teacher*, 43-51.

Progress, 2. (2015). *Demographic growth of people of color.* Center for American Progress.

Rebecca Rittenburg, Brant G Miller, Cindy Rust, Jamie Esler, Rusti Kreider, Ryan Boylan, & Audrey Squires. (2015). The community connection. *The Science Teacher, 82*(1), 47.

Rodriguez, A. (2015). What about a dimension of engagement, equity, and diversity practices? A critique of the next generation science standards. *Journal of Research in Science Teaching*, *52*(7), 1031-1051.

Tillman Kennon, J., Fong, B., & Grippo, A. (2016, March). Does it mix? Introducing students to partition coefficients. *The Science Teacher*, 41-46.

U.S. Census Bureau. (2013). *Disparities in STEM employment by sex, race, and hispanic origin*.

U.S Census Bureau, Population Division. (2016). Annual estimates of the resident population by sex, age, race, and hispanic origin for the united states and states: April 1, 2010 to July 1, 2015 Retrieved from http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

Footnotes

[1] Culturally relevant pedagogy reinvigorated the conversation surrounding students of color and education, and this led to another teaching style, culturally responsive pedagogy, to be created. Like culturally relevant pedagogy, culturally responsive pedagogy was created due to students of color falling behind their white classmates and it was coined by Geneva Gay. There are four key parts-caring-- taking interest in students and recognizing their outside experiences, communication-- honoring students' variation in discourse and communication and allowing students to explain their information in their preferred discourse style, curriculum-- having meaningful and relevant curriculum that connects student learning and students' lives, and instruction-- using students' backgrounds as scaffolds and bridges to academic achievement but not as rigid labels (Gay, 2000). For this paper, I am going to use culturally relevant pedagogy for the basis of my research. While culturally relevant pedagogy and culturally responsive pedagogy is used interchangeably in literature, I have found that culturally relevant pedagogy overlaps with the Next Generation Science Standards and Frameworks, which will be discussed later in the paper, better.