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Building English Language Learner's Knowledge of Chemistry
Through Inquiry Based Learning

by

Sarah Maggard

A thesis submitted to the Department of Education and Human Development of The College at
Brockport, State University of New York, in partial fulfillment of the requirements for the degree
of Master of Education

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Sarah Maggard
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Chapter 1: Introduction

Rationale

The National Science Teachers Association's (NSTA) position statement states that, "all students, including those identified as English Language Learners, can and should have every opportunity to learn and succeed in science" (NSTA Position Statement, 2009). Since, the language of science is already difficult for most students, the difficulty for ELLs is even greater. Meeting students where they are at is the most crucial step in fixing the problem. The lack of knowledge in addressing ELLs in the classroom can interfere with the opportunities for them to engage in science and to think and talk like a scientist (Bruna et al., 2010). Science teachers need more information about language acquisition and skills to teach the language of science.

"English Language Learners and native speakers of English alike require a foundation of contextual knowledge before embarking on a learning task" (Pray & Monhardt, 2009, p.35).

ELLs are like general education students in that they need instruction that ties into their prior knowledge, experience and vocabulary. Teachers are inclined to think that new lessons need to be created to accommodate ELLs in the classroom. However, an English Language Learner can be taught the same lesson when specific strategies are implemented (Smith-Walters et al., 2016).

In order for teachers to meet the needs of ELLs effectively and confidently, scaffolding and inquiry based learning should be utilized. Professional development in strategies to assist ELLs not only with English language acquisition but, also in disciplinary language is needed to support educators. To support ELLs, a teacher should use multiple scaffolding techniques to aid scientific literacy. Also, a teacher should utilize inquiry based instruction to help English language learners make meaningful connections in the scientific content.

Inquiry based learning provides students with a learning enriched environment. Through inquiry, students gain a deeper understanding of concepts. Science instruction lends itself well to the idea of inquiry and it is often encouraged. Inquiry in the science classroom demonstrates how science investigation is carried out, therefore students are not just reading about science concepts. Rather they are investigating and learning about science concepts through hands on approach.

Significance

Teachers identify themselves as teachers who teach science, not as teachers who teach language causing the isolation of English Language Learners with different work than their English speaking peers, often watering down the content. Most teachers are not aware of how to differentiate for ELLs in their classroom causing ELLs to receive an unequitable education compared to their native English speaking peers. Isolation of ELLs in the classroom widens the achievement gap between English Language Learners and English speaking students.

With respect to widening the gap between ELLs and English speaking students, an article by Bruna, Vann, & Escudero (2010) discussed the need of bringing integrated instruction into the classroom, and address the nature of academic language so that this gap starts to close.

Scaffolding the inquiry lesson aids in English Language Learners constructing more meaningful connections to the science content. Language differentiation within a lesson will aid ELLs with making connections between their native language and the English language. This includes the use of their native language in worksheets and classroom posters to help aid with comprehension and attainment of vocabulary. Science provides a great opportunity to develop ELLs language skills with hands on activities and through inquiry based instruction.

Analogies are a tool used in most science classes to help students make connections between what they know and the content that they are learning. This is difficult for ELLs as the

analogies used are typically based on American culture, a culture that ELLs may not quite understand yet themselves. Therefore, it is important that there is an equivalent analogy used in the ELLs culture so that they are able to make the same connections that their native English speaking peers made. In addition to cultural relevant analogies, ELLs benefit from pictures that represent the science content they are learning. This is valuable when learning vocabulary. A picture of a flower looks the same across all languages and cultures. An ELL student can compare the vocabulary of the parts of a flower in their native language and in English to help attain scientific vocabulary. ELLs can also be given worksheets in their native language and in English or they can answer in both languages to help with the language acquisition.

When teachers simplify scientific concepts (watering down the content), they are not effectively helping ELLs as the assignments given are not equal academically (Sandefur et al., 2007). Teaching English Language Learners to think like scientists is nonexistent in a science classroom. In fact, these students are taught at a lower level. Unlike, general education students who are taught to think more like scientists, teachers tend to lower their expectations for ELLs (Bruna et al., 2010). Using Bloom's taxonomy will help aid teachers to ask questions at a higher level and strengthen ELL's critical thinking skills. By choosing questioning from all levels, a teacher is providing a more equitable educational experience for ELLs. Some tasks in Bloom's may be difficult for ELLs since they may not have the English vocabulary necessary to answer. This can be aided by asking the same questions in their native language so that they can make the necessary language connections. The mindset of the teacher impacts how well the ELL will succeed in the classroom. Lowered expectations do not accurately depict the knowledge and ability of the ELLs (Sandefur et al., 2007).

The goal of this capstone is to help teachers create inquiry based units that scaffold scientific literacy with a specific focus on English Language Learners. Teachers can use this resource as a way to help them gather specific information about their ELL, how to use that information to their advantage, consider ways to differentiate, include the NGSS framework, and ways to assess their ELL effectively. My project will help teachers gather their thoughts, and think deeper as they help ELLs in their chemistry classroom.

Definition of terms

- English Language Learner (ELL): a student whose first language is not English
- Next Generation Science Standards (NGSS): set of science standards to engage students in science and engineering practices
- Scaffolding: Introducing skills or topics that build student knowledge
- Inquiry Based Learning: engages students in scientific practices where they construct their own knowledge of the content with the help of a facilitator

Chapter II: Thesis

Abstract

English Language Learners (ELLs) are becoming more prevalent in classrooms across the United States. This diverse group of students is not receiving an equitable education in comparison to their native English speaking peers, causing an area for concern. Science is one of the most problematic courses that these students are not adequately instructed in. Teachers may not be prepared for ELLs in their classrooms, and need help with adequately addressing this group of students in their classrooms. The literature expresses the need for specific differentiation for ELLs in the classroom. Inquiry based learning aids in second language acquisition and provides an academic setting for deeper learning than traditional teaching for English Language Learners.

Keywords: English Language Learners, Secondary Science, Equity, Inquiry Based Learning

Building English Language Learner's Knowledge of Chemistry Through Inquiry Based Learning

Walk into any classroom and you will see a diverse student body with their own learning styles and interests. Diversity in classrooms is only increasing as more English Language Learners (ELLs) enter US classrooms (Carr, Sexton & Lagunoff, 2007). An ELL is defined as “a student who is not fluent in English or is unable to effectively learn in English without support; often these students come from non-English speaking homes and backgrounds. Most ELLs require modified instruction” (Glossary of education reform, 2013). In the past decade, ELLs have become more prominent in US schools. The number of ELLs in US schools has increased by 51% and is projected to make up about 40% of the student population by the year 2050 (Ardasheva, Norton-Meier & Hand, 2015).

The purpose of science education is to foster knowledge of science. Such an education should set all students up to become more scientifically literate, and develop the skills needed to pursue a career in a science, technology, engineering, or mathematics (STEM) related field (Carr et al., 2007). This paper will discuss the learning of English Language Learners in a United States science classroom. Topics to be discussed include major challenges for ELLs and their teachers, how ELLs learn best, effective strategies for teachers to adequately educate science ELLs, the Next Generation Science Standards demands on ELLs and how to assess an ELL in the classroom.

This paper will discuss how inquiry aids English language learners in developing science literacy through scaffolding. Guided and structured inquiry provides a deeper understanding of scientific phenomena over conformational inquiry. Open inquiry is a difficult task for most high school students, however when properly setup, this form of inquiry provides the deepest

understanding of scientific phenomena (Buntrum, Lee, Srikoon, Vangpoomyai, Rattanaavongsa & Rachahoon, 2014). With the strategies that teachers utilize and inquiry, ELLs can build their scientific literacy while deepening their understanding.

Challenges

Cultural Challenges ELLs Face

Crossing the US border is the first challenge that foreign families can face. Once, living in the US, these families are then exposed to constant challenges in everyday life as they try to fit into the US society. These obstacles are rooted in culture, and have an impact on education. Early in their education, ELLs may have frequently moved around and as a result, their attendance in school may have been sporadic. Therefore, these students may come into US classrooms unprepared and already behind in their schooling. ELLs could also be from a country where formal education was not as easily accessed. This could be the first time these students have set foot into a classroom (Patel, 2013). The experiences that these students bring with them into the classroom influence how they will learn and how much support they will need (Franquiz & Salinas, 2013).

Parents may push their students to achieve success academically, if their culture values education as a tool for a better life. This causes these parents to take more of an interest in the development and success of their child academically. However, if the culture doesn't place a high value on education the opposite is true, (Souto-Manning, 2010; Bruna, Chamberlin, Lewis, & Ceballos, 2007) the parents will not be engaged in the student's education. For example, an ELL from rural Mexico can have a different culture and set of educational values compared to a student from the United States. These values will ultimately form the student's perspective of education and often dictates how involved the parents will be. Most immigrants from rural

Mexico had to prioritize survival, and education became a luxury of secondary importance. Therefore, Mexican (rural) immigrant parents rarely feel the need for their children to pursue an education. Since, there was little to no formal schooling for these students, their skills in their own language may be lacking (Bruna et al., 2007).

Patel (2013) discussed that most immigrant families try to hold onto their native cultures and heritage as much as possible. For an English Language Learner, this causes them to be caught between two cultures, their native culture and the US culture. The student tries to acclimate into the culture of his or her peers while still participating in the family culture as well. This balancing of the two cultures often adds stress to the student and a feeling of not being understood. For example, achievement in the US is attributed to the individual, where as in China achievement is attributed to the collection of people who helped with the achievement. A Chinese ELL may find it difficult to understand the way Americans celebrate success. In contrast, an American student may not understand why Chinese students celebrate the achievement of an individual, as a team (Franquiz & Salinas, 2013).

Challenges faced in School

General education students, or English speaking students are not always aware of why ELLs are in need of so much support. Often, general education students see their English language learning peers as ordinary students that speak a different language. This disconnect ultimately separates these two groups of students within a school. ELLs need support in school in order to participate in a predominately English classroom. An ELL is a student with special needs as they need help not only in their classes but with acquiring a new language. ELLs may find it hard to befriend their new peers for fear they will not be accepted (Souto-Manning, 2010). If these students attend multiple schools during the year or if they miss a lot of school days then

they may not see the value in making friends. On the other hand, if there are multiple ELLs who speak the same language, these students feel more comfortable conversing with those peers, and consequently feel no need to make friends or converse with English speaking peers (Franquiz & Salinas, 2013). School provides an environment where socialization with English speaking peers influences an English Language Learner's English language acquisition, but only if the ELL student takes advantage of this opportunity. ELLs benefit from conversing with English speaking peers by practicing the language in a neutral environment (Souto-Manning, 2010). However, if the ELL student does not interact with English speaking peers then language acquisition may progress slowly.

Linguistic Challenges

Literacy status in the native language will have an impact on the learner's understanding of the new language. If a student is not well versed in their native language, their acquisition of a new language will be compromised, and the process will be long and frustrating. On the other hand, English acquisition can be a smoother transition if the learner is well versed in their native language. Due to how the brain processes language, the age of the learner plays an important role in how well they acquire a new language. Thus, at a younger age a learner will pick up the new language quicker than an older student (Paradis, 2016). Likewise, a student who comes into the classroom already able to speak multiple languages will tend to a new language a lot quicker; since their brains are able to process new languages more efficiently than a student who is learning a second language for the first time. However, if the student is from a culture where the native language is pictorial or symbolic, a Chinese ELL for example, may have a difficult time with the English language as they are used to symbols rather than alphabetic letters (Paradis, 2016).

Conversational language uses social conventions to learn the new language, often providing enough information about the language for the learner to survive in society. Academic language is more involved and specific which often challenges the learner (Sandefur, Watson & Johnston, 2007). This main difference causes ELLs to be able to speak English well with their peers but not comprehend content in the classroom. The difference here is that social conversation relies more on communication skills whereas academic language is more cognitive (Sandefur et al., 2007). Children learn conversational language first as they learn the language of their parents then acquire the academic language.

Challenges Faced in Science

English Language Learners in science face dual tasks, learning scientific language in addition to English. When a language barrier already exists, demands of learning science can become a daunting task for an ELL. Many ELLs may have more support at home or with their peers linguistically with conversational language, versus scientific language, as it is not a standard language the average person uses day to day. Specialized language in science contains vocabulary with different meanings, which can be confusing to ELLs (Jimenez-Silva, Rillero, Merritt, & Kelley 2016). Everyday words that the English Language Learner may know could be misunderstood in a science context. Making vocabulary assessable to ELLs provides them with more of an opportunity to participate and gain a deeper understanding of the science content (Bresser & Fargason, 2013).

Specialized vocabulary definitions are more precise than the meanings of everyday words. Most students shy away from science due to its language complexity, and the increased amount of exposure to new vocabulary within a science unit. Resulting in the students' struggle to remember the vocabulary causing the application to fall short (Carr et al., 2007). Science is

also deeply rooted in argumentation and reasoning. These aspects are not always included in other content areas.

Challenges for ELLs with the Next Generation Science Standards

The Next Generation Science Standards (NGSS) has examined the need for students to follow science-specific literacy practices essential for student learning in science. This poses a challenge for ELLs due to the demands of the science literacy coupled with literacy in English. NGSS wants all students to be able to ask questions, construct explanations, engage in argumentation based on evidence and then effectively communicate information (Ardasheva et al., 2015). All of these expectations pose a challenge to ELLs due to the language demands within science. These expectations force students to manipulate and engage with information, when a student is limited in the language this task becomes more challenging and frustrating.

Challenges Teachers Face Teaching ELLs

When an English Language Learner walks into a classroom, teachers are not often versed in how to teach an ELL science. Teachers are generally concerned with teaching course content to general education students, providing less support to a student with limited English understanding. Therefore, teachers may have a negative mindset when it comes to instructing ELLs in their classroom. In an article written by Lew (2016), teacher's identities were addressed. Teachers identify themselves as teachers who teach science, not as teachers who teach language, causing the isolation of ELL students with different work than their English speaking peers, often watering down the content. Isolation of ELLs in the classroom widens the gap between English Language Learners and English speaking students.

With respect to widening the gap between ELLs and English speaking students, an article by Bruna, Vann, & Escudero (2010) discussed the need of bringing integrated instruction into the

classroom, and address the nature of academic language so that this gap starts to close. When teachers simplify scientific concepts (watering down the content), they are not effectively helping ELLs as the assignments given are not equal academically (Sandefur et al., 2007). Teaching English Language Learners to think like scientists is nonexistent in a science classroom. In fact, these students are taught at a lower level. Unlike, general education students who are taught to think more like scientists, teachers tend to lower their expectations for ELLs (Bruna et al., 2010). The mindset of the teacher impacts how well the ELL will succeed in the classroom. Lowered expectations do not accurately depict the knowledge and ability of the ELLs (Sandefur et al., 2007).

Most teachers are not equipped to teach ELLs in their classroom, which may cause reluctance on their part to teach a student with special language needs. Teachers are given strategies and tools to help students who are already proficient in English but not for students who have a limited proficiency in English (Smith-Walters, Bass & Mangione, 2016). Sandefur et al. (2007) stated, “Supporting second language acquisition in the classroom can be an overwhelming and complex task for a teacher to have dropped on them” (p. 43). If teachers were more aware of how to effectively differentiate their instruction to include English Language Learners, they may feel more at ease when an ELL walked into their classroom. Providing teachers with the tools to diversify their lessons to include ELLs could ease an educators’ frustration and allow them to effectively teach all students.

English language learners create experiences with academic texts and language through the academic tasks provided. Santana-Williamson (2014) determined that through academic and scaffolding tasks ELLs are able to create experiences that aid the development of language which ultimately aids in comprehension of the content material. This is crucial for science classes as

students need to be able to learn the language of science in order to be successful. The dual task for ELLs to learn English and the language of science can be achieved by allowing ELLs to acquire the English language in conjunction with learning science.

Two theories describe how experience and academic tasks promote second language acquisition; output hypothesis and cognition hypothesis (Robinson, 2011). These theories each provide an argument that teaching language through experience provides a more inclusive learning environment for English language learners. Promoting the acquisition of a second language through direct experiences depend on input and output language tasks. Literacy skills that students need to be successful in any content area are considered input language tasks. Examples of the tasks include, reading skills, decoding skills, comprehension and listening skills (Robinson, 2011). Output language tasks are those that students use to communicate their understanding such as writing and speaking. These input and output learning tasks are the foundation of learning language according to Robinson (2011). When instruction focuses on these tasks and experiences second language acquisition is achieved while the student is learning the content.

Output Hypothesis

Focusing on second language acquisition through outputs allows the English language learner to construct meaning in English by strengthening their communication skills. Tasks and experiences aid the learner to self-reflect on their own learning and understating of the content they are learning. Robinson (2011) argues that by producing the second language, ELLs begin to notice where they lack in understanding of the target language as the gap between what they want to say and what they are able to say is noticed. Consequently, the ELL is able to recognize what they know and what they don't know and is provided the opportunity to test their

understanding of the second language. Therefore, through communication an ELL is able to strengthen their second language acquisition through testing their understanding of the second language as they communicate their knowledge of the content. Inquiry forces students to communicate their findings and understandings of the science content through increasing the complexity of the task. Increasing the amount of reasoning the task requires, forces English language learners to use the target language and promotes cognitive reflection (Robinson, 2011).

Cognition hypothesis

Increasing the language demand must be done with a strategic sequencing of tasks to aid in the second language acquisition through the learning of academic content. The cognitive hypothesis suggests that the implicit sequencing of tasks offers optimal support for second language acquisition as it reflects the cognitive order that occurs naturally as children learn their first language. Increasing the complexity of the academic task allows learners to attempt to use accurate and complex language at the level needed to meet real-world target task demands (Robinson, 2011). It is important that ELLs are able to use their native language to support their second language acquisition as it supports their cognitive development in the second language acquisition. Inquiry based learning provides a cognitive foundation for learning a second language as the tasks allow ELLs to use language to communicate their understanding of the content. ELLs are forced to reason through the scientific phenomena further demanding a more cognitive connection to language and learning.

What needs to change?

The National Science Teachers Association's (NSTA) position statement states that, "all students, including those identified as English Language Learners, can and should have every opportunity to learn and succeed in science" (NSTA Position Statement, 2009). Since, the

language of science is already difficult for most students, the difficulty for ELLs is even greater. Meeting students where they are at is the most crucial step in fixing the problem. The lack of knowledge in addressing ELLs in the classroom can interfere with the opportunities for them to engage in science and to think and talk like a scientist (Bruna et al., 2010). Science teachers need more information about language acquisition and skills to teach the language of science.

“English Language Learners and native speakers of English alike require a foundation of contextual knowledge before embarking on a learning task” (Pray & Monhardt, 2009, p.35).

ELLs are like general education students in that they need instruction that ties into their prior knowledge, experience and vocabulary. Teachers are inclined to think that new lessons need to be created to accommodate ELLs in the classroom. However, an English Language Learner can be taught the same lesson when specific strategies are implemented (Smith-Walters et al., 2016).

A study by Valdiviezo (2014) found that teachers need to be taught how to address student diversity through multicultural examples in order to reach their ELLs. To do this, teachers need to become familiar with their ELL student’s culture and background so that they can build a better rapport. In this way, teachers can acknowledge success in language acquisition and science knowledge even if the test scores don’t necessarily show it.

In order for teachers to meet the needs of ELLs effectively and confidently, teachers need tools to differentiate teaching, assignments, and assessments. Professional development in strategies to assist ELLs not only with English language acquisition but, also in disciplinary language is needed to support educators. This support can change a teacher’s mindset from teachers of science to teachers who teach all students science. A professional development program that equips teachers to teach ELLs will further benefit teachers and this diverse student

body (Lew, 2016). The mindset that ELLs are unable to learn science content through inquiry also needs to be addressed and changed.

How English Language Learners Learn

Every student learns differently. What works for one student may not work for another. Student's diverse learning styles should drive the teacher's decision on instruction, assignments, and assessments. ELLs are no different than general education students, when it comes to learning new information. Differentiation is imperative to reach all learners (Cho and McDonnough, 2009). Language barriers and cultural differences separate ELLs from English speaking students. English Language Learners benefit from instruction that fosters prior knowledge, native language, and literacy skills (Smith-Walters et al., 2016). ELLs are not blank slates when they come into the classroom, they bring with them their experiences and knowledge of the world. In order for ELLs to learn science content, educators need to bring these experiences and prior knowledge into instruction (Smith-Walters et al., 2016). Using examples in the US culture is not beneficial for English Language Learners. Therefore, using examples that are relevant to the ELLs culture provides a way for the student to connect the content to their prior knowledge. Relating science concepts to prior knowledge and culture is an effective strategy for students to make connections between their world and the content. Students can be encouraged to create their own cultural analogies to the content to help deepen their own understanding (Yu, 2013).

Prior knowledge helps students construct meaning and comprehend what they are learning. As with most students, ELLs develop misconceptions that also need to be addressed. Addressing student's prior knowledge and misconceptions provides a stronger foundation for learning new content. Activating student's prior knowledge provides valuable information about

where the student is in their skills and knowledge on a subject, allowing a teacher to meet them where they are academically. Science concepts are concrete facts that have been discovered and tested experimentally. These fixed answers help English Language Learners to be at ease when they are answering questions, as there is only one correct answer. Prior understanding of American culture is not necessarily needed, as the answer would be correct in the student's culture as well (Cho and McDonnough, 2009). "Aligning what is taught to previous instruction, background knowledge of students, and developmentally appropriate learning outcomes are essential for English Language Learners to learn. ELLs and their peers must be able to see the story of science in and around their lives. In order to do this, they need to understand how science operates not only in the classroom, but also in their lives" (Fathman & Crowther, 2006).

Science knowledge an ELL learned in their native language will help them learn science content in English. An English Language Learner's ability to translate skills and knowledge learned using their native language is a valuable asset (Swanson, Bianchini, & Lee 2014) as they make connections between the two languages. Therefore, it is beneficial to have ELLs learn the science content in English with the support of their native language. A study by Swanson et al. (2014) found that by providing visuals with wording in both languages helped students make connections faster than just leaning about the concepts by reading about it in English. Yu (2013) discussed that by incorporating both languages in the classroom motivation and a willingness to attempt assignments are increased. The ELLs comprehends more and is engaged while learning. This is an example of differentiating instruction to support an ELL student in a science classroom while building their confidence.

A study by Adams, Jessup, Criswell, Weaver-High & Ruston (2015) found that students conversed in English during the times of low cognitive demand and they typically switch to their

native language as the cognitive load of the task increased. The researchers concluded that this is due to students having more conversational dialogue early on while the cognitive load is low such as reading or explaining instructions. However, as the cognitive load increases the ELL students switch to their native language to alleviate the task of switching their thoughts into English. The researchers found that it is easier for ELLs to think in their native language than it is in English. They further explain that this switch in language could be an important indicator into how ELL students are handling the course content. Teachers can encourage ELL students to use English while the cognitive load is light and their native language if they need to while the content becomes more intense to understand. A balance of languages within the classroom seems to be the best practice for ELLs to learn content.

Structured and guided inquiry makes it possible for students to focus on the explanatory mechanisms and the underlying principles of a phenomenon instead of exerting energy in a daunting task of learning English and content at the same time. By allowing students to engage in dialogue in both English and their native language, ELLs are allowed to use their native language to support their learning in English. Once ideas, explanations, and understanding is formed in the student's native language then the student can formalize that understanding into English without falling behind the rest of their peers in their achievement. As stated in the article by Adams et al. (2015) a study by Rollnick and Rutherford "found that students' use of native language during science investigation promoted more through exploration of the phenomena and greater propensity to communicate different ideas, including alternative conceptions."

More focus on how to structure lesson plans and less focus on the ELL label of the student is the only way to aid English Language Learners learning the science content at a deeper level. Students can have a deep understanding of scientific concepts but are limited in their

ability to express this understanding. Language scaffolds, and supports should be maintained to provide ELLs the opportunity to share their learning (Carr et al., 2007).

All students need to make sense of the natural world; science helps them piece phenomena that they experience every day. English Language Learners need to be able to draw on their prior knowledge first in their native language and then translate that into the second language. This prior knowledge helps them piece together how science and the natural world are connected. Incorporating scientific literacy into basic everyday life experiences allows all students especially ELLs to link what they know to what they are learning.

Learning Environments

The learning environment within a classroom affects all students, but it has a dramatic effect on ELLs. Most ELLs can be insecure since, they are learning English in conjunction with the science content. A safe learning environment helps students to take risks and feel valued (Fayon, & Duranczk, 2010). A risk free environment where validation is prevalent fosters a growth mindset creating a motivation to learn and an allowance to make mistakes. A risk free environment supports an ELL with second language acquisition. Language development is heavily supported through a positive social environment (Sandefur et al., 2007).

Creating a learning community within the classroom helps ELLs to be more actively engaged in the learning process and fosters greater self-awareness (Fayon, & Duranczk, 2010). Bridging the gap between ELLs and their English speaking peers, through small group learning benefits English Language Learners by promoting them to challenge and share their ideas in a less intimidating environment. A sheltered learning environment provides meaningful interactions between students. Frequent, interactions support a greater exposure to the English

language for ELLs in science content through discourse with their peers and teachers (Pray & Monhardt, 2009).

Teaching Strategies

Teachers utilize teaching strategies to differentiate instruction for their students. Most of these teaching strategies also benefit ELLs, by providing support for these students science knowledge can be attained. It is important to remember that the strategies that help students with disabilities and ELLs also help general education students. Scaffolding aids students by building their skills through a series of steps. For language, scaffolding allows students to confidently complete tasks on their own. For scaffolds, the teacher should model their expectations so that ELLs understand what is expected of them. This technique provides multiple strategies to bridge the learning gap. The most helpful strategies that scaffold the learning of an English Language Learner are text modification, modeling, visuals, and graphic organizers (Carr et al., 2007). The utilization of task centered lessons supported deeper comprehension of science content through important connections between prior knowledge and new knowledge.

Text Modification

Teaching strategies need to help students meaningfully listen, speak, write and read to satisfy content standards (Carr et al., 2007). Teachers can modify the text that they give ELLs to aid in comprehension. The text is put into a simpler format for ELLs through modification. A teacher could supplement the text with a translation in the student's native language (Swanson et al., 2014). An outline is a great example of a modification for ELLs as the key points and information is pulled out (Smith-Walters et al., 2016).

Visuals

Visual actions help these students construct meaning within the content. Also, this can help engage students by having them physically demonstrate or visually represent their understanding. Visuals help students understand content without the use of language. ELLs make meaningful connections within science content when they are able to see a picture with the description in English and in their native language (Yu, 2013). Abstract concepts in science are easier to understand through the use of visual aids.

Hands on activities and manipulatives are another useful tool to engage all students. For ELLs, providing an opportunity for them to use their senses facilitates a more meaningful learning experience. Students who do science rather than read or hear about scientific phenomena ultimately retain information better (Smith-Walters et al., 2016).

Graphic Organizers

Providing graphic organizers is a way to help English Language Learners organize their thoughts and understanding in a conceptual manner (Carr et al., 2007). Since, vocabulary is an obstacle for ELLs, teachers can utilize specific graphic organizers that target the precise vocabulary. Scaffolding can include graphic organizers such as: systematic maps and word sorts to enhance vocabulary for an ELL. Word sorts aid in making connections between the vocabulary terms. Depending on the teacher's goal, vocabulary words can be presorted into categories or left up to the student. When the student is expected to categorize the vocabulary words, pattern recognition and deeper connections are made (Smith-Walters et al., 2016). Systematic mapping is a second vocabulary tool for ELLs to use. This strategy has the students visualize the vocabulary term and brainstorm key words that are associated. Both of these strategies help ELLs to explore the content, expand their understanding and knowledge, and experience the scientific meanings of the words.

Task-Centered Lesson Planning Model

Santana –Williamson (2012) developed a task-centered lesson planning model where every written or oral test was approached with academic and scaffolding tasks. As a result of her case study, she concluded that a task centered approach strengthened ELLs skills in academics and language. This model helps address the need for ELLs to prepare for future academic classes. Academic learning tasks maintained a focus on the content challenges, choosing tasks that build upon the skills and language needed for ELLs to be successful. Scaffolding tasks were considered in order to close the achievement gap between ELLs and their native English speaking peers, Santana-Williamson (2012) utilized paraphrasing and identification of essential vocabulary to help ELLs to “close the gap” academically with their native English speaking peers. Preparing students to read and paraphrase rather than memorize texts aided in deeper comprehension of the academic texts. On the same token, teaching ELLs to identify essential vocabulary provided a way for ELLs to learn the academic language and make connections. These scaffolding tasks aided in ELLs to develop stronger reading skills so that they can comprehend what they are reading and write with academic sophistication.

Inquiry Based Learning

Inquiry based learning provides students with a learning enriched environment. Through inquiry, students gain a deeper understanding of concepts. Science instruction lends itself well to the idea of inquiry and it is often encouraged. Inquiry in the science classroom demonstrates how science investigation is carried out, therefore students are not just reading about science concepts. Rather they are investigating and learning about science concepts through hands on approach. Buntrum, et al., (2014) describes inquiry as a process that resembles the methods that real world scientists use in scientific investigations. Buntrum et al. (2014) further explains that

inquiry encourages acquisition of science content and process skills which are important to learning scientific phenomena. Furthermore, scientific inquiry provides an avenue for teachers to gain student interest through investigations that satisfy student curiosity. Students are able to explore scientific phenomena in a more authentic learning environment than traditional instruction where they read about it and memorize scientific facts (Buntrum et al., 2014).

However, most teachers find themselves equating hands on activities to inquiry. Buntrum et al. (2014) expresses that hands on activities that do not have explicit attention drawn to research questions is not inquiry. Inquiry is based on discovering answers to scientific question through investigations. A study referenced in Gooding & Metz (2012) found that inquiry based activities and instruction led to more student questioning and reflection than basic hands on scientific activities. The study also found that conceptual change happened less with hands on activities compared to inquiry based activities leading to the conclusion that deeper scientific learning and connections were being made for students participating in inquiry. Students are more engaged in science as a result of inquiry based learning. “The actual doing of science or engineering can peak students’ curiosity, capture their interest, and motivate their continued study” (Gooding & Metz, 2012).

The question, why don’t teachers implement inquiry based learning in their classroom arises. Researchers have found that the cause is based on the fact that there is a continuum of inquiry that doesn’t provide a set way of teaching or creating lessons (Bianchi & Bell, 2008). The amount of specific instruction given to students varies among the four levels of inquiry. Most teachers find that this creates more work for them and that the traditional method of teaching science is easier and less time constrictive than inquiry lends itself to be.

The four levels of inquiry are conformational, structured, guided and open. As you go from the lowest level (confirmation) to the highest level (open) inquiry, the teacher's role is diminished and students have more responsibility in their learning (Buntrum et al., 2014; Bianchi & Bell, 2008). Confirmation inquiry is the traditional cookie cutter labs where students are given the procedure, the research question and the results are known in advanced. Students are confirming scientific phenomena that they have previously learning. Structured inquiry provides students with the questions and procedures, but, the students come up with the explanation as to how the scientific phenomenon exists and the relationships pertaining to the concept being explored. For guided inquiry, students design the procedures to investigate a question that the teacher proposes. The students then explain how their results provide further information about the scientific phenomena being explored.

Lastly, open inquiry provides students the opportunity to develop their own questions, procedures, and communicate their results (Bianchi & Bell, 2008). Ultimately the progression of teacher structured instruction diminishes into a more student structured environment allowing for students to take on the role of scientist in a more authentic scientific environment. Gooding and Metz (2012), discussed the process of shifting from conformational inquiry to more structured and guided inquiry. The shift speaks to making subtle changes to how the activities are carried out, introduced and to student responsibilities. They suggest a rearrangement of the lesson to lend to more of an inquiry setting rather than confirming what the students already know.

For example, instead of providing all the information on scientific phenomena, students are expected to come to the conclusions through experiments and observations. Teaching this way allows students to gain a deeper understanding of the science concept. Providing students with less information is also a strategy to guide students to more of an inquiry based learning

experience. Having students come up with how they are going to investigate a question posed by the teacher is a step in the right direction. Having students pose the questions and developing a process to help them find the answer is the highest level of inquiry as students are expected to discover for themselves the scientific phenomena. As teachers provide opportunities for different levels of inquiry, students will be better-rounded in their understanding of science content (Gooding & Metz, 2012). “Reading, vocabulary development, writing, discussions, editing, research, and so on should follow and complement the activity or investigation. This suggested procedure may not be appropriate in all cases, and providing a variety of learning strategies will help differentiate the teaching methods” (Gooding & Metz, 2012).

Guided and structured inquiry seems to be more in the comfort level of teachers however most teachers shy away from these two levels of inquiry and stay within the conformational cookie cutter activities and labs (Buntrum et al., 2014). Researchers have found that structured inquiry provides a reasonable avenue for students learning scientific phenomena. In comparison, guided inquiry provided a more beneficial avenue for science knowledge attainment and skills. Researchers concluded that this difference is based on the level of student engagement in the different levels of inquiry activities. The students take more away when they are required to do more in their learning rather than taking a more passive role (Buntrum et al., 2012).

Gooding & Metz (2012) suggest that teachers should ask themselves the following questions to transform their “cookbook” laboratory experiments or activities into more of an inquiry based task, “Can some of the recipe be eliminated or selectively altered to allow for decision making on the part of students? Could the responsibility for selecting and gathering materials be given to students? Could students create the procedure, collect data, or even craft a data display? Could low-level knowledge questions be transformed into higher-level synthesis

and application questions? Could students apply their findings in appropriate extension investigations or suggest alternative solutions themselves?” These questions guide teachers to make adjustments to their teaching as well as to activities implemented in the classroom. Making the classroom more student centered is the goal with inquiry therefore, teachers should have students perform demonstrations, offer explanations and express what they are thinking. This provides a setting where ELLs are able to develop language skills and content skills while learning is facilitated.

Inquiry and English Language Learners

An overlaying assumption that English language proficiency is a prerequisite for learning science content has influenced teachers using more of the traditional approach with English language learners as they teach science content. On the contrary, inquiry based learning can provide an enriched environment for these students to learn even when there is a language barrier. Hands on learning (through inquiry) provide ELLs with opportunities to acquire the English language while they are learning about science concepts. Meaningful connections are made, ELL students learn by doing rather than through a traditional approach, they are able to apply their learning to different situations, and they have important peer interaction (Bergman, 2011).

The achievement gap between mainstream and not-English students continues due to the lack of instruction that targets teaching students who are learning English for the first time according to Fradd, Lee, Sutman & Saxton (2001). A focus on literacy development has made a step in the right direction for closing this achievement gap. Fradd et al. (2001) promotes that inquiry should be built throughout the school year. A gradual release with inquiry is beneficial for ELLs as it helps build their comprehension and participation as ELLs acquire English

through learning science. Students are able to represent their ideas, data and findings through multiple ways. This form of communication is crucial for ELLs to be able to express themselves in their work. (Fradd et al, 2001). There is a shift from “communicating at a personal, concrete level to using a variety of forms of representation to express both concrete and abstract understandings. Instruction needs to include explicit focus on literacy development, ELLs are often excluded” (Fradd et al. pg 492).

Next Generation Science Standards

Teaching science is more than just using strategies to aid student learning. A teacher of science also needs to utilize effective teaching models that align with the standards. As New York is on its way to adopting the New Generation Science Standards (NGSS), teachers need to be aware of what these standards are expecting of students. ELLs have been excluded from science, technology, engineering and math (STEM) opportunities in the past. NGSS provides a path for students to pursue STEM opportunities with confidence. The focus of these standards has students recognize how the science content explains the natural world (Miller, 2015; Lee et al., 2014).

The goal of the NGSS is to have students of all ages engage in science and engineering practices. With the crosscutting concepts, ELLs are able to work further on their scientific literacy and discourse in multiple ways as they make connections within the science. Crosscutting concepts recur throughout the year and demonstrate how science relates to the real world (Miller, 2015). The NGSS requires students to understand how to explain phenomena and design solutions to problems. NGSS points to practices that are involved in argumentation, explanations, questioning and communicating ideas. For ELLs, NGSS can help them with their language skills in reading and in speaking (Smith et al., 2015).

The goal of the NGSS is to provide a better opportunity for students who are typically overlooked and underserved in the traditional classroom. Appendix D of the NGSS addresses the need for more diversity and equity in the classroom. Diversity and equity in conjunction with three dimensional learning provides a way for ELLs to excel in a science dominated classroom (Lee, Miller & Januszyk, 2014).

Assessment

Assessment comes in two forms: formative and summative. Each is used depending on the goal of the teacher. Formative assessments are used to gauge student learning progress during instruction. These assessments provide immediate feedback if a student understands the content. The most popular forms of formative assessments: are thumbs up and thumbs down, color coded cards, and white boarded responses. These quick and easy methods, to check for understanding, provide essential feedback to the teacher about student during the lesson. For ELLs, these techniques provide a way for them to demonstrate their understanding in a non-intimidating way (Carr et al., 2007).

A summative assessment on the other hand, is a test at the end of a unit that covers what has been taught. A written test that is full of multiple choice and short answers is the typical form of assessing students in science. This traditional test style focuses on whether or not the answer is right, not so much what the student knows. For an ELL these types of assessments can be troubling with their limited proficiency in English (Carr et al., 2007). Therefore assessments for English Language Learners should be differentiated so that they can demonstrate what they know.

Teachers can utilize multiple techniques for summative assessments. These accommodations provide a way for ELLs to demonstrate their knowledge without giving them

an advantage over native English speaking students (Carr et al., 2007). Having a verbal assessment is easier for an ELL. Retelling verbally allows ELLs to demonstrate their understanding of the science concepts (Faggella-Luby et al., 2016). Teachers are then able to identify misunderstandings and misconceptions that may have been overlooked in a written test. A study by Faggella-Luby et al., (2016) found that when teachers use this form of assessment, ELLs scored higher than if they took a traditional exam. There are limitations to this type of assessment, mainly time constraints.

However, to strengthen ELLs reading and writing, test prompts that are scaffolded help students to gather their thoughts. Pictorial instructions aid ELLs in understanding what is being asked of them. Equitable assessments elicit student understanding by challenging them to think about difficult ideas. Scaffolds in assessments provide an opportunity for ELLs to respond to a question that had the potential to go unanswered because of linguistic misunderstandings (Siegel, 2014). The accommodation that the teacher chooses should be based on the needs of the ELL so that they can effectively demonstrate their content knowledge.

Lastly, assessing students who are English Language Learners should also be done in a way that provides equity among all students. The goal of assessments is for students to demonstrate their understanding and knowledge on a subject (Faggella-Luby et al., 2016). Due to their lack of English proficiency, science exams could easily become a language comprehension exam, providing an unfair advantage to native English speaking students. Equitable assessments can provide an equal opportunity for ELLs to demonstrate what they know (Siegel, 2014). Therefore, teachers need training in creating equitable assessments that foster testing content knowledge of all students.

Recent research in high stakes testing has found that ELLs perform poorly on content area exams such as science and math due to a lack of academic vocabulary and English literacy (Huerta & Jackson, 2010). A low test score seriously impede English Language Learners' motivation to stay in school, and is evident in the high dropout rate of English language learners. Building vocabulary and English literacy through meaningful classroom experiences has lowered the dropout rate. Inquiry based instruction allows ELL students to gain more meaningful experiences with the scientific content, and supporting students as they construct their own knowledge while teachers facilitate and guide investigations. Teachers can further aid ELLs in inquiry based instruction by using scaffolding techniques that help them make critical connections between their prior knowledge and what they are learning. Huerta & Jackson (2010) further explain that inquiry provides ELLs with a natural teaching ground for them to build vocabulary and English proficiency through tactile experiences. Also, they state that inquiry is a gateway for ELLs to use the English language to help them construct better understanding of the scientific content. Student motivation is increased as they are able to strengthen their English skills alongside their scientific skills. Acquiring spoken and written languages directly linked to developing higher thinking skills.

Summary

Classrooms in the United States are becoming more diverse and it is time for educators to be prepared to embrace these ELLs in their classrooms. ELLs and teachers each face their own set of unique challenges, due to cultural and linguistic factors. English Language acquisition can be attained while the ELL is learning science. Research has shown that these students learn best with linguistic supports put in place. Providing ELLs with examples specifically relating to their

culture, and translations in their native language in conjunction with English, benefits these students in a science classroom.

The literature urged that diverse accommodations in the classroom support ELLs with the scientific content. Expecting that an English Language Learner will do poorly in a science classroom is a fixed mindset, and must to be addressed. Much like providing ELLs with cultural and linguistic supports, a teacher can assist an ELL through scaffolding the content and assessments. Utilizing these scaffolds provides an ELL a more equitable education. The new science performance standards stated in the NGSS, places high expectations on all students. Under these performance standards ELLs are expected to be able to argue and explain their knowledge.

Professional development in strategies to assist ELLs not only with English language acquisition but, also in disciplinary language is needed to support educators. Focusing on how to modify teaching strategies to meet the needs of ELLs in a science classroom is a step in the right direction. Inquiry based learning can provide an enriched environment for English Language Learners to learn even when there is a language barrier. Hands on learning (through inquiry) provide ELLs with opportunities to acquire the English language while they are learning about science concepts. Meaningful connections are made, ELL students learn by doing rather than through a traditional approach, they are able to apply their learning to different situations, and they have important peer interaction (Bergman, 2011). Guided and structured inquiry is the best strategies to use engage ELLs in the science classroom. However, teachers need to take the initiative to apply inquiry coupled with learning strategies in their lessons. Inquiry based instruction provides a shared common experience between ELLs and their native speaking peers.

Only when teachers are ready for this diverse group of students will a change be seen in ELL achievement in science.

Chapter III: Capstone Project

Overview

In order to assist fellow science teachers and myself in building scientific literacy skills through inquiry, I propose the creation of a resource that focuses on scaffolding scientific content in inquiry based instruction to support English Language Learners' science literacy. This resource will contain four key areas that teachers can take into consideration as they scaffold their lessons for English Language Learners. Also, this resource will demonstrate how to incorporate these literacy components within an inquiry based lesson. Next, I will provide 3 unit plans each containing 8-10 lessons demonstrating how this can be put into practice for a secondary chemistry classroom. These unit plans will align to the Next Generation Science Standards and Common Core standards. Scaffolding academic language through visual representation, analogies, graphic organizers and utilizing the student's native language benefit English language learners as they strengthen their scientific literacy skills. In conjunction with inquiry, these scaffolding techniques provide a solid foundation for ELLs attain their second language while learning science content.

Inquiry allows ELLs to experience scientific phenomenon and take an active role in their learning. Hands on learning (through inquiry) provide ELLs with opportunities to acquire the English language while they are learning about science concepts. Meaningful connections are made, ELL students learn by doing rather than through a traditional approach, they are able to

apply their learning to different situations, and they have important peer interaction (Bergman, 2011). Students are able to represent their ideas, data and findings through multiple ways. This form of communication is crucial for ELLs to be able to express themselves in their work. (Fradd et al, 2001). There is a shift from “communicating at a personal, concrete level to using a variety of forms of representation to express both concrete and abstract understandings. Instruction needs to include explicit focus on literacy development, ELLs are often excluded” (Fradd et al. pg 492). Scaffolds in assessments provide an opportunity for ELLs to respond to a question that had the potential to go unanswered because of linguistic misunderstandings (Siegel, 2014). The accommodation that the teacher chooses should be based on the needs of the ELL so that they can effectively demonstrate their content knowledge.

Inquiry based instruction allows ELL students to gain more meaningful experiences with the scientific content, and supporting students as they construct their own knowledge while teachers facilitate and guide investigations. Teachers can further aid ELLs in inquiry based instruction by using scaffolding techniques that help them make critical connections between their prior knowledge and what they are learning. Huerta & Jackson (2010) further explain that inquiry provides ELLs with a natural teaching ground for them to build vocabulary and English proficiency through tactile experiences. Also, they state that inquiry is a gateway for ELLs to use the English language to help them construct better understanding of the scientific content. Student motivation is increased as they are able to strengthen their English skills alongside their scientific skills. Acquiring spoken and written languages directly linked to developing higher thinking skills.

Project Outline

The three units outlined in chapter three each contain inquiry based lessons incorporating researched based strategies to develop an English Language Learner's scientific literacy. Each lesson is sixty minutes long and follows the 5e model of instruction. No two lessons are exactly alike even though they share the same format. Each lesson starts with engaging student's minds on chemistry content. Most lessons use this time to address questions about the previous day's lesson or getting students to address what they may know about the content they will be learning that day. Each lesson then provides an inquiry based activity where they explore the scientific phenomenon and construct their own understanding. Depending on the content the teacher either follows this with guided notes and practice or students teach their peers the information that they learned. Each lesson has an extension where the students are use the information they gained and apply it.

Each unit provides a student centered learning environment to allow English Language Learners to learn scientific phenomena in a more authentic way. Each unit utilizes visuals and videos with closed captioning to help ELLs to visualize what they are learning. The visuals provide an avenue for teachers to teach the content without the language barrier interference. Students also are analyzing and forming conclusions from data specific to each unit to further their understanding of the scientific concepts. Laboratory activities are used to introduce the science content rather than confirm what they have learned. The labs in each unit provides a setting where students are expected to explore the scientific phenomena before learning what is happening to build their understanding, lending to a more inquiry based setting.

Students demonstrate their knowledge through formative and summative assessments. The teacher will observe student discourse for misunderstandings and addresses them. Also, student created posters, and practice provides evidence on what the student understands and knows. Summative assessments are in the form of quizzes, laboratory write ups, cumulative tests and project based assessments. Each of these summative assessments will align to meet the needs of an English Language Learner to create a more equitable assessment.

After the three units outlined in chapter three, there is a discussion of how each unit addresses the needs of English Language learners. This section of chapter three discusses how each unit is inquiry based to facilitate authentic learning for all students. The alignment for the Next Generation Science Standards is discussed for each unit. Next, one teacher created analogy is used to explain how a teacher could change these analogies to relate to an ELL's prior knowledge. Visual representations are then given for each unit as well as an explanation of the visual and how it is used to facilitate understanding of the scientific concept. Examples of suitable graphic organizers for the three units with an explanation are provided to demonstrate how to use these tools to deepen the learning of ELLs. Lastly, a discussion of where a teacher could use an ELL's native language is provided creating a more diverse classroom setting.

Chemistry Unit: Acids and Bases

Overview

This unit incorporates guided inquiry and the 5e model. A student centered classroom is achieved as students investigate scientific phenomenon to construct meaning of their world. Beginning with the pH scale, students explore ways to use indicators to distinguish between an acidic, basic or neutral solution. As the unit progresses, students are exposed to other indicators. Students then learn the theories behind acids and bases, strength and neutralization; all properties of acids and bases that are important to understand and utilize. Students perform a titration to determine the concentration of an unknown base. Lastly, students will use a webquest/online inquiry lab to learn about the effects of acid rain in the United States. Brief session of teacher driven notes will be present however, the majority of the unit is student centered. An estimated 10 to 15 days should be allotted for this unit, depending on how fast students' progress through the inquiry based lessons. This unit plan is based on 10 days but the teacher can extend any day as needed.

Prior knowledge needed

- Students should already know:
 - what a solution is
 - how to calculate molarity
 - students should have an understanding of the mole
 - types of reactions
 - how atoms bond and how compounds break into ions in solution

How are ELLs addressed

Each lesson in this unit emphasizes peer discourse; the research has shown that ELLs learn best by talking with their peers about scientific concepts. This unit is designed using inquiry and the 5e model to scaffold the content for all students, creating an equitable learning experience. There are many opportunities within this unit to differentiate for English Language Learners to help meet their needs in the classroom.

Standards Covered in Unit

3.1rr: An electrolyte is a substance which, when dissolved in water, forms a solution capable of conducting an electric current. The ability of a solution to conduct an electric current depends on the concentration of ions

3.1ss: The acidity or alkalinity of an aqueous solution can be measured by its pH value. The relative level of acidity or alkalinity of these solutions can be shown by using indicators.

3.1tt: On the pH scale, each decrease of one unit of pH represents a tenfold increase in hydronium ion concentration.

3.1uu: Behavior of many acids and bases can be explained by the Arrhenius theory. Arrhenius acids and bases are electrolytes.

3.1vv: Arrhenius acids yield $H^+(aq)$, hydrogen ion as the only positive ion in an aqueous solution. The hydrogen ion may also be written as $H_3O^+(aq)$, hydronium ion.

3.1ww: Arrhenius bases yield $OH^-(aq)$, hydroxide ion as the only negative ion in an aqueous solution.

Enduring Understandings

- a. Know (facts)
 - pH is the measure of the hydrogen ion (H^+) concentration in solution
 - pH scale runs from 0 to 14
 - a pH of 7 is neutral, lower than 7 is acidic and greater than 7 is basic
 - Acids and bases have unique properties
 - Acids and bases are described based of the amount of H^+ ions and OH^- ions in solution based of the two theories
 - When an acid and base react with each other, neutralization occurs
 - Indicators are used to determine if a solution is an acid or a base, based off of pH
- b. Understand (big idea)
 - Acid base theories help us understand the chemical and physical properties of specific matter and reactions
- c. Do (skills)
 - Use different indicators to determine the pH of solutions

<p>3.1xx: In the process of neutralization, an Arrhenius acid and an Arrhenius base react to form a salt and water.</p> <p>3.1yy: There are alternate acid-base theories. One theory states that an acid is an H⁺ donor and a base is an H⁺ acceptor.</p> <p>3.1zz: Titration is a laboratory process in which a volume of a solution of known concentration is used to determine the concentration of another solution.</p> <p>NGSS</p> <p>HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction.</p> <p>HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.</p> <p>HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.</p> <p>HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.</p> <p>Crosscutting Concept: Structure and Function, Patterns, Stability and Change</p> <p>Science Practices: Developing and Using Models, Planning and Carrying out Investigations</p>	<ul style="list-style-type: none"> • Measure the pH of a solution and classify it as acidic, basic or neutral • Perform a titration • Calculate molarity of an unknown acid or base • Design and implement an experiment • Analyze and present data to class
<p style="text-align: center;">Essential Questions</p> <ul style="list-style-type: none"> • Do you know how to test a substance to see if it is an acid or base? • How is strength of an acid or base calculated? • What distinguishes between a strong acid/base from a weak acid/base? • How do indicators help determine if a solution is acidic, basic or neutral? • What is pH and how is it calculated? • What are the products when we react an acid and base? • How do titrations help us find an unknown molarity? • What are common acids and bases? • How is acid rain harmful? 	<p style="text-align: center;">Key Vocabulary</p> <ul style="list-style-type: none"> • Neutralization • Ionization • Acid • Base • Strong Acid • Weak Acid • Strong Base • Weak Base • Dissociation • Molarity • Titration • pH • Electrolyte • Concentration

<p style="text-align: center;">Misconceptions</p> <ol style="list-style-type: none"> 1. Acids are more harmful than bases 2. Acids are stronger than bases 3. All water is neutral with a pH of 7 4. Strength and concentration mean the same thing 5. When a proton donor acid reacts, the nucleus of an atom loses a proton 6. Substances containing H^+ are acidic and substances containing OH^- are basic 7. Higher pH value mean more acidic 	<p style="text-align: center;">Proper Conceptions</p> <ol style="list-style-type: none"> 1. Both acids and bases are harmful, proper safety needs to be considered 2. Strength of acids and bases take on the properties of the specific acid or base 3. Water can take on properties of an acid or a base 4. Concentration is defined as moles of solute per liters of solution, strength refers to percent of molecules that ionize and form ions in solution 5. Acids as proton donors refers to the hydrogen ion not a proton from the nucleus 6. Many substances contain H^+ that are not acids and the same goes for substances that contain OH^-. Table sugar contains both H^+ and OH^- and is not an acid or a base. When it comes to acids and bases we are looking specifically about H^+ ions and OH^- ions in solution. 7. Opposite is true, pH is the measurement of H^+ ions in solution, the more H^+ ions the lower the pH
<p style="text-align: center;">Instructional Strategies/Learning Tasks</p> <ul style="list-style-type: none"> • Teacher will act as a facilitator of information throughout the majority of the unit while keeping direct instruction to a minimum. • Students will participate in guided inquiry where they will discover pH, acids and bases through hands on activities that keep them questioning. 	<p style="text-align: center;">Instructional Materials</p> <ul style="list-style-type: none"> • White board/Smart board • Student white boards • pH <ul style="list-style-type: none"> ○ Acid, base, water and indicator for teacher demonstration ○ pH scale lab materials ○ notes, homework on pH scale, acid base properties ○ antacid lab materials • Theories <ul style="list-style-type: none"> ○ Jigsaw notes/homework • Titration <ul style="list-style-type: none"> ○ Notes and practice ○ Titration lab materials • Regents Reference Tables <ul style="list-style-type: none"> ○ Reference table for each student ○ Notes and practice • Acid Rain Inquiry Lab <ul style="list-style-type: none"> ○ Lab materials ○ http://www.glencoe.com/sites/common_assets/science/virtual_labs/CT11/CT11.html
<p style="text-align: center;">Research Based Practices</p> <ul style="list-style-type: none"> • Inquiry based instruction • 5e model of instruction • Blooms Taxonomy • Jigsaw • Graphic organizers 	

Differentiation

(Should be based on student's IEP/504 plans)

- **Kinesthetic learners: manipulating materials through inquiry**
- **Visual learners: observing chemical reactions and color changes**
- **Auditory learners: listening to peers and class discussions**
- **ELL:**
 - **Graphic organizers to organize thoughts, vocabulary, and notes**
 - **Outlined notes**
 - **Notes provided before class discussions**
 - **Documents provided in their native language**
 - **Pictorial representations**
 - <https://s-media-cache-ak0.pinimg.com/originals/03/a6/09/03a609d64bf1d3a0e53738c768fa0870.jpg>
 - **Analogies: provided by teacher, or created by student or by peers**
 - **Football analogy**
 - **Scaffolded assignments**
 - **Videos to help with visualization:**
 - http://my.hrw.com/content/hmof/science/high_school_sci/na/gr9-12/hmd_chem_9780547708089_dlo/whyitmatters/index.html#p/12
 - http://my.hrw.com/content/hmof/science/high_school_sci/na/gr9-12/hmd_chem_9780547708089_nsmedia/visualconcepts/75282.htm
 - http://my.hrw.com/content/hmof/science/high_school_sci/na/gr9-12/hmd_chem_9780547708089_nsmedia/visualconcepts/75284.htm
 - http://my.hrw.com/content/hmof/science/high_school_sci/na/gr9-12/hmd_chem_9780547708089_nsmedia/visualconcepts/75291.htm
 - http://my.hrw.com/content/hmof/science/high_school_sci/na/gr9-12/hmd_chem_9780547708089_nsmedia/visualconcepts/75290.htm
 - **PHET on acids and bases:** <https://phet.colorado.edu/en/simulation/acid-base-solutions>

Lesson: pH

Day 1

Standard	Learning Objectives	Assessment
3.1 ss	Student will be able to make a decision if a solution is acidic, basic or neutral based on pH with the use of indicators	Formative: Student discourse Summative: pH lab

Instructional Steps

Engage (15 mins)	<ol style="list-style-type: none"> 1. Teacher begins with 3 colorless solutions: an acid, base and water. Teacher instructs students to write observations: teacher puts 2 drops of universal indicator in each solution. <ol style="list-style-type: none"> a. Students are expected to write or draw what they see and come up with an explanation 2. Class discussion: teacher elicits responses from students about what just happened <ol style="list-style-type: none"> a. Teacher provides information: indicator was used, solutions are either an acid, a base or neutral 3. Universal indicator pH color chart is projected on Smartboard or copies given to each student <ol style="list-style-type: none"> a. Students determine pH of the solutions based off the color observed b. Makes predictions which solution is an acid, base or neutral
Explore (40 mins)	<p>pH Scale Lab</p> <ol style="list-style-type: none"> 1. Students get into groups (3-4 students) to complete guided inquiry lab where they test the pH of various solutions to construct their own pH scale <ol style="list-style-type: none"> a. Students will see color spectrum of acids and bases using universal indicator b. Based off their results students will construct a pH scale 2. Teacher travels around each group to answer lab technique questions, asks questions to guide students in their investigation. Teacher shouldn't provide too much information about what the students are investigating 3. At end of class, students should have a completed pH scale 4. HOMEWORK: Lab homework where students are exposed to Reference Table M (Indicators), using the pH scale to determine if a solution is an acid, base or neutral based off pH <p>5 minutes left to clean up</p>

Day 2

Standard	Learning Objectives	Assessment
3.1 rr	Student will be able to discuss how acids and bases dissociate into ions	Formative: reflection Summative: quiz
3.1 ss	Student will be able to make a decision if a solution is acidic,	Formative: Student discourse, reflection Summative: pH lab, quiz

	basic or neutral based on pH with the use of indicators	
3.1 tt	Students will be able to mathematically explain the pH scale	Formative: student explanation Summative: quiz

Instructional Steps

Bell ringer/ Lab homework (10 mins)	Students get into lab groups to go over lab homework and discuss what they learned, and have questions about it. Teacher visits each group to provide guidance and answer questions
Explain (45 mins)	<ol style="list-style-type: none"> 1. Teacher provides notes on pH scale and Reference Table M (10 mins) <ol style="list-style-type: none"> a. Students: take notes and ask questions 2. Students revisit lab homework to correct misunderstandings, homework is turned in (5 mins) 3. Notes on pH log scale and practice (20 mins) 4. Students are given properties of acids and bases and are expected to organize the notes in a way that makes sense to them. Students are expected to provide examples of common acids and bases (10 mins)
Closure (5 mins)	Students write a reflection in science journal about what they have learned about pH, acids and bases HOMEWORK: more practice on pH scale, indicators, and properties.

Day 3

Standard	Learning Objectives	Assessment
3.1 rr	Student will be able to discuss how acids and bases are dissociate into ions	Formative: student discourse Summative: quiz, lab
3.1 ss	Student will be able to make a decision if a solution is acidic, basic or neutral based on pH with the use of indicators	Formative: Student discourse Summative: pH lab, quiz
3.1 tt	Students will be able to mathematically explain the pH scale	Formative: student discourse Summative: quiz, lab

Instructional Steps

Quiz (10 mins)	<ol style="list-style-type: none"> 1. Students are given a quiz on pH scale, indicators and properties 2. Students are given antacid inquiry lab to look over when finished and ask questions.
Extend (40 mins)	<ol style="list-style-type: none"> 1. Students investigate which antacid is better at neutralizing stomach acid. <ol style="list-style-type: none"> a. Students are expected to plan and carry out investigation b. Teacher can aid in safety and guide students in their investigation
Closure (10 mins)	<ol style="list-style-type: none"> 1. Students should clean up after inquiry lab 2. Students are given a set of notes/information that they are expected to read and prepare

for next class. These sets up for a jigsaw next class.

- a. Students are given notes on one of the following topics: Arrhenius Theory, Bronsted-Lowery Theory, Strong/Weak acid and bases, neutralization and acids reacting with metals (table J)
- b. Students can ask clarifying questions

Lesson: Acid Base Theories

Day 4

Standard	Learning Objectives	Assessment
3.1 uu	Students will be able to describe the behaviors of an Arrhenius acid and base	Formative: homework Summative: student generated notes, test
3.1 vv	Students will be able to recognize that an Arrhenius acid yields a H^+ ion commonly written as H_3O^+	Formative: homework Summative: student generated notes, test
3.1 ww	Students will be able to recognize that an Arrhenius base yields a OH^- ion	Formative: homework Summative: student generated notes, test
3.1 xx	Students will be able to determine the products of an Arrhenius acid and an Arrhenius base	Formative: homework Summative: student generated notes, test
3.1 yy	Students will be able to describe an acid as a H^+ proton donor and a base as a H^+ proton acceptor	Formative: homework Summative: student generated notes, test

Instructional Steps

Students Prepare for notes (60 minutes)	<ol style="list-style-type: none"> 1. On SmartBoard or white board, teacher puts names of students in groups 2. Students come in and get into their groups to discuss their notes on the topic they were given <ol style="list-style-type: none"> a. Teacher goes around and answers questions and clarifies any misunderstandings 3. Students are expected to develop a 15 minute presentation to the class about their topic: students are giving each other the notes next class
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Days 5 and 6

Instructional Steps

Students present notes (90 minutes)	<ol style="list-style-type: none"> 1. Each group of students will provide notes on their assigned topic in any way they want for 15 minutes 2. Teacher can add information or correct any misleading information but should keep this to a minimum- students should be the experts
Practice (30)	Practice on theories, strong/weak acids and neutralization- becomes homework if not finished

Lesson: Titration

Day 7

Standard	Learning Objectives	Assessment
3.1 xx	Students will be able to determine the products of an Arrhenius acid and an Arrhenius base	Formative: Summative: Lab write up, test
3.1 zz	Students will be able to describe what a titration is and what important it provides LAB: Students will be able to perform a titration and determine the molarity of an unknown base	Formative: Summative: Lab write up, test

Instructional Steps

Homework Check (10 minutes)	Teacher will facilitate student discussion on homework and answer any questions they have
Quiz (15 minutes)	Students will take a quiz on theories, strong/weak acids and bases, neutralization and table J
Titration and buret reading notes (20 minutes)	Teacher provides brief notes on Titration and calculation <ol style="list-style-type: none"> a. Notes will include what a titration is, and how to use the titration calculation to determine unknown molarity
Practice (15 minutes)	<ol style="list-style-type: none"> 1. Students practice titration molarity calculations 2. Go over practice 3. Students are given titration lab handout to read and take notes on

Day 8

Instructional Steps

Prelab (10 minutes)	Teacher answers questions about the lab
Titration Lab (45 minutes)	<ol style="list-style-type: none"> 1. Students perform lab 2. Teacher asks questions to further student investigation
Closure (5 minutes)	<ol style="list-style-type: none"> 1. Students should clean up lab 2. Students work on finishing lab calculations and lab homework if finished early

Lesson: Real World Application- Acid Rain

Day 9

Standard	Learning Objectives	Assessment
Standard 7: design solution to real world problems	Student will be able to state effects of acid rain on the environment and state a potential solution to correcting the damaging effects	Formative: Student discourse Summative: Webquest, test
Instructional Steps		
Webquest/virtual lab (30 minutes)	<ol style="list-style-type: none"> 1. Students will work on a webquest/virtual lab to discover acid rain and its effects on the environment 2. Students will work in pairs to complete task 3. Teacher walks around answering questions 	
Study (30 minutes)	When finished with webquest/virtual lab, students will begin to organize notes and study for their Acids and Bases test	
Day 10: Cumulative Test		

Chemistry Unit: Periodic Table

Overview

This unit incorporates guided inquiry and the 5e model. A student centered classroom is achieved as students investigate scientific phenomenon to construct meaning of their world. Students are first asked to think about how things are classified. This helps students start to think like the scientists who contributed to the development of the periodic table we have today. The alien activity that starts this unit off by recognizing the patterns in aliens. Introducing the periodic table through the patterns that were discovered by scientists allow students to see the thought process behind this crucial scientific discovery. Students are exposed to the properties of metals, non-metals and metalloids through a lab setting. Also, students are able to make necessary connections on how those properties affect the placement of elements on the periodic table. Students then learn about how the elements share similar properties in groups (families) and periods of the periodic table. Lastly, students analyze periodic trend data to gain a better understanding of how these trends affect the behavior of the elements. An estimated 10 to 12 days should be allotted for this unit, depending on how fast students' progress through the inquiry based lessons. This unit plan is based on 10 days but the teacher can extend any day as needed.

Prior knowledge needed

- Students should already know:
 - atomic structure
 - bohr models
 - protons
 - electrons
 - neutrons
 - electron configuration
 - valence electrons
 - ionic charge

How are ELLs addressed

Each lesson in this unit emphasizes peer discourse; the research has shown that ELLs learn best by talking with their peers about scientific concepts. This unit is designed using inquiry and the 5e model to scaffold the content for all students, creating an equitable learning experience. There are many opportunities within this unit to differentiate for English Language Learners to help meet their needs in the classroom.

Standards Covered in Unit	Enduring Understandings
<p>3.1v Elements can be classified by their properties and located on the Periodic Table as metals, nonmetals, metalloids (B, Si, Ge, As, Sb, Te), and noble gases.</p> <p>3.1w Elements can be differentiated by physical properties. Physical properties of substances, such as density, conductivity, malleability, solubility, and hardness, differ among elements.</p> <p>3.1x Elements can also be differentiated by chemical properties. Chemical properties describe how an element behaves during a chemical reaction.</p> <p>3.1y The placement or location of an element on the Periodic Table gives an indication of the physical and chemical properties of that</p>	<p>Know (facts)</p> <ul style="list-style-type: none"> • Classification of elements is based on their properties • The periodic table is a classification of the elements based on their physical and chemical properties • Periodic trends help identify how an element behaves in chemical reactions <p>Understand (big idea)</p> <ul style="list-style-type: none"> • The organization of the periodic table helps us understand how the elements behave based on their physical and chemical properties <p>Do (skills)</p> <ul style="list-style-type: none"> • Use patterns in the periodic table to place an unknown element • Effective communication <ul style="list-style-type: none"> ○ With peers ○ With data and information

<p>element. The elements on the Periodic Table are arranged in order of increasing atomic number.</p> <p>3.1z For Groups 1, 2, and 13-18 on the Periodic Table, elements within the same group have the same number of valence electrons (helium is an exception) and therefore similar chemical properties.</p> <p>3.1aa The succession of elements within the same group demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties.</p> <p>3.1bb The succession of elements across the same period demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties.</p> <p>NGSS</p> <p>HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.</p> <p>HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction.</p> <p>Crosscutting Concept: Structure and Function, Patterns, Stability and Change</p> <p>Science Practices: Asking questions, Developing and Using Models, Analyzing and Interpreting Data, Constructing Explanations, Obtaining, evaluating and communicating information</p>	
<p style="text-align: center;">Essential Questions</p> <ul style="list-style-type: none"> • How does the physical and chemical properties influence where an element is placed on the periodic table? • What do the periodic trends tell me about the behavior of an element? 	<p style="text-align: center;">Key Vocabulary</p> <ul style="list-style-type: none"> • Valence Electron • Ionization Energy • Electronegativity • Density • Conductivity • Malleability • Solubility • Hardness • Atomic radius • Ionic radius • Electron Affinity • Metal • Non-metal • Metalloid
Misconceptions	Proper Conceptions

<ol style="list-style-type: none"> 1. The elements on the periodic table are arranged by increasing atomic mass 2. Low ionization energy means that it is <i>hard</i> to remove that electron. 3. Atomic radius increases with increasing atomic number and mass 4. The periodic table was constructed using the atomic structure of the elements. 	<ol style="list-style-type: none"> 1. Elements are arranged by increasing atomic number. Atomic mass is the mass of the entire atom whereas the atomic number is the number of protons each atom has. 2. Ionization energy is the amount of energy required to remove an electron from that atom. Lower the energy the easier it is to pull an electron. 3. Atomic radius increases going down the group due to the attractive force of the nucleus is reduced due to shielding causing the electrons to be less attracted to the nucleus causing the radius to be larger. Atomic radius decrease across the period due to the strength of attraction between the nucleus and valence electrons is stronger thus reducing the size of the atom. 4. Mendeleev used atomic mass and properties to develop the periodic table. Moseley added using the number of protons to determine the organization.
<p>Instructional Strategies/Learning Tasks</p> <ul style="list-style-type: none"> • Teacher will act as a facilitator of information throughout the majority of the unit while keeping direct instruction to a minimum. • Students will participate in guided inquiry where they will discover how the periodic table was developed through classification. This is achieved through hands on activities, element properties lab and analyzing trend data. Students will also, learn from each other. 	<p>Instructional Materials</p> <ul style="list-style-type: none"> • White board/Smart board • Student white boards • Classification of the Periodic Table <ul style="list-style-type: none"> ○ Alien Activity ○ Element Properties Lab materials ○ Periodic Table for each student • History <ul style="list-style-type: none"> ○ Modern Periodic Table and Mendeleev's periodic table ○ Notes sheet • Periodic Table Families <ul style="list-style-type: none"> ○ Notes/ information on each family ○ Poster paper and markers ○ Note sheet/graphic organizer • Periodic Table Trends <ul style="list-style-type: none"> ○ Data of each trend ○ Pictures of each trend ○ Graph paper ○ Worksheet ○ Frayer model graphic organizer for trends • Regents Reference Tables <ul style="list-style-type: none"> ○ Reference table for each student ○ Notes and practice • Project Based Assessment Assignment
<p>Research Based Practices</p> <ul style="list-style-type: none"> • Inquiry based instruction • 5e model of instruction • Blooms Taxonomy • Galley Walk • Graphic organizers • Project Based Assessment 	

Differentiation

(Should be based on student's IEP/504 plans)

- **Kinesthetic learners: manipulating materials through inquiry**
- **Visual learners: observing physical properties, videos**
- **Auditory learners: listening to peers and class discussions**
- **ELL:**
 - **Graphic organizers to organize thoughts, vocabulary, and notes**
 - **Outlined notes**
 - **Notes provided before class discussions**
 - **Documents provided in their native language**
 - **Pictorial representations**
 - <https://s-media-cache-ak0.pinimg.com/originals/cd/01/12/cd0112622877cd596e74b6cc31690c1c.jpg>
 - http://images.slideplayer.com/24/7253094/slides/slide_26.jpg
 - http://2012books.lardbucket.org/books/principles-of-general-chemistry-v1.0/section_11/bd05f43d0392ab934fc21044ccca1cfd.jpg
 - http://jahschem.wikispaces.com/file/view/Ionic_Radii-metals.GIF/403043036/Ionic_Radii-metals.GIF
 - <http://sciencenotes.org/wp-content/uploads/2014/10/PeriodicTableTrends.png>
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 - **Analogies: provided by teacher, or created by student or by peers**
 - **Family**
 - **Scaffolded assignments**
 - **Videos to help with visualization:**
 - https://www.youtube.com/watch?v=93G_FqpGFGY&feature=player_embedded
 - https://www.youtube.com/watch?v=bPB0xThmpkg&feature=player_embedded
 - https://www.youtube.com/watch?v=ba2yN2HtPTA&feature=player_embedded
 - <https://www.youtube.com/watch?v=1Kxy-BWEQ6o>
 - https://www.youtube.com/watch?v=t_f8bB1kf6M
 - <http://slideplayer.com/slide/6227644/>
 - **Alternative to graphing periodic trends activity: done on excel**
 - http://academic.pgcc.edu/~ssinex/UCCEN_F07/

Day 1

Standard	Learning Objectives	Assessment
3.1 w	Students will be able to recognize differences, and classify those differences by using a table.	Formative: Student discourse, class discussion Summative: Alien activity sheet

Instructional Steps

Engage (20 mins)	<ol style="list-style-type: none"> Instruct students as they walk in to write down 5 physical characteristics that describe themselves. (Hair, eyes, height, clothes, skin tone, gender, age, etc.) Have students get together in groups to collect information and construct a chart/table to arrange students based on similarities and differences. Collect charts: choose a couple and share them without using names. Initiate a discussion regarding the development of a chart: <ol style="list-style-type: none"> What are the similarities and differences between the charts? Which characteristics were chosen? Why? Were the same characteristics chosen? Are they specific? What other characteristics could we use? Are the characteristics chosen subjective or objective? Testable? Discussion on the difficulties in achieving a consensus of characteristics to be used and arrangement of tables: why were the tables created different? <u>Reinforcement</u> of the activity: ask for 3 volunteers to stand in front of the class. <ol style="list-style-type: none"> Put two together, with the third off to the side for a moment. Ask: what similar characteristics the two students share, why would they be grouped together? Write answers on the board Separate the two and have the third student stand next to one of them and repeat. Have students pick out the similarities and differences between the lists. Pick out the characteristics that are specific to a human and ask if these characteristics can be measured (for example weight).
Explore (40 mins)	<p>Alien Activity</p> <ol style="list-style-type: none"> Students can work individually or in a small group (2 or 3 students) Students will arrange a series of characters (aliens) in a pattern using several organizing characteristics: body shape, number of hair stands, body type, number of arms, and facial features. On the board/smartboard give the students the following 3 clues <ol style="list-style-type: none"> There are different ways to arrange the characters Columns and rows of species do not have to have the same number of characters There will be three rows when finished Students will have to draw in the missing alien that fits with the sequence: Explain this after handing out the worksheet Teacher should encourage students to model their thoughts. Encourage struggling students to organize the aliens based on defining characteristics Students need to get the teacher's approval for accuracy before they start answering the questions on the activity sheet HOMEWORK: Finish activity

Day 2

Standard	Learning Objectives	Assessment
3.1 w	Student will be able to use the physical characteristics of elements to see similarities and differences	Formative: Prediction bell ringer and ticket out the door, student discourse Summative: lab homework
3.1 x	Student will be able to use the chemical characteristics of elements to see similarities and differences	Formative: Prediction bell ringer and ticket out the door, student discourse Summative: lab homework

Instructional Steps

Bell-ringer (5 mins)	Students turn in alien activity Warmup: KWL: properties of elements
Explore (45 mins)	Element Properties lab <ol style="list-style-type: none"> a. Students get into groups (3-4 students) to complete guided inquiry lab where they observe properties of specific elements. Students are given the properties to look at but are expected to organize their observations on their own. <ol style="list-style-type: none"> i. Students create their own table to organize their observations ii. Teacher travels around each group to answer lab technique questions, asks questions to guide students in their investigation. Teacher shouldn't provide too much information about what the students are investigating
Closure (10 mins)	Students revisit KWL chart from the beginning of class: in a different color revises KWL chart and discusses how the lab changed their ideas. Students should come to concluding that elements share similar properties and that may influence their location on the periodic table HOMEWORK: Lab homework

Day 3

Standard	Learning Objectives	Assessment
3.1 v	Students will be able to classify elements as a metal, non-metal or metalloid based on their properties and location on the periodic table	Formative: element family conclusion, student discourse Summative: quiz
3.1 w	Students will be able to separate elements based off their physical properties	Formative: element family conclusion, student discourse Summative: quiz
3.1 x	Students will be able to separate elements based off their chemical properties	Formative: element family conclusion, student discourse Summative: quiz
3.1 y	Students will be able to use the location on the periodic table to	Formative: element family conclusion, student discourse

	determine the properties of the element	Summative: quiz
Instructional Steps		
Explain (10 mins)	<ol style="list-style-type: none"> 1. Students get into their lab groups and hand in their lab homework 2. Whole group discussion <ol style="list-style-type: none"> a. Teacher introduces: metals, non-metals and metalloids b. Students are given periodic table to locate the elements used in the lab <ol style="list-style-type: none"> i. How do the characteristics observed influence where they are placed on the periodic table? 	
Elaborate (45 mins)	<ol style="list-style-type: none"> 1. Teacher will hand out element cards and activity sheet 2. Teacher explains Activity <ol style="list-style-type: none"> a. Students need to read element card and state what types of things are listed (# protons, #electrons, # neutrons, atomic #, atomic mass, # valence electrons, additional characteristics) b. Students are to pair up with 3 additional classmates and compare and contrast their elements. 3 minutes per pair up 3. Class discussion: (10 mins) <ol style="list-style-type: none"> a. How would you want to group elements? b. How do we know if elements are “alike”? c. How would you tell based on the information on the cards? (behaviors are listed on bottom of card) d. What properties might we compare to find elements that behave similarly? (guide towards valance electrons) e. Tell students that elements are like members of a family, so they need to find the other elements that are in their element’s family 4. Students are to find elements like them <ol style="list-style-type: none"> a. If have difficulties: <ol style="list-style-type: none"> i. Look at properties at the bottom, look at valance electrons 5. When students find their families they should return to their activity sheet and ask the questions posed <ol style="list-style-type: none"> a. Teacher should guide students who have chosen the wrong family to re-examine their element b. Teacher approves that family is correct and hands information sheet for their family (HOMEWORK) 	
Closure (5 mins)	Wrap up activity for the day, teacher places students still in wrong family in the right family HOMEWORK: finish activity if needed, students pick up information sheet on their family to take notes on, practice on metals, nonmetals, metalloids, and elemental characteristics	

Day 4

Standard	Learning Objectives	Assessment
3.1 v	Students will be able to classify elements as a metal, non-metal or metalloid based on their properties and location on the periodic table	Formative: bell ringer, posters, student discourse Summative: quiz
3.1 w	Students will be able to separate elements based off their physical properties	Formative: bell ringer, posters, student discourse Summative: quiz

3.1 x	Students will be able to separate elements based off their chemical properties	Formative: bell ringer, posters, student discourse Summative: quiz
3.1 y	Students will be able to use the location on the periodic table to determine the properties of the element	Formative: bell ringer, posters, student discourse Summative: quiz
3.1 z	Students will be able to use valance electrons to state why elements in the same group have the same chemical properties	Formative: bell ringer, posters, student discourse Summative: quiz

Instructional Steps

Bell ringer (5 mins)	Students answer question: What determines whether or not an element belongs to a certain family?
Elaborate extension (30 mins)	<ol style="list-style-type: none"> 1. Students get into groups to discuss their family and prepares a poster, students need their periodic tables from last class (15 mins) 2. Poster should include: <ol style="list-style-type: none"> a. Name of family b. Location on periodic table c. Properties shared by the elements in the family 3. Teacher should go around and ensure correct information is given and answers questions 4. Students put up poster and gets notebooks out to write notes down from the other group's posters 5. Gallery Walk/Note Taking: Students visit each poster and writes down information on each family (3 mins per poster)
Explain (20 mins)	<ol style="list-style-type: none"> 1. Teacher regroups students to discuss the families, group and periods 2. Color Code the Periodic Table: Students color and label each family on periodic table 3. Teacher adds information that was missing from student posters
Closure (5 mins)	Students write their muddiest point (questions they still have, what they don't understand) on a post it. HOMEWORK: finish coloring periodic table if needed, practice on locating families on periodic table, study for quiz next class

Day 5

Standard	Learning Objective	Assessment
3.1 v	Students will be able to classify elements as a metal, non-metal or metalloid based on their properties and location on the periodic table	Formative: bell ringer, posters, student discourse Summative: quiz
3.1 w	Students will be able to separate elements based off their physical properties	Formative: bell ringer, posters, student discourse Summative: quiz
3.1 x	Students will be able to separate elements based off their chemical properties	Formative: bell ringer, posters, student discourse Summative: quiz
3.1 y	Students will be able to use the	Formative: bell ringer, posters, student

	location on the periodic table to determine the properties of the element	discourse Summative: quiz
3.1 z	Students will be able to use valance electrons to state why elements in the same group have the same chemical properties	Formative: bell ringer, posters, student discourse Summative: quiz

Instructional Steps

Go over HOMEWORK (20 mins)	<ol style="list-style-type: none"> Students are assigned at random to provide answer to homework question on the white board/smart board Class compares their answers and notes any answers that were different than their own Teacher facilitates group discussion on the answers that are problematic: if a student changes their answer it must be in a different colored writing utensil HOMEWORK is collected
Quiz (10-15 mins)	Quiz on properties of elements and families
History Notes (15 mins)	<ol style="list-style-type: none"> Teacher provides brief notes on the history of the development of the periodic table Teacher should link previous activities (alien activity, lab, elemental families) to how the periodic table was developed
Closure (10-15 mins)	<ol style="list-style-type: none"> Students revisit their KWL chart and add new ideas in a different color Students should organize notes in a way that they understand <u>Ticket out the door:</u> How did Mendeleev and Mosley help to organize the periodic table? Asks any questions or states areas they are confused with

Days 6-7

Standard	Learning Objectives	Assessment
3.1 aa	Students will be able to explain how periodic trends define elements within the same group.	Formative: student discourse, summary of trends, frayer models Summative: trend activity sheet, graphs
3.1 bb	Students will be able to explain how periodic trends define elements within the same period.	Formative: student discourse, summary of trends, frayer models Summative: trend activity sheet, graphs

Instructional Steps

Bell ringer (Engage) (5 mins)	Students will answer: What trends can be observed on the periodic table? Provide evidence
Discuss (3 minutes)	Students talk with partner about the trends they wrote down as the teacher hands out activity packet
Explore (60 mins)	<ol style="list-style-type: none"> Count students off by 4 to assign groups to work on 4 trends in the activity <ol style="list-style-type: none"> Electronegativity Ionization energy

	<ul style="list-style-type: none"> c. Atomic radius d. Ionic radius <ol style="list-style-type: none"> 2. Students get into groups and work through the activity <ul style="list-style-type: none"> a. Students will graph data for each trend b. Students will look at a pictorial representation of each trend 3. Teacher should go around and aid with setting up the axis on the graphs 4. Encourage students to finish graphs for homework if they are not done (Day 6)
Elaborate (50 minutes)	<ol style="list-style-type: none"> 1. After students finish their graphs they should compare with the answer key 2. Students then interpret the graphs to come to a conclusion about how each trend influence behavior of the elements <ul style="list-style-type: none"> a. Teacher should check in and make sure they have the correct understanding, if not guide them using the data/graphs and pictures to the correct understanding b. Students fill out the frayer models for each trend to organize their understandings 3. Students are given the second part of the activity <ul style="list-style-type: none"> a. Students will draw the bohr models of elements and apply the trends to the elements
Closure (2 mins)	<ol style="list-style-type: none"> 1. Students hand in their activity sheet, if not done it becomes HOMEWORK 2. Students summarize the trends they examined 3. HOMEWORK: more practice on trends

Day 8

Standard	Learning Objectives	Assessment
3.1 aa	Students will be able to explain how periodic trends define elements within the same group.	Formative: bell ringer, predictions Summative: answers to critical thinking questions
3.1 bb	Students will be able to explain how periodic trends define elements within the same period.	Formative: bell ringer, predictions Summative: answers to critical thinking questions

Instructional Steps

Bell ringer (Engage) (10 minutes)	<ol style="list-style-type: none"> 1. Students answer the following questions about periodic trends <ul style="list-style-type: none"> a. Rank the following in order of increasing electronegativity: C, Li, Ne, F b. Rank the following elements in order of decreasing atomic size: Al, Mg, Cl, Rb, Sr c. Rank the following elements in order of increasing ionization energy: Na, Li, Ca, Mg 2. Students switch papers with a partner, write their name on the bottom and grade their partner's paper as the teacher provides the correct answers
Explore (30 minutes)	<ol style="list-style-type: none"> 1. Teacher will demonstrate the reactivity of the metals in the first 2 groups of the periodic table. For the more reactive ones, use YouTube videos 2. Students will write down observations and make predictions on how reactive the metals are with water and if they will be more or less reactive than another metal 3. Students summarize the trend that they observed
Elaborate (20 minutes)	Students answer critical thinking questions on activity sheet, can work with a partner

Days 9-10

Standard	Learning Objectives	Assessment
3.1 v	Students will be able to classify elements as a metal, non-metal or metalloid based on their properties and location on the periodic table	Formative: Student discourse Summative: Project, rubric
3.1 w	Students will be able to separate elements based off their physical properties	Formative: Student discourse Summative: Project, rubric
3.1 x	Students will be able to separate elements based off their chemical properties	Formative: Student discourse Summative: Project, rubric
3.1 y	Students will be able to use the location on the periodic table to determine the properties of the element	Formative: Student discourse Summative: Project, rubric
3.1z	Students will be able to use valance electrons to state why elements in the same group have the same chemical properties	Formative: Student discourse Summative: Project, rubric
3.1 aa	Students will be able to explain how periodic trends define elements within the same group.	Formative: Student discourse Summative: Project, rubric
3.1 bb	Students will be able to explain how periodic trends define elements within the same period.	Formative: Student discourse Summative: Project, rubric

Instructional Steps

Project Based Assessment (60 mins)	<ol style="list-style-type: none"> 1. Students have to determine the identity of an unknown element when given its properties 2. Students will demonstrate their knowledge of the periodic table by a project of their choice <ol style="list-style-type: none"> a. Museum director who needs to create an exhibit teaching the periodic table b. A Periodic Table game that serves as a learning tool c. Using the periodic table as an example, create your own periodic table of an object of their choice d. Story of your journey across/down the periodic table e. Student generated project idea (pending teacher approval) 3. Students work on the two part assessment during the class period <p>Students are given 2 class periods to work on, if not finished this assessment is due a week after it is assigned</p>
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Chemistry Unit: Bonding

Overview

This unit incorporates guided inquiry and the 5e model. A student centered classroom is achieved as students investigate scientific phenomenon to construct meaning of their world. Beginning with a bonding inquiry activity, students are introduced to chemical bonding upfront. Then they dive into each individual concept to develop their understanding of chemical bonding. Students then learn how chemical bonds influence the behaviors of the molecule or compound. Students begin to understand how chemistry happens through the valence electrons. Brief session of teacher driven notes will be present however, the majority of the unit is student centered. An estimated 15-18 days should be allotted for this unit, depending on how fast students' progress through the inquiry based lessons. This unit plan is based on 15 days but the teacher can extend any day as needed.

Prior knowledge needed

- Students should already know:
 - Ions
 - Periodic trends: electronegativity
 - Metals and non-metals
 - Periodic table
 - Structure of the atom

How are ELLs addressed

Each lesson in this unit emphasizes peer discourse; the research has shown that ELLs learn best by talking with their peers about scientific concepts. This unit is designed using inquiry and the 5e model to scaffold the content for all students, creating an equitable learning experience. There are many opportunities within this unit to differentiate for English Language Learners to help meet their needs in the classroom.

Standards Covered in Unit	Enduring Understandings
<p>5.2 a Chemical bonds are formed when valence electrons are shared between atoms</p> <p>5.2 b Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases have stable valence configurations and tend not to bond.</p> <p>5.2 d Electron-dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions.</p> <p>5.2 e In a multiple covalent bond, more than one pair of electrons are shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond.</p> <p>5.2 h Metals tend to react with nonmetals to form ionic compounds. Ionic compounds containing polyatomic ions have both ionic and covalent bonding.</p> <p>5.2 i When a bond is broken, energy is absorbed. When a bond is formed, energy</p>	<p>Know (facts)</p> <ul style="list-style-type: none"> • There are three types of bonds: ionic, covalent and metallic • Atoms bond to lower their energy and become more stable • Ionic bond transfer electrons, covalent bonds share electrons and metallic bonds have a sea of electrons • Anions and cations participate in ionic bonding • Polyatomic ions and compounds with these ions have both covalent and ionic bonds • Electronegativity differences play a part of deciding what bond two elements have • Bond breaking absorbs energy and bonds formation releases energy • Polar covalent and non polar covalent bonds are determined by electronegativity and occurs within the bond • Molecule polarity is based off the symmetry of the molecule • Covalent bonds can be single, double or triple • Atoms bond to gain a full octet with their valence electrons • Ionic and covalent bonds have specific physical

<p>is released</p> <p>5.2 j Electronegativity indicates how strongly an atom of an element attracts electrons in a chemical bond. Electronegativity values are assigned according to arbitrary scales</p> <p>5.2 k The electronegativity difference between two bonded atoms is used to assess the degree of polarity in the bond.</p> <p>5.2 l Molecular polarity can be determined by the shape of the molecule and distribution of charge. Symmetrical (nonpolar) molecules include CO₂, CH₄, and diatomic elements. Asymmetrical (polar) molecules include HCl, NH₃, and H₂O.</p> <p>5.2 m Intermolecular forces created by the unequal distribution of charge result in varying degrees of attraction between molecules. Hydrogen bonding is an example of a strong intermolecular force.</p> <p>5.2 n Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.</p> <p>NGSS</p> <p>HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.</p> <p>HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction.</p> <p>Crosscutting Concept: Structure and Function, Patterns, Stability and Change</p> <p>Science Practices: Asking questions, Developing and Using Models, Analyzing and Interpreting Data, Constructing Explanations, Obtaining, evaluating and communicating information</p>	<p>properties that distinguishes from the other</p> <p>Understand (big idea)</p> <ul style="list-style-type: none"> • Chemical bonding occurs to stabilize atoms through the attainment of a full octet <p>Do (skills)</p> <ul style="list-style-type: none"> • Analyze and present data to class • Use patterns to determine what is happening when atoms bond • Effective communication <ul style="list-style-type: none"> ○ With peers ○ With data and information
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<p style="text-align: center;">Essential Questions</p> <ul style="list-style-type: none"> • Why do atoms bond? • What physical properties does each bond have and how do they • How do valence electrons behave in an ionic, covalent and metallic bond? • How can a polar molecule have nonpolar bonds? 	<p style="text-align: center;">Key Vocabulary</p> <ul style="list-style-type: none"> • Octet • Ion • Anion • Cation • Ionic • Covalent • Metallic • Polar covalent bond • Nonpolar covalent bond • Polar molecule • Nonpolar molecule • Bond formation • Bond breaking • Dipole • Net dipole
<p style="text-align: center;">Misconceptions</p> <ol style="list-style-type: none"> 1. Bonding must be either ionic or covalent 2. Covalent bonds must be weak because covalent compounds are generally soft with low melting points 3. Bond polarity is the same as molecular polarity 	<p style="text-align: center;">Proper Conceptions</p> <ol style="list-style-type: none"> 1. There are three types of bonds. Also, compounds can have both ionic and covalent bonds. 2. Weak bonds relate to intermolecular forces, covalent bonds are intramolecular bonds 3. Bond polarity determines the pull of electrons between the atoms. Molecular polarity is determined by symmetry and influences how the molecule behaves in reactions. 4.
<p style="text-align: center;">Instructional Strategies/Learning Tasks</p> <ul style="list-style-type: none"> • Teacher will act as a facilitator of information throughout the majority of the unit while keeping direct instruction to a minimum. • Students will participate in guided inquiry where they will discover chemical bonding through hands on activities that keep them questioning. 	<p style="text-align: center;">Instructional Materials</p> <ul style="list-style-type: none"> • White board/Smart board • Student white boards • Chemical Bonding Inquiry Lab • YouTube videos • Student laptops or access to computers • PHET Simulations • Properties of Bonds Lab materials • ExploreLearning website • Electronegativity data for polar and nonpolar covalent bonds: Inquiry Activity • Molecular Bonding Model Kits
<p style="text-align: center;">Research Based Practices</p> <ul style="list-style-type: none"> • Inquiry based instruction • 5e model of instruction • Blooms Taxonomy • Graphic organizers 	

- Jigsaw

Differentiation

(Should be based on student's IEP/504 plans)

- **Kinesthetic learners: manipulating materials through inquiry**
- **Visual learners: observing chemical reactions and color changes**
- **Auditory learners: listening to peers and class discussions**
- **ELL:**
 - **Graphic organizers to organize thoughts, vocabulary, and notes**
 - **Outlined notes**
 - **Notes provided before class discussions**
 - **Documents provided in their native language**
 - **Pictorial representations**
 - <http://seplessons.ucsf.edu/node/2241>
 - http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Chemical_Bonding/General_Principles_of_Chemical_Bonding/Covalent_Bonds
 - **Analogies: provided by teacher, or created by student or by peers**
 - **Food Sharing Analogy**
 - **Scaffolded assignments**
 - **Videos to help with visualization:**
 - https://www.youtube.com/watch?v=93G_FqpGFGY
 - <https://www.youtube.com/watch?v=M9khs87xQ8>
 - **PHET on Bonding**
 - <https://phet.colorado.edu/en/contributions/view/3751>
 - <https://phet.colorado.edu/en/simulation/molecule-shapes>
 - <https://www.explorelearning.com>
 - **Intermolecular Force Jigsaw**
 - http://chemwiki.ucdavis.edu/Physical_Chemistry/Physical_Properties_of_Matter/Intermolecular_Forces/Hydrogen_Bonding
 - http://chemwiki.ucdavis.edu/Physical_Chemistry/Physical_Properties_of_Matter/Intermolecular_Forces/Dipole-Dipole_Interactions
 - http://chemwiki.ucdavis.edu/Physical_Chemistry/Physical_Properties_of_Matter/Intermolecular_Forces/London_Dispersion_Interactions

Day 1

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, questions from evaluation Summative: quiz, test, inquiry activity, project
5.2 b	Students will be able to describe why elements bond	Formative: student discourse, questions from evaluation Summative: quiz, test, inquiry activity, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse, questions from evaluation Summative: quiz, test, inquiry activity, project

Instructional Steps

Bell Ringer (15 mins)	What is an anion and cation? What are the three types of elements? Predict how two atoms come together to form a compound?
Explore/ Explain (20 mins)	Intro to Bonding Inquiry Activity
Elaborate (15 mins)	<ol style="list-style-type: none"> Students practice drawing Lewis Dot structures (LDS), the inquiry activity provides an introduction to this Teacher should walk around and aid students with their structures
Evaluate (10 mins)	<ol style="list-style-type: none"> What type of elements make up a bond? Draw the LDS for Chlorine Does chlorine gain or lose electrons? Is it a cation or anion? <p>Questions become homework</p>

Day 2

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, Summative: quiz, test, inquiry activity, project

5.2 j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse Summative: quiz, test, inquiry activity, project
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Instructional Steps

Bell-ringer (5 mins)	Go over questions: Students get into pairs and discuss their answers, then have a whole group discussion.
Engage (10 mins)	Video: Electronegativity https://www.youtube.com/watch?v=93G_FqpGFGY How can we use electronegativity to predict if a covalent or ionic bond will form?
Explore/Explain(40 mins)	PHET Simulation: Electronegativity Inquiry activity
Elaborate/Evaluate: HOMEWORK	Revisit Periodic Trends Electronegativity graphs, have students form explanations from the electronegativity trends and the inquiry activity to write a summary of how electronegativity influences bonding and what type of bond.

Day 3

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse Summative: quiz, test, lab, project
5.1 n	Students will be able to use the physical properties of compounds to determine the type of chemical bond	Formative: student discourse Summative: quiz, test, lab, project

Instructional Steps

Lab Introduction (10 mins)	Collect HOMEWORK, answer questions Students pick up properties of bonds lab to look over, read and form questions
Lab (45 mins)	Students will cycle 5 stations testing properties of ionic and covalent bonds: Each station allow 5-8 minutes <ul style="list-style-type: none"> • Conductivity: pure form and aqueous form • Solubility in Water • Solubility in Hexane • Melting point • Brittleness/hardness
Closure (5 mins)	Lab clean up, for Lab HOMEWORK students should complete lab analysis tables to organize data for next class

Day 4

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use	Formative: student discourse, muddiest

	valance electrons to form chemical bonds	point Summative: quiz, test, lab
5.1 n	Students will be able to use the physical properties of compounds to determine the type of chemical bond	Formative: student discourse, muddiest point Summative: quiz, test, lab

Instructional Steps

Elaborate extension (30 mins)	<ol style="list-style-type: none"> 1. Get into lab groups, students are to look at their data and determine what properties distinguishes an ionic bond from a covalent bond. 2. Each group is given one property to construct their own explanation for to share with the class
Explain (25 mins)	Group discussion on how the properties influence bond type
Closure (5 mins)	Muddiest point: post it note HOMEWORK: lab report due at the end of the week

Day 5

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse Summative: quiz, test, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse Summative: quiz, test, project
5.1 h	Students will be able to state the two types of elements that create an ionic bond	Formative: student discourse Summative: quiz, test, project
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse Summative: quiz, test, project

Instructional Steps

Bell ringer, discussion (10 mins)	<p>Prior knowledge activation: An ionic bond is found between what two elements? What is an ion? Cation? Anion?</p> <p>Talk with partner and share with class</p>
Engage (10 mins)	<ol style="list-style-type: none"> 1. Intro to Ionic Bonding: Predict: why are there two chlorine atoms in $MgCl_2$? 2. Have students make observations of calcium chloride so students <ol style="list-style-type: none"> a. Explain: chlorine is a poisonous gas, and calcium is a silver metal, however when combined a white solid is formed <p>Have student get an activity sheet, laptops, and sign in when they are finished with their prediction. Students should start with the warm up questions as they wait for their computers</p>

	to load https://www.explorelarning.com/index.cfm?method=cResource.dspDetail&resourceID=514
Explore/Explain (30 mins)	Working in pairs or groups of 3 <ul style="list-style-type: none"> Students explore ionic bonding with the program <ul style="list-style-type: none"> When students are near activity B, stop the class and do a comprehension check and explain that the idea is that atoms bond to obtain a full octet <ul style="list-style-type: none"> in ionic bonding that happens due to a transfer of electrons. Teacher walks around and guides students, providing enough information for them to construct their own understanding but leading them to the correct understanding.
Closure (10 mins)	<ol style="list-style-type: none"> As students finish they need to answer the questions on the last page of the packet (5 assessment questions) and turn them in for a check for understanding. Students need to revisit their answer to why are their two chlorine atoms in $MgCl_2$, and correct their answer to demonstrate what they have learned. HOMEWORK: practice on ionic bonding

Days 6

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, bonding with a classmate activity Summative: quiz, test, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse, bonding with a classmate activity Summative: quiz, test, project
5.1 h	Students will be able to state the two types of elements that create an ionic bond	Formative: student discourse, bonding with a classmate activity Summative: quiz, test
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse, bonding with a classmate activity Summative: quiz, test, project

Instructional Steps

Bell ringer (10 mins)	Students at random provide their answers to the homework questions on the white board, students compare their answers with their peers. Go over homework and discuss different answers.
Explain (20 minutes)	Guided practice on LDS showing transfer of electron in ionic bonding Notes on how to name ionic compounds
Elaborate (30 mins)	Bonding With a Classmate Activity
Closure (2 mins)	HOMEWORK: students practice naming the compounds they created in the activity

Day 7

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, bell ringer, Summative: quiz, test, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse, bell ringer, Summative: quiz, test, project
5.1 h	Students will be able to state the two types of elements that create an ionic bond. Students will also be able to explain how a molecule can have two types of bonds.	Formative: student discourse, bell ringer, Summative: quiz, test, project
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse, bell ringer, Summative: quiz, test, project

Instructional Steps

Bell ringer (10 minutes)	Post 3 ionic compounds have students draw the LDS and name the compound; students turn this in and turn in their activity sheet.
Explain (30 minutes)	Notes on naming ionic compounds with transition metals and polyatomic ions
Elaborate (15 minutes)	Practice: students struggle with this concept
Closure (5 mins)	In own words students explain ionic bonding. Quiz next class on ionic bonding HOMEWORK: Give students pictures of HCl, CO ₂ , C ₂ H ₂ : write down observations and what you wonder about

Day 8

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse Summative: quiz, test, assessment questions, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse Summative: quiz, test, assessment questions, project
5.2 e	Students will be able to state the two types of elements that create a covalent bond	Formative: student discourse Summative: quiz, test, assessment questions, project
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse Summative: quiz, test, assessment questions, project

Instructional Steps

Quiz (20 mins)	Students come in and get into quiz setting, study and ask questions for the first 5 mins of class Quiz on covalent bonding
Engage (10 mins)	Display the three molecules on the white board, have students use post it notes to write one observation and one wonder and put it under the picture (this should be from their homework) Have a mini discussion
Explore (30 mins)	https://www.explorelarning.com/index.cfm?method=cResource.dspDetail&resourceID=512 Students should start with the warm up questions as they wait for their computers to load Working in pairs or groups of 3, students explore covalent bonding with the program. When students are near activity B, stop the class and do a comprehension check and explain that the idea is that atoms bond to obtain a full octect, in covalent bonding that happens due to a sharing of electrons. Teacher walks around and guides students, providing enough information for them to construct their own understanding but leading them to the correct understanding. Students should turn in the 5 assessment questions for a check for understanding HOMEWORK: covalent bonding practice

Days 9-10

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, homework discussion, closure explanation Summative: quiz, test, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance	Formative: student discourse, homework discussion, closure explanation

	electrons	Summative: quiz, test, project
5.2 e	Students will be able to state the two types of elements that create a covalent bond	Formative: student discourse, homework discussion, closure explanation Summative: quiz, test, project
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse, homework discussion, closure explanation Summative: quiz, test, project
5.2 k	Students will be able to assess the degree of polarity through electronegativity	Formative: student discourse, homework discussion, closure explanation Summative: quiz, test, project

Instructional Steps	
Bell Ringer (20 mins)	Students at random provide their answers to the homework questions on the white board, students compare their answers with their peers. Go over homework and discuss different answers.
Explain (45 mins)	Guided practice on LDS showing sharing of electrons: single, double, triple
Notes (30 mins)	Notes on how to name covalent compounds and practice
Engage (3 mins)	Watch video: https://www.youtube.com/watch?v=M9khs87xQ8 Students should predict what happens with the electrons in a polar covalent bond based off what they see in the video. The ionic bond part of the video is just a fun review.
Explore (10 mins)	Non Polar and Polar Covalent: Electronegativity difference Give data on 10 covalent compounds where it shows the electronegativity difference of the elements involved in each compound. Have students analyze the data to find the trend and come up with the rule that non-polar covalent bonds have an electronegativity difference of 0 and polar covalent molecules have an electronegativity difference that is greater than 0.
Explain (5 mins)	Non polar covalent is an equal sharing of electrons, give examples (H ₂ , O ₂ ..) Polar covalent is the unequal sharing of electrons, give examples (H ₂ O)
Closure: (7 mins)	Write 3-5 sentences explaining covalent bonds to your mom: include everything you have learned to this point. HOMEWORK: Molecular bonding lab: students need to read the lab and annotate, Quiz on covalent bonding

Day 11

Standard	Learning Objectives	Assessment
5.2a	Students will be able to use valance electrons to form chemical	Formative: student discourse Summative: lab, test, lab homework,

	bonds	project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse Summative: lab, test, lab homework, project
5.2 e	Students will be able to state the two types of elements that create a covalent bond	Formative: student discourse Summative: lab, test, lab homework, project
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse Summative: lab, test, lab homework, project
5.2 k	Students will be able to assess the degree of polarity through electronegativity	Formative: student discourse Summative: lab, test, lab homework, project

Instructional Steps

Quiz (20 mins)	Students come in and get into quiz setting, study and ask questions for the first 5 mins of class Quiz on covalent bonding
Lab: Elaborate (40 mins)	<ul style="list-style-type: none"> • Introduction to Molecular Bonding Model Lab <ul style="list-style-type: none"> ○ Students should get into lab groups ○ Teacher will quickly go over the lab focusing on explain the model kit so students know what color corresponds with what element ○ Students are released to perform the lab
Closure (2 mins)	Lab HOMEWORK

Day 12

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, practice, graphic organizer Summative: lab, test, lab homework, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse, practice, graphic organizer Summative: lab, test, lab homework, project
5.2 e	Students will be able to state the two types of elements that create a covalent bond	Formative: student discourse, practice, graphic organizer Summative: lab, test, lab homework, project
5.2j	Students will be able to use electronegativity differences to determine the type of bond	Formative: student discourse, practice, graphic organizer Summative: lab, test, lab homework, project
5.2 k	Students will be able to assess the degree of polarity through	Formative: student discourse, practice, graphic organizer

	electronegativity	Summative: lab, test, lab homework, project
Instructional Steps		
Bell ringer: Engage (5 mins)	<p>What is molecular shape?</p> <p>Students hand in lab HOMEWORK but keep lab</p>	
Explain (30 mins)	<ol style="list-style-type: none"> 1. Teacher provides brief notes on molecular polarity <ol style="list-style-type: none"> a. Demonstration: on a piece of paper write HCl: <ol style="list-style-type: none"> i. Draw a dotted line between the H and the Cl ii. Flip the paper upside down; do you have the original compound you started with? iii. Go back to starting position; if you rotate your paper 180° do you get the same compound? <ol style="list-style-type: none"> 1. If yes to both: non polar molecule 2. If you have a “no” to either question: polar molecule <p>Practice</p>	
Elaborate (20 mins)	Look back at lab and find the molecular polarity of the compounds examined	
Closure (5 mins)	<p>Questions I still have exit ticket</p> <p>HOMEWORK: graphic organizer using notes organize information on bond polarity versus molecule polarity</p> <p>Students are assigned an intermolecular force and given information to prepare</p> <ul style="list-style-type: none"> • Van der Waals and London Dispersion Forces • Hydrogen Bonding • Dipole-Dipole 	

Day 13

Standard	Learning Objectives	Assessment
5.2 m	Students will be able to explain how intermolecular forces form and influence behaviors of molecules based on the strength of the force	Formative: student discourse, practice, graphic organizer Summative: test, project

Instructional Steps	
Jigsaw Part 1 (20 mins)	<ol style="list-style-type: none"> 1. Students get into groups based off their intermolecular force 2. Students discuss their intermolecular force and come to an agreement with what the force is and how it affects molecular bonding in reactions 3. Teacher should walk around, and guide students to deepen their understanding
Jigsaw Part 2 (30 mins)	<ol style="list-style-type: none"> 1. Students are regrouped so that an “expert” from each intermolecular group is together 2. Students share their knowledge about their force while their peers write notes and asks questions

Closure (10 mins)	<ol style="list-style-type: none"> 1. Students summarize intermolecular forces 2. Answer: what is the difference between intermolecular forces and intramolecular forces? 3. Study guide for test and project sheet
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Day 14

Standard	Learning Objectives	Assessment
5.2 a	Students will be able to use valance electrons to form chemical bonds	Formative: student discourse, practice, graphic organizer Summative: test, project
5.2 d	Students will be able to use Lewis Dot Structures to represent valance electrons	Formative: student discourse, practice, graphic organizer Summative: test, project

Instructional Steps	
Engage (5 mins)	Last bond type: Metallic Ask students why copper is used in electrical wiring
Explain (10 mins)	<ol style="list-style-type: none"> 1. Notes: electron movement: “sea of electrons” 2. Demonstration: call 4 students up, you are all metal atoms in a compound, show how the electron is randomly passed around with in the group to simulate the “sea of electrons”
Elaborate (10 mins)	Students use notes on ionic, covalent and metallic bonds to fill in a chart to help them distinguish between the 3 types of chemical bonds
Study (35 mins)	<ol style="list-style-type: none"> 1. Study guide for test and project sheet are given out 2. Students choose a supplemental project that will be graded and added to their test score <ol style="list-style-type: none"> a. Supplemental project ideas: <ol style="list-style-type: none"> i. Story: Choose one type of bonding and write “A Day in the Life of an Atom” story describing what it's like to be an atom that forms your chosen bond type. The story should incorporate at least 5 properties from your Bonding Comparison Chart. ii. Comic Strip: Choose one type of bonding and write a comic strip with 5+ frames. The comic should incorporate at least 3 properties from your Bonding Comparison Chart.

Day 15: Test Day, project is due 1 week from this day

Explanation of how English Language Learners are addressed

Inquiry Explanation

The units are set up to teach chemistry content to students through guided inquiry to engage students in scientific exploration. English Language Learners learn with demonstrations that spark curiosity. Through the inquiry process, ELLs are investigating the scientific phenomenon. In each unit, students start with recognizing patterns, and how those patterns provided the necessary information for the scientific phenomena being studied. ELLs are working alongside their native English speaking peers as they explore and the chemistry concepts. School provides an environment where socialization with English speaking peers influences an English Language Learner's English language acquisition (Souto-Manning, 2010). ELLs benefit from conversing with English speaking peers by practicing the language in a neutral environment. Through the inquiry process, ELLs are learning the same concepts with the same process and achieving the same results as their English speaking peers. In all three units, students are discussing with each other their observations, predictions and revisions as they learn about scientific phenomena, and construct their own understanding. The teacher's role is to act like a facilitator throughout most of each unit. Some content may be more advanced for the level of the students; guided practice and guided notes aid in students' knowledge of the scientific phenomena being learned. The teacher makes sure that their students are moving towards the correct understandings while refraining from simply providing them the information. Throughout each unit, ELLs are exposed to multiple forms of representations of the content, and have multiple ways to demonstrate their understanding. Through communication, an ELL is able to strengthen their second language acquisition while testing their understanding of the second language. Inquiry forces students to communicate their findings, and understandings of the science content through increasing the complexity of the task. Increasing the amount of

reasoning the task requires, forces English language learners to use the target language and promotes cognitive reflection (Robinson, 2011).

1. Acid Base:

- a. For the pH scale, ELLs learn about pH and the effects of acids and bases on pH through laboratory activities where they see the color change, and construct their own pH scale. This activity focuses on numerical values, therefore, the language barrier doesn't interfere as much if they were to read about it. Students use what they have discovered and apply their knowledge to determining what antacid is better. ELLs are working alongside their native English speaking peers to learn about how acids and bases affect pH. In this unit, students are able to have discussions about what they are observing and offer possible explanations. Through the Jigsaw activity, an ELL is able to prepare ahead of time and contribute to an overall classroom discussion on acid base theory, strong/weak acids and bases, neutralization, and Reference Table J. The English Language Learner may choose not to speak in front of the class but they will have helped in the creation of the student presentation; boosting the confidence of the English Language Learner. With limited teacher instruction, the English Language Learner can experience the scientific phenomenon of acids and bases first hand. There are topics that the teacher must cover like titrations and calculations to guide the students on the right path. Students are expected to demonstrate their understanding of acids and bases through an acid rain webquest and a cumulative test.

2. Periodic Table:

- a. Activities that focuses students to use patterns to figure out the periodic table forces students to form conclusions and revise their initial thoughts as they add to their understanding of the periodic table. The language barrier can be overcome by using the student's native language as much as possible. Relying on prior knowledge of patterns in everyday life can help a teacher relate an ELL's prior knowledge to how the periodic table provides valuable information about the elements. In this unit, students are able to have discussions about what they are observing and offer possible explanations. Through the Gallery walk activity, an ELL is able to prepare ahead of time and contribute to an overall classroom discussion on the periodic table. English Language Learners may not speak in front of the class but they will have helped in the creation of the student poster; boosting the confidence of an English Language Learner. Students are expected to demonstrate their understanding of the periodic table through their end of the unit project.
3. Bonding:
- a. Students are engaged in activities that require them to notice patterns, and how stability plays a role in chemical bonding. The language barrier can be overcome by using the student's native language as much as possible. Students also observe, predict and revise their conclusions as they discover new information simulating what the process that scientists undergo. In this unit, students are able to have discussions about what they are observing, and offer possible explanations. Guided practice allows the teacher to guide students through the more abstract concepts that students find hard to understand. This provides the teacher an

avenue to still allow their students to discover the concepts, and give them the information. During the laboratory activities, students explore bond properties and molecular shape to help construct their own knowledge about chemical bonds.

NGSS Alignment

Each unit aligns with the NGSS through the three dimensional learning. Throughout the units, students construct, and revise explanations of the scientific concepts being studied through various inquiry based activities and guided practice. Utilization of the three dimensional learning framework, ELLs with their peers are able to deepen their understanding of chemistry concepts and perform scientific skills at a higher level. With the crosscutting concepts, ELLs are able to work further on their scientific literacy and discourse in multiple ways as they make connections within the science. Crosscutting concepts recur throughout the year and demonstrate how science relates to the real world (Miller, 2015). The NGSS requires students to understand how to explain phenomena and design solutions to problems. NGSS points to practices that are involved in argumentation, explanations, questioning and communicating ideas. For ELLs, NGSS can help them with their language skills in reading and in speaking (Smith et al., 2015).

1. Acid Base:

- a. Throughout the unit, the students construct and revise explanations of acid base reactions through the various laboratory activities. With the antacid lab, the students are expected to plan and conduct an experiment to test which antacid is better. The pH scale demonstrates how students are refining their understanding of how a chemical system is changing. With their peers, students communicate their findings, and explain why their findings support the theories behind acids

and bases. All of these ideas are the disciplinary core ideas outlined in NGSS. As the students are exploring the effects of acids and bases on pH and in solution they are exploring three crosscutting concepts outlined in NGSS. Structure and function help the students determine how the properties of acids and bases affect their behavior in solutions. Students can use patterns to come up with the cause and effect of acids and bases have on the pH and each other in solution. As well as be able to explain what happens in a neutralization reaction. Lastly students will explore how stable acid reactions are and how they can change under certain conditions. All of these crosscutting concepts aid in the understanding of what is happening on the microscopic level. Lastly, students act and think like scientists as they explore the content through activities. Students develop their own models on pH, and they plan and carry out an investigation like a scientist would.

2. Periodic Table:

- a. Throughout the unit, the students construct and revise explanations of the periodic table through the various inquiry based activities as outlined in the NGSS within the disciplinary core ideas. Crosscutting concepts are also prevalent throughout the unit. With the alien activity, the students are expected to notice patterns and how those patterns affect the organization of the aliens. The same concept is repeated in the activity where the students are given an element and must find what family that element belongs in based off the element's properties and characteristics. Essentially scaffolding the process of recognizing patterns within the periodic table to construct their own understanding. Students will discover that the structure of the element (valance electrons) cause the element to behave a

certain way in chemical reactions. This idea is crucial for students to grasp as they need to understand how reactions take place, and how elements bond to one another. Students continuously revise their explanation as they gather more information to guide their learning. The Periodic trends graphing activity, provides an avenue for students to analyze data, and interpret the data just like the scientists did as they developed the periodic table.

3. Bonding:

- a. Throughout the unit, the students construct and revise explanations of chemical bonds through the various inquiry based activities. NGSS crosscutting concept, patterns, are made apparent in analyzing electronegativity data trends, as it influences how atoms bond to one another. Students analyze this data to construct their own conclusions about what types of elements are involved in the different types of bonds. Stability and change is also addressed in this unit as atoms bond to become more stable. As a result, the structure and function of the chemical bond influence how the molecule or compound reacts in chemical reactions which they will explore in the next unit. Throughout the unit, students are using the periodic table to help them understand and predict what is going on when atoms bond.

Analogies

Acid Base Unit: Football Analogy		
Players	Proton donor (Acid) Proton Acceptor (Base) Proton	Quarterback Receiver Football
Concept	In acids and bases, a strong acid and base fully dissociates. Meaning they provide a proton in solution, the more ions they put into solution the stronger they are	The quarterback throws the football to the receiver during a play. The quarterback is considered good or bad depending on how many successful throws he has.

Putting it together	<p>Acids are compared to quarterbacks, whose job is to get rid of the ball (H^+). A strong acid, like an excellent quarterback, delivers the ball effectively; a weak acid, like a poor quarterback, is often left holding the ball. Furthermore, bases may be likened to wide receivers, whose job is to catch and hold onto the ball (H^+). A strong base, like an excellent wide receiver, holds onto the ball; a weak base, like a poor receiver, often drops the ball. The concept of throwing and catching a ball is easy to visualize and the analogy to acids and bases can help even students unfamiliar with the mores of the gridiron to comprehend the mores of aqueous protons.</p> <p>(Adapted: http://pubs.acs.org/doi/abs/10.1021/ed077p849?journalCode=jceda8)</p>
Focus on ELLs	<p>Most are familiar with the game of football; however, this analogy works well with other sports. Therefore, to reach English Language learners who are not familiar with football, the teacher can alter the analogy to a sport that they are familiar with. For example, soccer is a sport that is common in most countries in the world. By changing the analogy to a player and goalie, students from countries where soccer is prevalent, they will be able to make the needed connections with the analogy and the concept. Another alternative sport is baseball, where the teacher could change the analogy to involve the pitcher and person hitting the ball. By changing this analogy to fit the ELL's culture, diversity in the classroom is achieved. Also, ELLs are able to use what they know about the sport, and apply it to a scientific concept.</p>

Periodic Table Family Analogy		
Participants	<p>Elements Going down a group: Row in the periodic table</p>	<p>Members of a family The family unit</p>
Concept	<p>Elements within a group of the periodic table have the same characteristics due to the same number of valence electrons in their outer shell.</p>	<p>Each member of a family are all individuals but also have the same values and outlooks as the entire unit.</p>
Putting it together	<p>An element is a member of the family, who has its own characteristics that make it unique. The family that the element belongs to all share the same chemical properties as they all have the same number of valence electrons. Similar to how each family unit all share the same values.</p> <p>(Adapted: http://scienceanalogies.com/chemicalbondinganalogies.html)</p>	
Focus on ELLs	<p>This analogy works for all students. Everyone has a family and can recognize characteristics specific to themselves and their family. For ELLs, they are able to further connect how each periodic table</p>	

	family is different from another by comparing their family to their peers. ELLs may practice different traditions or value different things than their peers.
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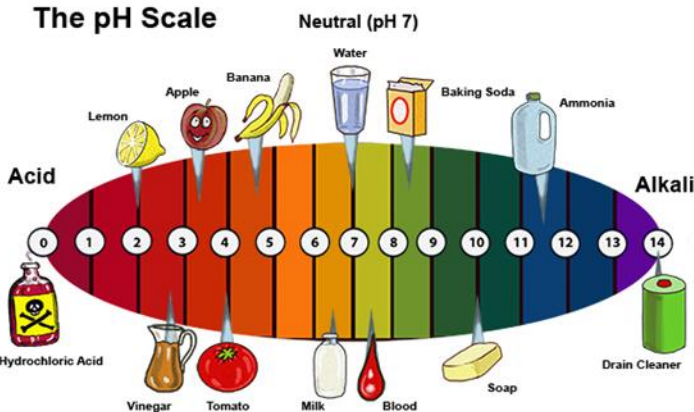
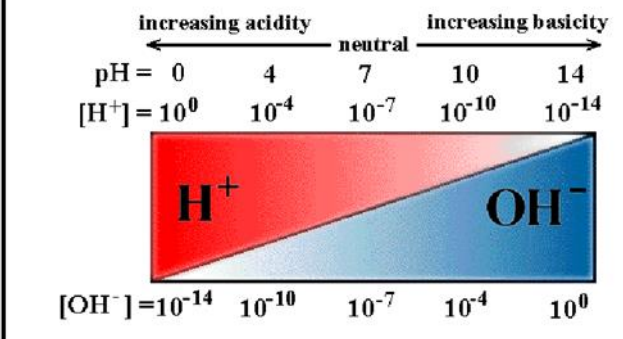
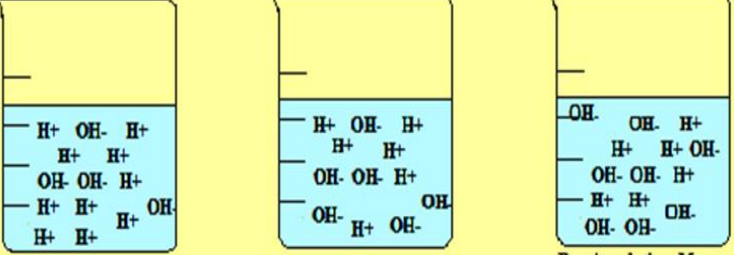
Bonding: Food Sharing Analogy		
Players	Elements Covalent Bond	2 friends food
Concept	Electrons are shared equally in a nonpolar bond. In a polar covalent bond, electrons are shared unequally.	A nonpolar covalent bond is formed if you give your friend half of your cheeseburger for half of his chicken burger. A polar covalent bond is like your friend taking all of your cheeseburger and in exchange giving you a small bite of his chicken burger.
Putting it together	Comparing the electrons to food being shared between friends takes something that high school students know very well, and applying that to the sharing of electrons in a covalent bond. Food is a great middle ground for students as it is something that everyone is familiar with. The food in this analogy can be changed to suit student's interests or culture. (Adapted: http://pubs.acs.org/doi/abs/10.1021/ed077p849?journalCode=jceda8)	
Focus on ELLs	Food is something that everyone has in common, so ELLs can easily relate to this analogy. A teacher can use food that is found in their ELL's culture to further the comparison.	

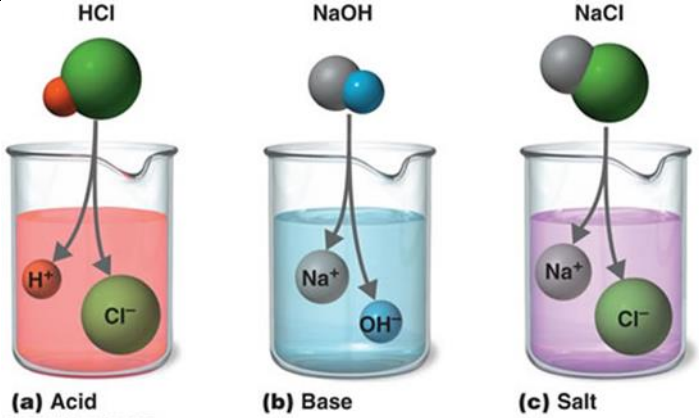
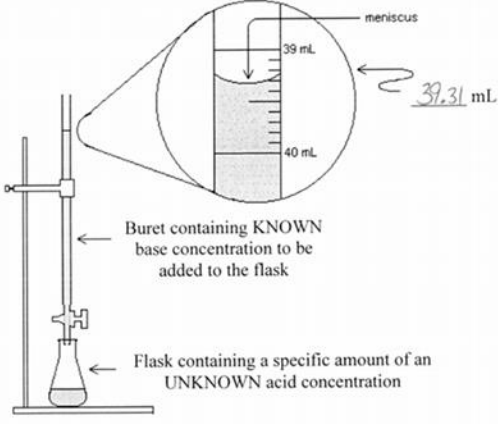
Explanation

By changing analogies used in the classroom to fit the ELL's culture, diversity is achieved. Also, ELLs are able to use what they know about the sport their family construct and food, in order to apply it to a scientific concept. Smith-Walters et al. (2016) discussed how ELLs bring with them their experiences and knowledge into the classroom. By using that prior knowledge to aid in the comprehension of a scientific concept, teachers are helping ELLs make valuable connections between what they already know to what they are learning. Student created analogies can provide information to the teacher about how well the student understands the

concepts. As mentioned in Yu (2013) when students create their own analogies they deepen their understanding of the concept. Yu (2013) discusses how students understand the scientific concepts better when they create their own analogies in addition to a teacher created analogy.

Visual Representations

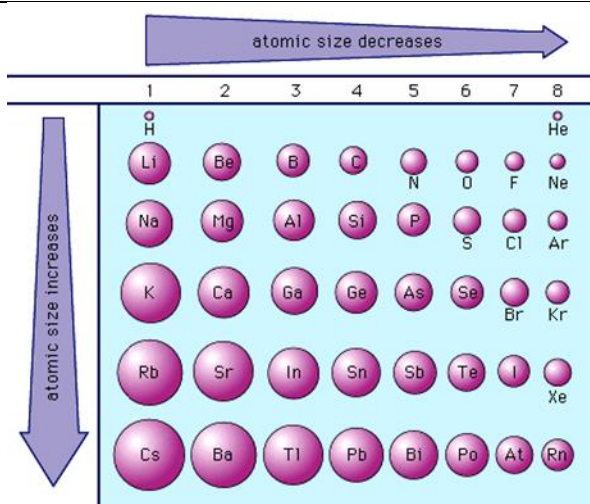
Acid Base Unit	
<p style="text-align: center;">The pH Scale</p> 	<p>A visual demonstrating where common household chemicals fall on the pH scale, to aid in prior knowledge. The teacher could add to this with specific common household chemicals that their ELL is familiar with if they are not familiar with these.</p> <p>(http://bkkthon.ac.th/home/images/post/754/2db66b3d5c2515519ac6dda2e8994fd3.jpg)</p>
	<p>A visual demonstrating the concentration of the H⁺ ion and the OH⁻ ion, and how those ions relate to the pH of a solution. This visual may need some explanation of the teacher's part as the log scale is involved.</p> <p>(http://biology12-lum.wikispaces.com/file/view/pH_scale.png/163710949/800x411/pH_scale.png)</p>
 <p style="text-align: center;"> Acidic solution. More H⁺ than OH⁻. Neutral Solution equal H⁺ and OH⁻. Basic solution. More OH⁻ than H⁺. </p>	<p>A visual demonstrating the concentration of the H⁺ ion and the OH⁻ ions in an acidic, basic and neutral solution. The students can see how the amount of H⁺ and OH⁻ ions change depending on the solution being examined. The students should be able to conclude that there are more H⁺ ions in an acidic solution, and less in a basic solution. Also, there are less OH⁻ ions in</p>

	<p>an acidic solution where as there are more OH⁻ ions in a basic solution. In a neutral solution the H⁺ and OH⁻ ions are equal. This representation helps all students visualize what is going on in the solution. For ELLs, this representation helps them make more connections rather than just reading about what is going on. They are able to see how the concentration of a specific ion changes the solution to be acidic, basic or neutral.</p> <p>(http://www.freesciencestuff.com/images/PS%20Sco46.gif)</p>
 <p>(a) Acid Copyright © 2010 Pearson Education, Inc.</p> <p>(b) Base</p> <p>(c) Salt</p>	<p>A visual demonstrating dissociation and how acids and bases break apart like salts in solution. This aids in the comprehension that acids and bases are electrolytes and conduct electricity like salts do. This further demonstrates how acids and bases have their properties. Another representation demonstrating how weak acids and bases dissociate can be used to help visualize the difference between strong and weak acids and bases.</p> <p>(https://s-media-cache-ak0.pinimg.com/originals/03/a6/09/03a609d64bf1d3a0e53738c768fa0870.jpg)</p>
 <p>meniscus</p> <p>39 mL</p> <p>40 mL</p> <p>39.31 mL</p> <p>Buret containing KNOWN base concentration to be added to the flask</p> <p>Flask containing a specific amount of an UNKNOWN acid concentration</p>	<p>These visuals demonstrate how to read a buret and a titration. Students are often confused on how to read a buret and often misread the chemistry glassware. By showing the students what the endpoint looks like will help students as they perform their titrations in lab. For ELLs these visuals will help them understand what their teacher is referring to as they instruct how to use a buret and perform a titration.</p>



(Visuals adapted from notes create by Mrs. Cook, Greece Olympia School Rochester NY)

Periodic Table Unit



A visual that demonstrates how the atomic radius changes across the periodic table and down the periodic table, this visual depicts the size of the atom. Teachers need to explain how valence electrons are responsible for the atomic radius.

(<https://s-media-cache-ak0.pinimg.com/originals/cd/01/12/cd0112622877cd596e74b6cc31690c1c.jpg>)

Periodic Trends Summary

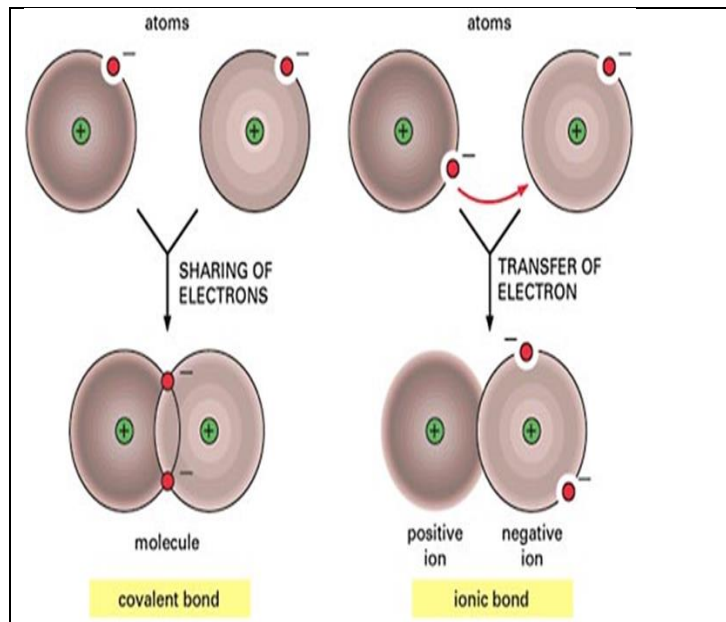
(use reference Table S for data comparison)

Trend	Across a period	Down a group
Ionization energy	increases	decreases
Electronegativity	increases	decreases
Atomic radii	decreases	increases
Metallic properties	decreases	increases

A visual that also serves as a graphic organizer provides the periodic trends in a concise manner. This visual can be used towards the end of the periodic trend discovery as a way to quickly find information.

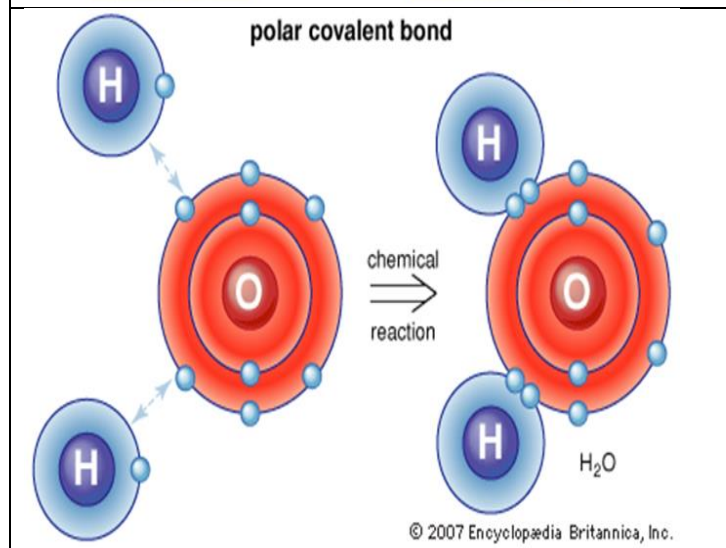
(http://images.slideplayer.com/24/7253094/slides/slide_26.jp)

	<p>g)</p> <p>This visual demonstrates the location of metals, non-metals and metalloids on the periodic table. Students can use this as they look at their own periodic table to see where these elements are located. Also, this visual reinforces the idea that metals have a larger atomic radius than non-metals.</p> <p>(http://2012books.lardbucket.org/books/principles-of-general-chemistry-v1.0/section_11/bd05f43d0392ab934fc21044ccca1cfd.jpg)</p>																														
<h3 style="text-align: center;">Atomic/Ionic Radii</h3> <table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="2">1A</th> <th colspan="2">2A</th> <th colspan="2">3A</th> </tr> </thead> <tbody> <tr> <td>Li 1.52</td> <td>Li⁺ 0.60</td> <td>Be 1.11</td> <td>Be²⁺ 0.31</td> <td></td> <td></td> </tr> <tr> <td>Na 1.86</td> <td>Na⁺ 0.95</td> <td>Mg 1.60</td> <td>Mg²⁺ 0.65</td> <td>Al 1.43</td> <td>Al³⁺ 0.50</td> </tr> <tr> <td>K 2.31</td> <td>K⁺ 1.33</td> <td>Ca 1.97</td> <td>Ca²⁺ 0.99</td> <td>Ga 1.22</td> <td>Ga³⁺ 0.62</td> </tr> <tr> <td>Rb 2.44</td> <td>Rb⁺ 1.48</td> <td>Sr 2.15</td> <td>Sr²⁺ 1.13</td> <td>In 1.62</td> <td>In³⁺ 0.81</td> </tr> </tbody> </table>	1A		2A		3A		Li 1.52	Li⁺ 0.60	Be 1.11	Be²⁺ 0.31			Na 1.86	Na⁺ 0.95	Mg 1.60	Mg²⁺ 0.65	Al 1.43	Al³⁺ 0.50	K 2.31	K⁺ 1.33	Ca 1.97	Ca²⁺ 0.99	Ga 1.22	Ga³⁺ 0.62	Rb 2.44	Rb⁺ 1.48	Sr 2.15	Sr²⁺ 1.13	In 1.62	In³⁺ 0.81	<p>This visual helps students visualize ionic radii. This is a sticking point for most students as the trend goes against what they initially think. This visual shows how the ionic radius compares to the atomic radius as the atom gains or loses an electron. For ELLs, the size difference is apparent and allows them to understand without the need for language.</p> <p>(http://jahschem.wikispaces.com/file/view/Ionic_Radii-metals.GIF/403043036/Ionic_Radii-metals.GIF)</p>
1A		2A		3A																											
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	<p>This visual demonstrates the periodic trends in one picture. This can be overwhelming for some students. Each trend is depicted and either increasing or decreasing depending on the direction of the arrow.</p> <p>(http://sciencenotes.org/wp-content/uploads/2014/10/PeriodicTableTrends.png)</p>																														
Bonding Unit																															



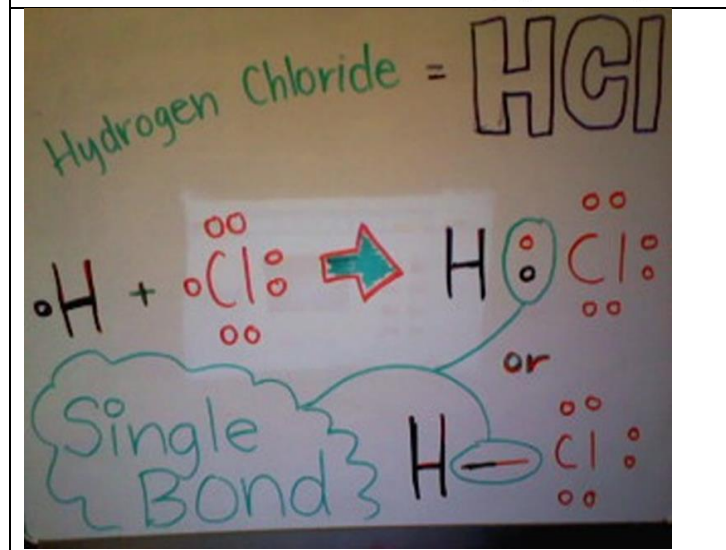
This visual demonstrates the electron movement for covalent and ionic bonds. Students are able to see how the electrons are shared or transferred. For ELLs this provides a concrete representation of an abstract concept.

<http://seplessons.ucsf.edu/node/2241>

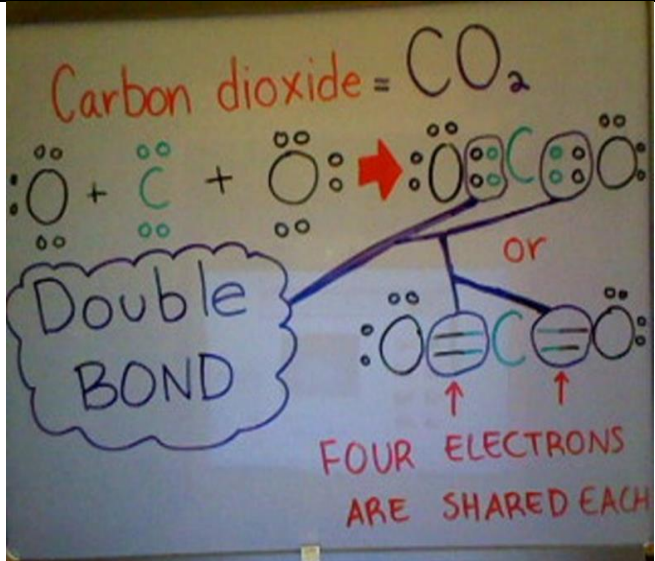
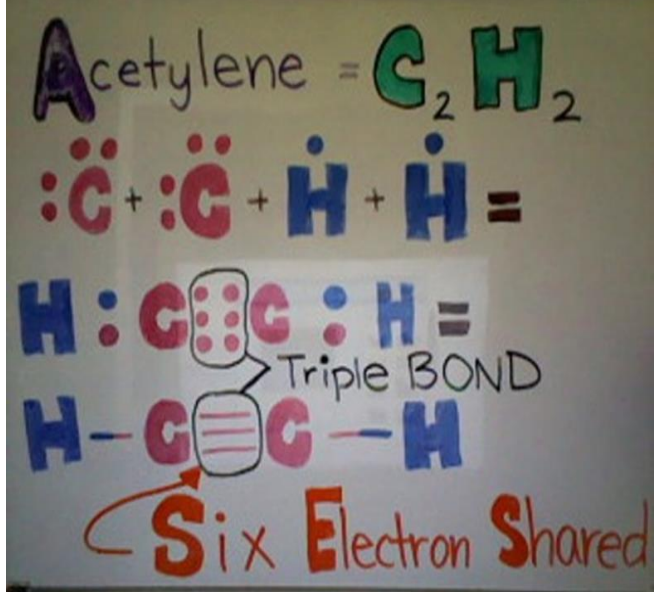


This visual demonstrates the bond between hydrogen and oxygen in the water molecule. Students can see how the electron from hydrogen is being shared with one of the electrons from the oxygen atom. Students have a difficult time visualizing this concept. For ELLs, having a visual to correspond with the content allows for a deeper understanding.

<http://seplessons.ucsf.edu/node/2241>



This visual demonstrates the single covalent bond between hydrogen and chloride through Lewis Dot Structures. This picture shows the process to drawing the bond between two non-metal atoms.

 <p>Carbon dioxide = CO_2</p> <p>Double BOND</p> <p>FOUR ELECTRONS ARE SHARED EACH</p>	<p>http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Chemical_Bonding/General Principles of Chemical Bonding/Covalent Bonds</p> <p>This visual demonstrates the double covalent bond between carbon and oxygen through Lewis Dot Structures. This picture shows the process to drawing the bonds between two non-metal atoms. Also, reinforces how many electrons are being shared.</p> <p>http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Chemical Bonding/General Principles of Chemical Bonding/Covalent Bonds</p>
 <p>Acetylene = C_2H_2</p> <p>Triple BOND</p> <p>Six Electron Shared</p>	<p>This visual demonstrates the triple covalent bond between carbon and hydrogen through Lewis Dot Structures. This picture shows the process to drawing the bonds between two non-metal atoms. Also, reinforces how many electrons are being shared.</p> <p>http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Chemical Bonding/General Principles of Chemical Bonding/Covalent Bonds</p>
PHET	<p>PHET simulations provide visualization for students to see how atoms act at the molecular level. These simulations can be used as an extra tool for students who need it. For ELLs this simulation is an excellent visualization to see what is happening at the molecular level.</p>

	https://phet.colorado.edu/en/simulation
Videos	In the differentiation part of each unit plan, several videos are listed. These videos can be used to help students visualize what is happening at the molecular level. Each video is able to provide closed captioning so ELLs are able to see the English words. Teachers also, could find videos in the student's native language.

Explanations

For ELLs, these visuals will not only help with the concept but, also with vocabulary. Making vocabulary assessable to ELLs provides them with more of an opportunity to participate, and gain a deeper understanding of the science content (Bresser & Fargason, 2013). Visuals help students understand content, and vocabulary without the use of language. ELLs make meaningful connections within science content when they are able to see a picture with the description in English, and in their native language (Yu, 2013). Providing each visual representation with the student's native language, aids in better comprehension of the content.

1. Acid Base:

- a. For this unit, the teacher should include visual representations for each topic demonstrating how acids and bases act on the molecular level. For pH, the teacher should show common household chemicals to relate to their student's prior knowledge. Also, a representation of the H^+ ion concentration at each pH will help students see the relationship of the concentration of these ions to the pH of an acid and base. Dissociation is a vocabulary term that confuses most students, therefore, a visual of how an acid and base dissociate in water to form the ions we are concerned with will help students to see what is happening at the molecular level. This will also help when students are trying to visualize how water can be an acid and a base.

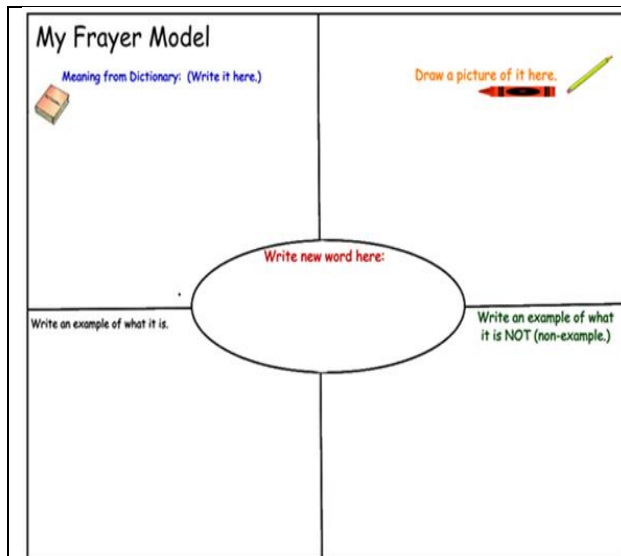
2. Periodic Table:

- a. For this unit, the teacher should include visual representations for each topic demonstrating the elemental chemical and physical properties. Pictures that depict each periodic trend at the molecular level allow all students to visualize abstract ideas better. Teachers should provide as many of these visuals as possible for all. Pictorial representations that show the comparisons of the trends, and properties provide a concrete resource for students to use as they put the pieces of the periodic table.

3. Bonding:

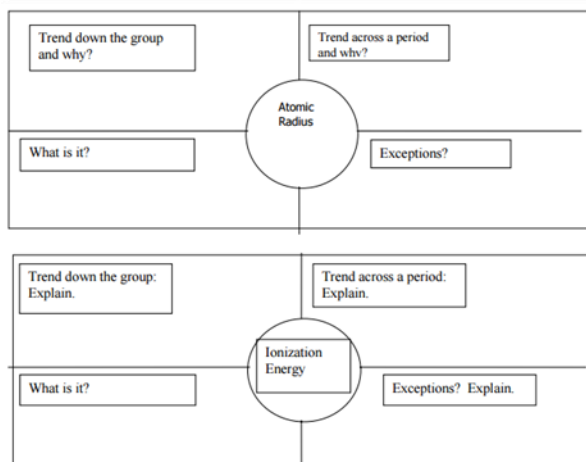
- a. For this unit, the teacher should include visual representations for each topic demonstrating how atoms bond, and the motion of the electrons. These are abstract topics for every student; by providing visuals, the molecular level becomes visible. Students can also analyze the visual representations to come up with the scientific phenomena behind what they are seeing. This approach lends itself to a deeper understanding what is going on at the molecular level. Bonding is one of the most difficult units in chemistry that most students struggle with. Representing these concepts in multiple ways will reach all students. ELLs use visuals and pictures to help them construct meaning about the scientific concepts as stated in the literature.

Graphic organizers



The Frayer model is a great resource to use with ELLs as it causes the student to create something to help them remember the concept or word. A teacher can use this to help ELLs to use their prior knowledge while introducing new concepts. The ELL could adapt this to fit their needs as a learner.

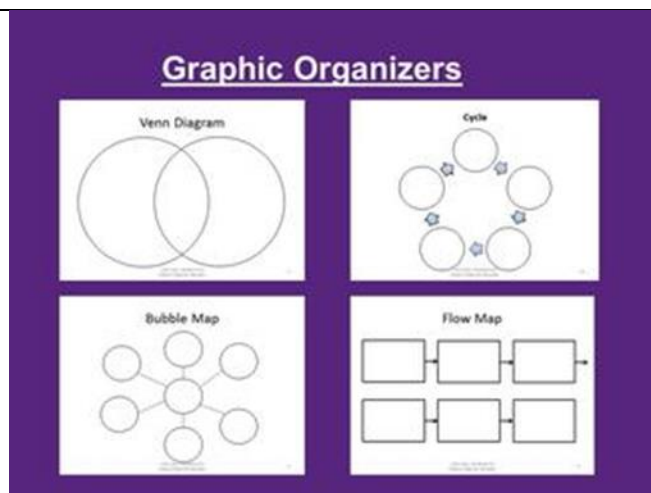
<https://dryuc24b85zbr.cloudfront.net>



Periodic Table: These frayer models provide a way for students to organize important information about the periodic trends. Students are able to use their own understanding and can organize their thoughts. For ELLs it's a more precise way visualize the information since the amount of information can be overwhelming to learn; especially since there are multiple trends that each operate in a different way.

<https://www.georgiastandards.org/>

(Periodic Table)



These are other graphic organizers that help ELLs sort through the science concepts to gain a better understanding. For the acids and bases unit, these graphic organizers can help with comparing and contrasting acids and bases, or demonstrate how a neutralization reaction works through a flow chart.

<http://d32ogoqmya1dw8.cloudfront.net>

KWL		
What I Know	What I Want to Know	What I Learned

A KWL chart provides students a way to take ownership of their learning. KWL charts allow students to see the progression of their learning. Also, with inquiry, the “what I want to know” column provides the first step to an inquiry based exploration of the concept, directs the learning of students in a way where they can

(<http://www.readingeducator.com/strategies/kwl.gif>)

Explanations

Graphic organizers help students organize their thoughts, and the content to deepen their understanding of the science content (Carr et al., 2007). A teacher can use specific graphic organizers that will help their specific English Language Learner(s) in their classroom. Since the acid base unit is taught later in the school year, the teacher, and ELL will know what works best for learning. Graphic organizers can be used for vocabulary, specific scientific concepts, reactions, and scientific processes. For the periodic table and bonding units since they are taught in the beginning of the year, a teacher and their ELL may need to figure out what graphic organizer works best for learning. Graphic organizers aid in students seeing patterns within the scientific concepts through organizing the information. A teacher can utilize these organizers in a way where an ELL’s native language is used, and visual representations could be added, to deepen learning.

Native Language Utilization

Areas where Native Language can be used	Specific to Unit: Acids and Bases
Notes	Key words can be translated in native language Glossary of the vocabulary in both languages
Handouts	Homework in Native language Word Bank

Visuals	Provide both languages on visuals or a key with the word in the native language Closed Captioning: videos
Directions on test or quizzes	Write directions in native language Translate entire test or quiz in native language
Reference Tables	Translate Reference Tables used into native language
Project Based Assessment	Can use their native language on their project with translation for the teacher

Explanation

A study by Swanson et al. (2014) found that by providing visuals with wording in both languages helped students make connections faster than just leaning about the concepts by reading about it in English. Yu (2013) discussed that by incorporating both languages in the classroom motivation and a willingness to attempt assignments are increased. ELLs comprehend more and is engaged while learning. A balance of languages within the classroom seems to be the best practice for ELLs to learn content (Adams et al., 2015). The notes or outline of notes can be translated into the student's native language. Key words can be translated instead of all the notes in their native language. The idea is to strengthen the student's skills in English as well as their language in the science content.

Homework in their native language will help parents at home when they help their child if they aren't fluent in English. Adding native language to visuals help students process what they are looking at. Often tests and quizzes become comprehension based, by adding native language or a glossary will help ELLs understand what is being asked of them, and demonstrate their knowledge. For the periodic table unit, a project based assessment allows ELLs to use creativity to demonstrate their learning. A teacher could encourage their ELL to use their native language on their final product as long as they provide a translation for their teacher and peers.

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