Stewardship of Trees and Forests for Environmental and Human Health

Wikiup LightHouse STEM Based Learning Using Western Apache Plants

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Acknowledgements:

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Context and Rationale

San Carlos High School (SCHS) is one of the four schools of San Carlos Unified School District (SCUSD) which includes San Carlos Primary School, San Carlos Intermediate School, San Carlos Middle School, and San Carlos High School (SCHS). All schools have the mission to educate and empower students to become culturally responsive, global Nnee. “Nnee” is the Apache name for people. There are approximately 354 students enrolled in SCHS; 31% are freshmen, 24% are sophomores, 25% juniors, and 20% are seniors (San Carlos Unified School District, 2022). While the vast majority (99.35%) of the enrolled students identify as Native American, 0.64% are of Native Hawaiian/Pacific Islander descent. It’s a Title 1A school which means that SCHS provides financial assistance as the majority of the students are from low income families (Arizona Department of Education, 2017) and 84% are eligible for a free lunch and 4% are qualified for reduced-price lunch (National Center for Education Statistics, 2022).

I was hired as the 11th grade Physics teacher in SCHS in 2012. In 2015, I was offered the position of teaching a science research elective class which was focused on the study of Western and Native American plants like the yucca, mahonia, greasewood, coleus, and Apache corn. Currently, I am working as the lead teacher for the Natural Resources Youth Practicum for the San Carlos Forestry Department to design a program and curriculum for 3rd-12th graders. Our summer camp program includes presentations on Water Conservation, Safety in the Wildlife, Plants, Gardening, Plant identification, Recreation and Wildlife, Entomology, and learning Apache words, phrases, and culture.

All 9th grade students taking Physics will build a wikiup and must demonstrate a proficient level of mastery on ten Physics Safety Net Standards that focus on scientific inquiry skills and engineering design process. One of the Culturally Responsive Engineering design-based learnings (CREDBL) is the Wikiup LightHouse Project. This CREDBL will use the engineering design process to design and build their own Wikiup Lighthouse project using the Yucca (Igaye), Mesquite tree (Iyah), Willow tree (K’ailtsoge), and Beargrass (Bį’) as materials.

The Wikiup

Wikiup came from the Algonquian word “wikiyap” meaning “dwelling” or “house” and has been used by Native American tribes such as the San Carlos Apache tribe. As described on the website, Native American houses, The wikiup was a small, round, dome shape structure made using a frame of thin poles that were covered with brush, grass, reeds, mats, or any other materials that were available and lashed together with tough yucca fibers. Sometimes the domed-shaped wickiups were built over a 2 - 3-foot foundation. Bark and sometimes earth were added to the covering of the wickiup to keep out the cold” (2017).

Native American trees and plants were used to build the wikiup. Some of these plants include Yucca (Igaye), Mesquite trees (Iyah), and Willow trees (K’ailtsoge). It is also thought that the Beargrass (Bį’) was used to build wikiups. Also, Ms. Joyce Johnson (personal communication, June 19) shared that the wikiup for men and women started with four that represents the four cardinal directions and multiplied it by 2 to get the 8, eight will be multiplied by 4, finally, thirty two will then represent the songs during sunrise dance.

Arizona’s Instrument to Measure Standards (AIMS) is the state test for all schools that tracks the academic achievement of students based on grade level standards. In 2007-2008, AIMS added science to the traditional tests on math, reading, and writing for grades 4,8, and 10. Since 2008, San Carlos High School students have always scored at the minimally proficient level on the Science AIMS test. In 2017, 169 students took the AIMS test and 83% were in the “Falls Far Below” (FFB) category with only 2% in the “Exceeds” (E) level. In 2018, 179 high school sophomores took the test and 84% were FFB and 2% were E. Only 3 of the 179 students had passing scores. Lastly, in 2019, none of the students who took the test passed (“Arizona Department of Education,” 2022). These results are concerning. While SCHS students do not perform well on the state science test, the students who have graduated and are attending NAU do well in their Forestry classes (personal commutation, May 2022). SCHS sophomores also struggle in Math and ELA and I believe that introducing hands-on, project-based learning, and using culturally relevant classroom activities can support low performing students and help minimize achievement gaps (Han et al., 2015).

Classroom instructions and activities that address students’ cultural traditions and beliefs can affect the learning process and can increase the students’ self- value and their belief that they can achieve their goals in life (Bandura, 1977 as cited in Martins-Shannon, & White, 2012). Merging the cultural and the STEM PBL activities into a Culturally Responsive Engineering Design-Based Learning can help physics students apply the knowledge they learn in class into hands-on activities. They learn about their culture by building a Wikiup Lighthouse and learn about physics when connecting the light bulbs in series and parallel connections.

Content Objectives

Arizona Department of Education (2021) set standards for all core classes including science. This unit covers the High School Physical Sciences Standards that enables students to gain a concrete understanding of both the scientific process and engineering design process. Students

are expected to use mathematics and computational thinking to explain relationships between power, current, voltage, and resistance (Plus HS + Phy.P4U1.8) and the difference between series and parallel connections. According to Hewitt (2014), "Electricity is the name given to a wide range of electrical phenomena that, in one form or another, underlie just about everything around us. It's in the lightning from the sky, it's in the spark when we strike a match, and it's what holds atoms together to form molecules" (p. 407).

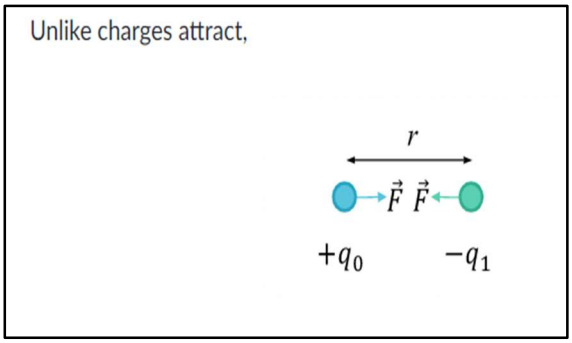
The San Carlos Nnee still use wikiups today during ceremonies like the sunrise dance to store foods for all the people attending or watching. Traditionally, the wikiup was a dwelling place for the Nnee that was built near a seasonal food source. This is why the wikiups built by the San Carlos Nnee are smaller compared to other Native American wickiups. Today, the wikiup used for ceremonies uses light bulbs for a source of light. Students who are knowledgeable in physics can help in these ceremonies by installing the lights and will know how to make different connections based on what type of light is needed. Prior to learning about how light is made with electricity, students will learn that material objects are composed of atoms and molecules with different compounds and have distinctly different electrical properties, such as which electrical charges each type of element carries. (Protons carry a positive charge, electrons have a negative charge, and neutrons have a neutral charge.) The unit will also emphasize that atoms are electrically neutral because they have the same number of electrons as protons. The positive charges balance the negative charges. Students will learn that when atoms interact with other atoms, electrons can move and this makes the atoms no longer neutral. Atoms with more electrons become negatively charged while atoms with fewer electrons become positively charged.

Summary of Subatomic Particles

Proton	Neutron	Electron
In nucleus	In nucleus	Outside nucleus
Tightly Bound	Tightly Bound	Weakly Bound
Positive Charge	No Charge	Negative Charge
Massive	Massive	Not very massive

Figure 1. Physics classroom, Subatomic particles

Khan Academy (n.d.) discusses the electric force that exists between these charges and the force of attraction and repulsion are often observable. The concept of electric charge gives rise to this observed force, same as the concept of gravity, electric force "acts at a distance" but unlike gravity that attracts only, charges have two types, "Unlike charges attract while like charges repel."



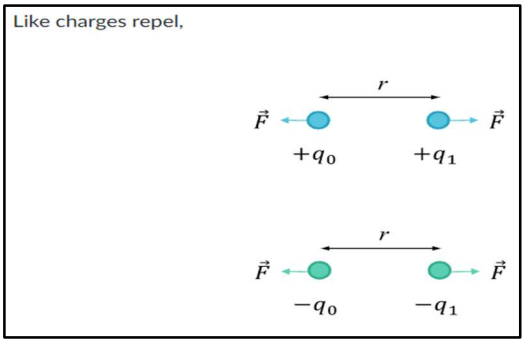


Figure 2, Khan Academy, Electric force- Attraction *Figure 3, Khan Academy, Electric force-Repulsion*

Students will gain knowledge of the concepts and definitions related to electricity such as voltage, volts, current, ampere, resistance, ohms, and Ohm's laws. Students will participate in short, engaging activities that will add to their understanding of the difference between series and parallel circuits, measuring the current, voltage, and resistance between these two circuits, as well as describing the effects of additional resistors (loads) into the voltage and currents. Current is the flow of charge (electrons) which is measured in ampere or amps and is abbreviated with the letter A. Current can be measured using an ammeter connected in series with the loads (bulbs). Charges can only flow if there is a "push" or potential difference like batteries and electric generators that can pull negative charges away from positive ones. The unit of electric potential difference (called voltage) is volt and can be measured using a voltmeter. The amount of current depends not only on the voltage but also on the electrical resistance offered by conductors to the flow of charge. A good analogy is the rate of flow of water in a pipe. The flow of water can be compared to current. The rate of flow depends not only on the pressure difference between the ends of the pipe (which is analogous to voltage), but also on the resistance offered by the pipe itself. In the flow of a charge, the resistance depends both on the thickness and length of the wires and on its particular conductivity (The Physics Classroom, n.d.).

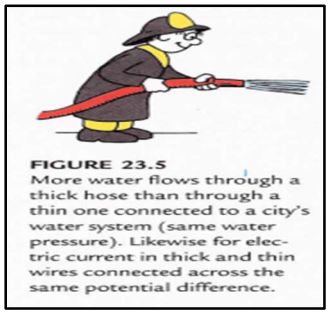


FIGURE 23.5
More water flows through a thick hose than through a thin one connected to a city's water system (same water pressure). Likewise for electric current in thick and thin wires connected across the same potential difference.

Figure 4. Conceptual Physics, Electrical Resistance

The relationship among current (I), voltage (V), and resistance is explained by George Simon Ohm in a 1827 statement which has become known as Ohm's law. He discovered that current is directly proportional to the voltage and inversely proportional to the resistance of the circuit. The higher the voltage, the higher the current (directly proportional) and the higher the resistance the lower the current (inversely proportional). In short,

$$\text{Current} = \frac{\text{voltage}}{\text{resistance}}$$

Or, in units form,

$$\text{Amperes} = \frac{\text{volts}}{\text{ohms}}$$

Figure 5. Conceptual Physics, Ohm's law

loads like bulbs or resistors that are connected to the same two points of an electrical circuit are said to be connected in parallel. Some of the major characteristics of the parallel circuits are that the voltage is the same across each device (bulbs or resistors), the total current divides among the parallel branches which means that the total current in the circuit is equal to the sum of the currents in its parallel branches, and lastly, as the number of parallel branches increases, the overall resistance of the circuit is decreases (Hewitt, 2014).

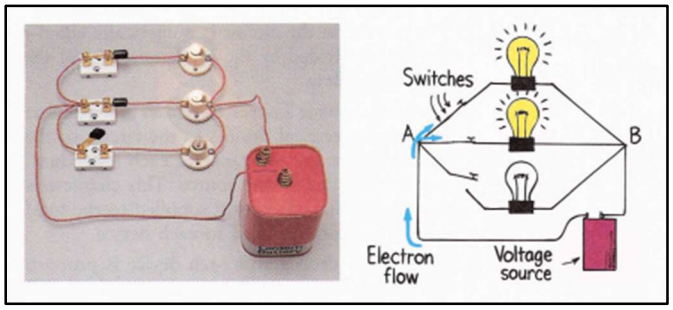


Figure 6. Conceptual Physics, Parallel Circuit

If the lamps are connected in series with a battery then it is called a simple circuit or series circuit. The important characteristics of series connections are the current has a single pathway through the circuit means that all lightbulbs have the same brightness and if one lightbulb is out, the rest of the light bulbs will be out too, and the total voltage across a series circuit devices among individual electrical devices in the circuit so the sum of the voltage drop across the resistance of each individual device is equal to the total voltage supplied by the source (Hewitt, 2014).

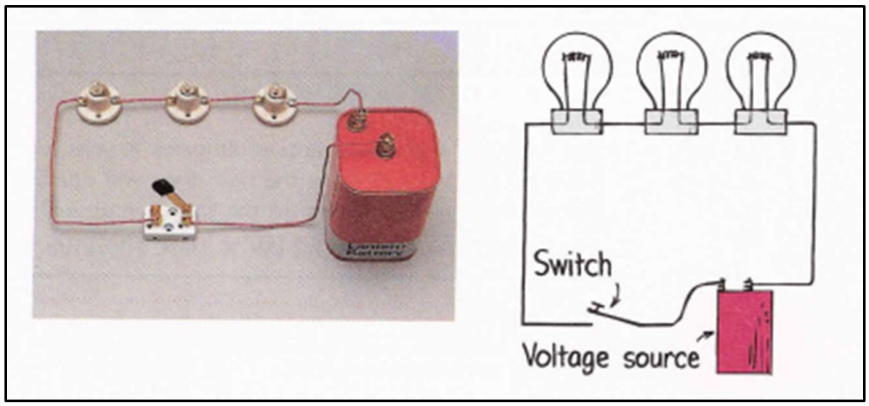


Figure 7. Series circuit

Table 1. Summary of the difference between Series and Parallel connections in terms of the Current, Voltage, and Resistance.

Quantities	Series Circuit	Parallel Connection	Ohm's Law
Current (I)	Same	Shared	I = V/R , Ampere (A)
Voltage (V)	Shared	Same	V = I x R, Volts (V)

Resistance (R)	Rt= R1 + R2 + Rn….	1/Rt= 1/R1 + 1/R2 + 1/Rn …	R = V/I, Ohms (Ω)

Native Plants used in the Wikiup

The following native plants are the traditional plants used by the Nnee to build wikiups. Roberta Patten (personal communication, 2022) said that because the Apache people moved to where they could find ample food, they would have to find plants from that area to use to build their wikiups. The primary materials that they would find were the Yucca (Igaye), Mesquite tree (Iyah), Willow tree (K'ailtsoge), and Beargrass (Bį').

Mesquite tree (Iyah)

A member of the bean family, mesquite is related to mimosa. To identify Mesquite trees, look for long spikes (catkins) of tiny white flowers (which appear yellow when they are full of pollen), and pairs of rounded, elongated leaflets along the leaf stem. Mesquite can look like a small shrub or as small ground cover plants in the Chihuahuan Desert. When it inhabits desert riparian areas, it can grow to heights of up to 40 feet. Due to the dominant presence of cattle in the Southwest over the past two hundred years, and their appetite for mesquite seed pods, the plant has spread over a great swath of terrain. They primarily grow as trees in desert washes and grasslands, riparian areas, backyards, urban promenades, and parking lots, and will likely produce more pods than in the desert. There has been a recent outpouring of evidence that mesquite pods can harbor *Aspergillus flavilus fungus,* leading to a relatively rapid formation of aflatoxins in the seedpod. Best practices suggest harvesting the seedpods before rainfall, or only from trees which you know have remained dry during the full ripening of the seedpods (Slattery, 2016).

(Slattery, 2016).

Table 2. Mesquite Basics

Flower Bud and Bloom Season	Spring/Dry Summer: April, May, June, and sometimes again in August, September
Nutrition	Gluten-free, contains calcium, magnesium, protein, dietary fiber, iron, zinc

Caution	Mesquite can have sharp thorns, so use caution. Aflatoxins may be present in pods in certain conditions especially when collected off the ground.
Other Uses	Firewood: both pods and wood can be used for grilling and smoking foods to impart flavor. Wood for building and craft. Medicinal Nitrogen fixing bacteria in its roots and nitrogen in its leaf drop enhance soil fertility. Source of pigment/dye and cordage. Footer for pollinators, myriad nature songbirds, desert tortoise, chickens, goats, dogs, and cattle. Pods that fall to the ground make great mulch. Excellent climbing tree.

(Tekiela, 2021).

Coyote Willow tree (K'ailtsoge)

A small, clumping, deciduous shrub or tree that grows 4-15 feet tall. The bark is gray and furrowed and the leaves are silky gray. Catkins (a type of cylindrical flower) appear after the leaves. This hardy species has perhaps the greatest range of all willow trees. It can be found from the Yukon River in central Alaska to the Mississippi River in southern Louisiana. A common and characteristic shrub along streams throughout the interior, especially the Great Plains and Southwest, it is drought-resistant and suitable for planting on stream bottoms to prevent surface erosion. Livestock browse the foliage and Native Peoples made baskets from the twigs and bark. The frame of Apache wickiups would traditionally be covered with sagebrush, willow, bear grass, branches, big bluestem grass, leaves, and bunches of grass (brush) Lady Bird Wildflower Center.

(Lady Bird Wildflower Center, 2022)

Yucca (Igaye)

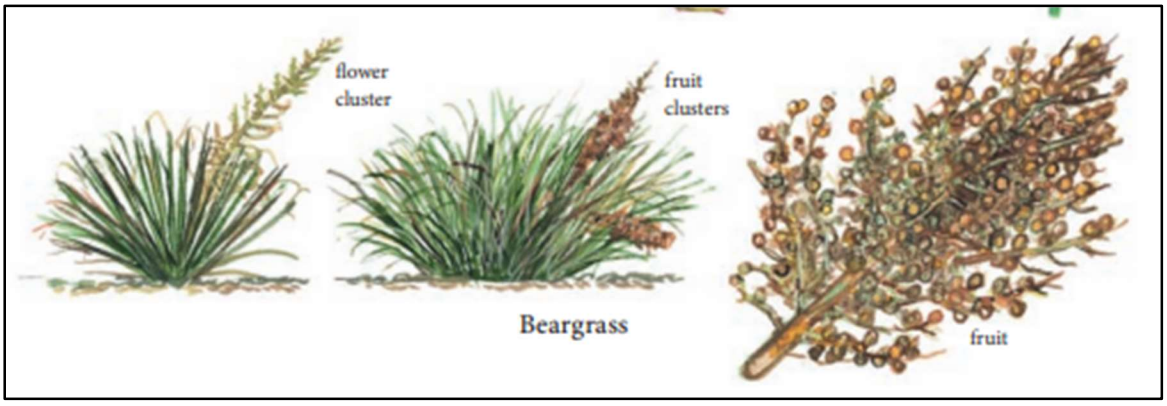
Banana yucca was one of the sweetest foods available to Southwest foragers before the arrival of honeybees. Banana yucca is identified by its long, dagger-like, blue-green leaves that end in a sharp spike. The leaf makes a U shape in cross section, and its margins are often covered in thin, curling white fibers. The inflorescence, or the flower, of banana yuccas just barely extends beyond the leaves or may be contained within the rosettes. The cream-color (sometimes tinged

with pink or purple) flowers droop down languidly. They have a thick, moist texture, a beautiful aroma, and a soapy, acrid taste when fresh. The green, fleshy fruits can be quite large and hang downward in large clusters along the upright central stem. The black seeds are compressed together in circumferential rows throughout the length of the fruit. Banana yucca can be found throughout the western region, including southwest Texas. All broad-leaf Yucca species possess edible fruits. The fruits of narrow-leaf Yucca species have edible parts and can be found in desert grasslands, chaparral, oak woodlands, and the piney woods of East Texas. The budding flower stalks and flowers are gathered in the spring, immature fruits in the early summer, and the sweet, mature fruits in the late summer to early autumn (Slattery, 2016).

(Slattery, 2016).

Nolina: Bear Grasses (Bį’)

About 30 species of bear grasses (also called. sacahuista) occur from the southern U.S. to north central Mexico. Fourteen of the species are found north of the border. The four or so bear grasses that are treelike are common and conspicuous components of the vegetation of deserts and arid grasslands from pine scrub and piñon–juniper woodlands and can be found from sea level to moderate elevations. These rosette-forming plants have many flexible strap-shaped leaves aggregated in a dense, rounded clump that usually sits flush with the ground surface. In arborescent species the trunk is clothed with old, dried leaf bases. The leaves are simple, long, expanded into a broad base and tapering to a fine-pointed tip. The margins are entirely covered with minute, closely set teeth and sometimes shred into tough fibers. The flowers are born in a closely branched column and are tiny and outwardly symmetric. Bear grasses are unisexual, with either vestigial stamens or pistils on the same plant. There are six petals which are separate and cream or white colored. There are also six stamens and the fruit is small and is found in a three-chambered, stiffly papery capsule with each chamber containing one to three brown to black seeds. Species of Nolina are variable and in the Southwest are often difficult to identify. The leaves are used by rural people in Mexico to weave mats and coarse baskets and are used in thatching. Fibers from the leaves are used in fine basketry (Spellenberg et al., 2014).



(Spellenberg et al., 2014)

Teaching Strategies

The following research-based strategies as listed on the SCUSD Evidence of *SHIŁ GOZHÓÓ* will be used to engage the students throughout the lesson:

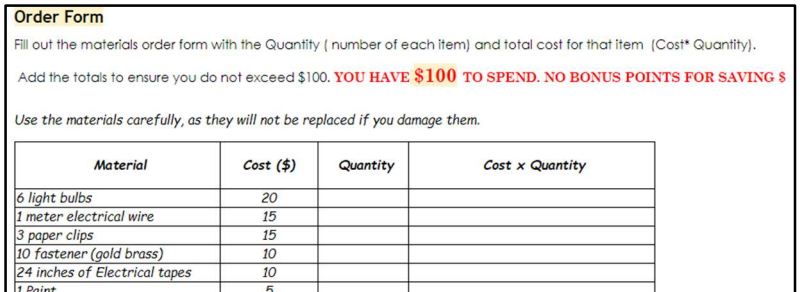
Real-life and Culturally Relevant Examples

The hook of this curriculum is a presentation of the history of the Apache Wikiups that includes a video interview of one of the Apache language teachers and PowerPoint slides with pictures from books and the internet that are focused on the history and cultural significance of wikiups and the native plants that can be used to build them. Sample light-house projects built by previous students will be used as a model. The emphasis for the new STEM PBL will be the series and parallel connection, and the change of structure from the regular light house to a wikiup house that can represent a real house while the Christmas lights will represent lights bulbs installed in different parts of the house like living room, kitchen, bathroom, bedroom, patio, and garage.
Building Vocabulary, Lecture/Direct Instruction, and similarities and differences among variables

To build knowledge of the physics behind the STEM PBL, there will be lessons on the concepts of series and parallel connections and how to use graphic organizers like t-charts to easily define, compare, and contrast the two in terms of the current (I), voltage (V), and resistance (R).

Project-Based Learning and Engineering Design Process

The expectations including the time-frame, the use of the engineering design process, state standards, rubrics, and resource materials for the wikiup project will be laid out clearly for the students. Building the wikiup will be done in groups with two to three students completing the steps together. Students will start by making a building plan (circuit diagram) of the series and parallel construction. This plan will need teacher approval before moving onto the next step. After getting approval, students will brainstorm with their partner(s) on how they will design their wikiup They will need to think about the types of rooms (bedrooms, living rooms, kitchens, bathrooms) and how to install the light bulbs. To verify if the design will work, students will use Phet simulations. These will be submitted to the teacher for approval. Once approved, students will request materials using a mock $100 budget and will start building the house using a regular size shoe box. This activity will give students skills in physics, culture, and finance. It's hands-on and will engage students beyond the teacher's lecture.



Order Form

Fill out the materials order form with the Quantity (number of each item) and total cost for that item (Cost* Quantity).

Add the totals to ensure you do not exceed $100. YOU HAVE $100 TO SPEND. NO BONUS POINTS FOR SAVING $

Use the materials carefully, as they will not be replaced if you damage them.

Material	Cost ($)	Quantity	Cost x Quantity
6 light bulbs	20		
1 meter electrical wire	15		
3 paper clips	15		
10 fastener (gold brass)	10		
24 inches of Electrical tapes	10		
1 Paint	5		

Science Research vs. Traditional Ecological Knowledge to learn about History and Culture

Part of this assignment will involve an interview of elders, community, and family members to learn about the history and culture. Students will gather information about the wikiup and traditional western Apache plants like Yucca (Igaye), Mesquite tree (Iyah), Willow tree (K'ailtsoge), Bear grass (Bį'), and other plants that are used to build wikiups. Students will also do research on the use and importance of these plants to the environment and human health of the Nnee people.

Claim, Evidence, and Reasoning (CER)

To communicate what they have learned, students will complete a science explanation using the CER format. To complete the "Claim," students will answer the question, "What do you know after the PBL project?" For the "Evidence," students will answer "How do you know that?" and "How can you support your claim?" Students must complete these questions using their experience in building and connecting the light bulbs in series and parallel. Lasty, for "Reasoning," the students must answer "Why/how does your Evidence support your Claim?"

Student Presentation

The last part of the project is the student presentation about the series and parallel connections as well as the traditional use of the wikiup. Students will be given four options to present their project. Option 1: Oral Presentation (with a question and answer portion at the end), Option 2: Infographics or Poster (using Canva or Google Suite), Option 3: Video Recording (with Flipgrid), and Option 4: PowerPoint/Google Slide presentations. Students from the other science classes will be invited to witness the presentations of wikiup lighthouse. They will provide feedback and ask questions that the physics students will answer.

Classroom Activities

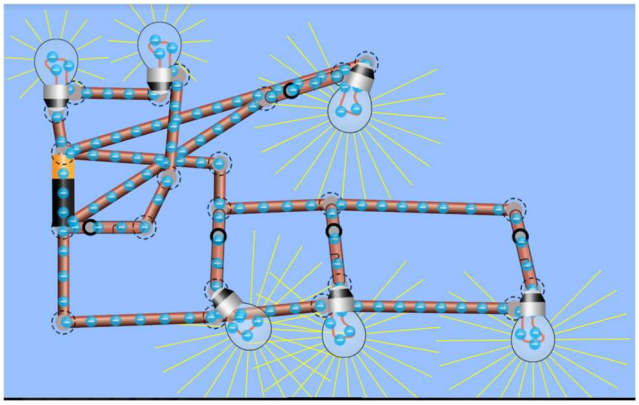
Summarizing and Notetaking (FNT-Cornell Notes)

Students will take down notes using the Advancement Via Individual Advancement (AVID) Cornell notes system as they listen to the TEK presentation about wikiups. The AVID Cornell notes is one of the focused notes taking tools and a learning tool to increase content class achievement. To make their notes more interactive, students will highlight, underline, or circle the important information. They will continue to use their notes during the lectures and direct instruction on the similarities and differences between series and parallel connections. After the lessons, students will review their notes, complete highlighting the terms, definitions, or

important information and will answer the questions they wrote as part of their AVID Cornell notes. They will also summarize what they have learned from the class discussions.

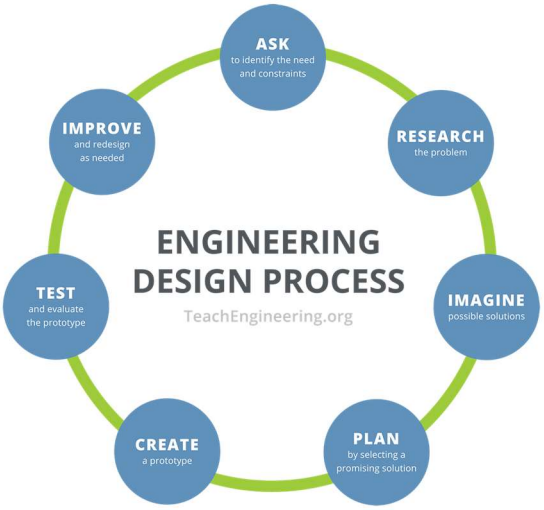
Online Interactive Simulations

Using the Phet simulations, students will be able to design their own house with how they want the rooms and to plan how they will set up the series and parallel connections. These simulations are a great way to practice what they have learned from the lessons and to see the effect of wrong connections, too many loads, too much resistance, the brightness of the lightbulbs, and they can analyze the similarities and differences between lightbulbs connected in series and in parallel. When all connections are working, students will submit the Phet simulation for printing and they can start planning for how they will build their wikiup.



Engineering design process

Students will follow the engineering design process within their group. These include six steps: (1) identifying the needed materials and constraints, (2) defining the expectations and the problem they have to solve, (3) putting together their ideas, (4) started creating the prototype, (5) evaluating the prototype through testing, and (6) redesigning the prototype if needed.



Designing the Wikiup using western Apache plants like Yucca (Igaye), Mesquite tree (Iyah), Willow tree (K'ailtsoge), and Beargrass (Bį')

Students will collect their Apache plants. The plants will be brought inside the classroom to help design the wikiup They can also bring clay, stones, and other items they find. Once they are finished decorating their wikiups, students will show the wikiup lighthouse project to the teacher for partial grading.

Presentations

Next, students will prepare their presentations. They will present the wikiup lighthouse to other students and must be ready to answer questions. They will be given two minutes to present and showcase their wikiup lighthouse before the Q and A portion will follow.

Student Assessment Plan

The primary goal of the Wikiup LightHouse STEM Based Learning Project is to integrate the students' cultural background and traditional ecological knowledge with the science of series and parallel connections. To measure both, the assessment will be divided into four categories, the pretest assessment, Formative assessments, summative assessment (post-test), and performance based assessment.

Proficiency Levels	Student Friendly Objectives	Assessment
Minimally Proficient	*Student define current, voltage, and resistance *Students complete research and interviews with elders, family, and community members about the environmental and human health contributions of Yucca (Igaye), Mesquite tree (Iyah), Willow tree (K'ailtsoge) and Beargrass (Bį') to the Apache people.	Pre-test (Inquiry process). Using the science investigation of paper clips, light bulbs, and batteries. "How can you make the light bulb work? Formative Assessment like drills, exit tickets, and frequent check for understanding using the high order thinking skills (HOTS)
Partially Proficient	*Students can calculate current, voltage, and resistance	Performance based assessment: students can calculate current, voltage, and resistance using the Ohm's law triangle.
Proficient	*Students demonstrate understanding by explaining the relationships between current, voltage, and resistance.	*Performance based assessment: students can predict what will happen to the amount of current as the voltage and resistance increases or decreases.
Highly Proficient	*Students use the STEM (Science, Technology, Engineering, and Math) process while building their Wikiup Lighthouse project. *Students interview elders, community, and family members about the Western Apache plants that can be used to build wikiups.	*STEM Project- based learning. 1.Identify the need and constraints. 2.Research the problem 3. Imagine the probable solutions. 4.Select promising solution (Plant). 5. Create and build the prototype using Western

		Apache plants 6. Test and evaluate the prototype. 7. Improve and redesign as needed. *Summative Assessment. Presentation of the STEM project with questions and answers.

Alignment with Standards

The Wikiup Lighthouse STEM based learning using Western Apache Plants will address the Arizona Science Standards Plus HS + Phy.P4U8. Use mathematics and computational thinking to explain the relationships between power, current, voltage, and resistance. It will focus on three dimensions of learning, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts (Arizona Science Standards, 2018). The lesson will be implemented as the 5th standard for 9th graders and the 10th standard for 11th graders and will be presented to the students as a PBL project in December 2022 and May 2023.

Resources

Reading List:

Yucca

- A piece of Fibre could save your life: Nature's general store: The Yuccas and Agaves

Source: https://www.primitiveways.com/yuccas_and_agaves.html

- Encyclopedia, Yucca

Source: https://www.primitiveways.com/yuccas_and_agaves.html

- Wikiup: NativeIndian Houses for kids

Source: https://www.google.com/search?q=Wikiup+native+house&rlz=1C1CHBF_enUS912US912&oq=Wikiup+native+house&aqs=chrome..69i57j33i10i160l3.6524j0j4&sourceid=chrome&ie=UTF-8&safe=active&ssui=on

Electricity

- Khan Academy, Series and Parallel Resistors

Source: https://www.khanacademy.org/science/electrical-engineering/ee-circuit-analysis-topic/ee-resistor-circuits/e/skill-check--identifying-series-and-parallel-resistors

- Khan Academy, Electric Force

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