Quantum Technologies: Early Exposure as a way to Prepare Students for the Next Technological Revolution.

Navajo Code of the Past and Quantum of the Future

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Introduction

All my life, I have had many relatives who served in the United States military branches including my dad, my little brother, my daughter, my sons-in-law and many more. My homelife included the encouragement of my dad who was my parent, my teacher, my counselor, and my Navajo instructor. My dad wanted a higher education for us (my siblings, the grandchildren, the great-grandchildren, and I) and to have a stable occupation in life. He entered the U.S. Army at a young age and was sent to Fort Sill, Oklahoma before being sent to the Korean War. My father passed away about 10 years ago, but he left us his teachings, historical stories, origin stories, prayers, and songs. Therefore, I am humbled and honored to have had such a wonderful man in my life.

With my father's teachings and stories came the military life and how we as Navajos need to keep the military people close to our hearts, whether they served in war time, were stationed overseas, or contributed to the military lifestyle. The Navajo Code Talkers are an integral part of our history.

> "The Navajos played an important role in World War II, but information about their contribution was kept a secret until 1968. Recruited by the Marines, young Navajo men who were bi-lingual in English and their own native language played a major role as radio operating "code talkers." The original 29 Navajo soldiers who participated in the program created a language within their own language. The words of the Diné came from a largely unwritten language which was nearly impossible for an adult to learn. Intonations necessary to develop the type of speech for pronouncing Navajo are learned during the first year of an infant's life." (Callister & Maryboy, 2004, p. 27-28).

In this unit I will a) introduce my students to the Navajo Code Talkers and their secret codes that they developed to help win World War II and b) relate the Navajo Code Talkers to new encryption schemes exploiting Quantum Science. This way, my students will learn about their history, strengthen their understanding of the Navajo language, and at the same time learn about new developments in science and how these seemingly disconnected topics are related.

Due to the focus on Navajo Code Talkers, this curriculum can best be shared within the month of August because on August 14th is the day that is celebrated as a historical event recognizing the contributions of the Navajo marines that contributed during World War II. At Monument Valley High School in Kayenta, we've celebrated and honored our Navajo Code Talkers with a celebration of a daily dress-up day from wearing Navajo Code Talker colors of yellow and red on one of the dress-up days to wearing the traditional Native American attire or Navajo clothing wear and adornments on another day. The viewing of a Code Talker film like "True Whispers: The Story of the Navajo Code Talkers (2007)" by PBS Home Video during school hours and inviting Veterans to come to the classrooms as a Guest Speaker for the Bring a Veteran to School Day is very enlightening and to hear the real-life experiences of a retired veteran or an active veteran is always an honor.

This curriculum could also be shared within the month of November in honor of all veterans that have or are serving within the United States Armed Forces. Veterans Day in America is recognized as a National Holiday which will be on Saturday, November 11th, and it's a day of tribute to all Veterans of all wars in the United States. Within the month of November is another celebration, the recognition of Native American Heritage Month which was officially passed in a joint resolution signed into law by President George H. W. Bush in 1990.

Context

At a young age, I was impacted by the Navajo-Hopi Land Settlement Act of 1974, where members of my maternal family tree line were affected by the Relocation Act and we were required to move from my maternal grandparents' homestead located by lower Hotevilla. Once I received the Relocation Settlement allotted to me, I established a homesite lease on my Father In-law's land to have our house built.

> "The United States Congress in 1974 ordered that the Navajo land be divided. There were 10,000 Navajos and 109 Hopis living on the wrong side of the boundary lines. This partition of lands came to be known as the "Relocation Act." Several Navajos were told to leave the land and move to the cities, even though many of them could not speak English and could not survive in the cities. The old traditionalists refused to leave their hogans and the land around them. It was ancestral land, sacred to them. By the end of the summer of 1986, one-third of those who had relocated had died. The most recent statistics estimate that relocation has cost over $700 million dollars. Approximately 3,000 Navajos in the summer of 1992 were still living in the Big Mountain area, north of the Hopi mesas." (Callister & Maryboy, 2004, p. 28-29).

The sharing of this sacred homeland that once belonged to my grandparents located near lower Hotevilla, demonstrates the importance of land to the Navajo people. By sharing this information of the importance of land, it will show how our Navajo Code Talkers must have felt about their own homeland and in protecting their mother land.

In the present day, I have resided in the community of Kayenta, Arizona for 35 years because of the relocation, I relocated to Kayenta and had my house built in Kayenta. The first few years, I lived in the teacher housing with my children and now I reside in our home for the past 26 years and it has been a safe environment for my family. As a resident of the Kayenta community and a member of the Kayenta Chapter, I am well-known here and enjoy living among wonderful people I call family and friends.

My spouse, Andrew Singer, works for the high school. We have two daughters, two son in-laws and four grandchildren. My daughters are both educators. We (my daughters and I) all have a Master's Degree in Bilingual-Multicultural Education from Northern Arizona University. The older daughter continued on, and she received her second Doctorate Degree, and the youngest daughter will be receiving her second Master's Degree in December of 2023 and she has served in the United States Army. Both of my son in-laws have served in the United States Army and have been stationed in other countries.

The community of Kayenta goes by two Navajo names, one is called To Dineeshzhee' and the other is Teeh'ndeeh. At one time, the term Teeh'ndeeh was located on a public sign by the highway, and I heard some Navajos calling it by the other Navajo name of To Dineeshzhee'. Below is an excellent explanation of these two terms:

> "To Dineeshzhee' means *fringed water* or *fingers of water*. (Young & Morgan, 1987, 706). Granger (1960) suggests that Kayenta is an English rendering of *Teeh'ndeeh*, which referred to a deep bog hole (where animals fall into deep water. (Young p.c., 1995). Navajos call a place one mile downstream from the old Indian Irrigation Service dam (and at a fall in the creekbed), *Teeh'ndeeh*." (Linford, 2000, p. 100-101).

Kayenta is located in Navajo county of northern Arizona with a population of 5,634 according to the 2020 U.S. Census Bureau. The elevation of Kayenta is 5,640 feet. About 93% of the racial/ethnic groups are American Indian and 4.2% are White and 1.3% are Islander. Located 25 miles south of Kayenta is a popular tourist place called Monument Valley, located in the states of Arizona and Utah.

In the town of Kayenta, there are three schools under the Kayenta Unified School District (KUSD #27): the Debbie Braff Elementary School (kindergarten to 4th grades), Baker Middle School (5th to 8th grades), and Monument Valley High School (9th to 12th grades). Another school that is located north of KUSD is the Kayenta Community School which serves students during the daytime or students that stay in the dorms and attend school on the premises during the daytime.

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According to the 2022-2023 Parent-Student Handbook, the School Mission and the School Philosophy are as follows:

> School Mission Statement:
>
> "The purpose of our school is to graduate students in four years who are literate, informed individuals capable of making effective decisions about their lives."
>
> Philosophy:
>
> Our philosophy is that given adequate time and appropriate teaching strategies, all children can achieve." (Monument Valley High School Student/Parent Handbook, 2023)

On May 20, 2023, the Graduating Class of 2023 graduated 154 students out of 163 students from Monument Valley High School, which was a success rate of 94% of the Seniors that graduated. Over the summer three more Seniors were able to graduate raising the number to 166 students.

I have been teaching in Kayenta mostly at the secondary level at Monument Valley High School for 35 years and am now entering year 36. The average classroom number of students ranges between 30-35 students per class. This coming Fall Semester of 2023, students will be returning to the 7 Periods per day for a full year credit and leaving the Semester Block Schedule of the 5 Periods per day per Semester. In 2021-2022 and 2022-2023 school years, the high school had their 3rd Period class as a Recovery Class for the students who didn't pass their Navajo Language classes during the pandemic and by retaking the Navajo Language class for credit, the students could receive only a half-credit for retaking the courses because the 3rd Period class was on a 45-minute seating time rather than the block schedule time of 90 minutes per class. At Monument Valley High School, I am currently the only Foreign Language teacher, so if a student needs a foreign language credit or credits, they will take the Navajo Language class or classes, these courses are also considered to be an elective course. Many Chief Manuelito scholars have taken my courses to fulfill the requirements as a recipient of the Chief Manuelito scholarship.

> "The Navajo Nation established the Chief Manuelito Scholarship program in 1980 to recognize high achieving high school graduates. The scholarship honors Chief Manuelito, Hastiin Ch'ilhaajiin, (1818-1893) who encouraged the Navajo people to seek education and protect and preserve Navajo tradition and culture. Students meeting the criteria for the Chief Manuelito Scholarship are awarded $7,000 per academic year to cover direct education expenses associated with attending a post-secondary institution." (Office of Navajo Nation Scholarship & Financial Assistance, 2023)

The classroom textbook that I use is entitled "Rediscovering the Navajo Language" by Evangeline Parsons-Yazzie, Ed.D. and Margaret Speas, Ph.D. The following is a quote that Evangeline Parsons-Yazzie has in the Preface of the textbook that gives the student the purpose for the book, which states:

> "We hope that you will find our book helpful as you journey toward a deeper understanding the Navajo language and culture. The Navajo language is the heartbeat of the Navajo culture. Navajo Nation officials, Navajo language teachers, Navajo elders, and linguists have declared that the Navajo language is now becoming an endangered language. They say that a key to the revival of a language is to ensure that parents of the next generation transmit the language and culture to their children." (Parsons-Yazzie et al., 2008, p. xiv.)

This curriculum unit will include the stories of the Navajo Code Talkers, there are two important elements that these Navajo Code Talkers had in common, and they were: (a) the Navajo language which helped to win World War II, and (b) in protecting their mother country or homeland. From the Children's Literature of "The Unbreakable Code" written by Sara Hoagland Hunter, the grandfather tells his grandson:

> "He was the grandson of a Navajo code talker, and he had a language that had once helped save his country." (Hunter, 1996, p. 27)

Rationale

This unit is specifically targeted to the high school grade level of 11th to 12th grades. The curriculum area will focus on the area of "World Languages" specifically the Navajo Language but also introduce students to the language of science and how we can use science to communicate with each other.

Navajo Code Talkers:

The unit is built around the "Skill Target" area where a real-time demonstration is the heart of learning. The "Skill Target" will also focus on the ELA Skill Target of pronunciation, vowels, consonants, blends, syllables in spoken words, tonal sounds, and diacritical markings of the Navajo language.

We will apply our Navajo language skills by discussing the Navajo Code Talkers and center our efforts on words used by the code talkers. Students will learn how the Navajo language was used to encode messages and at the same time increase their language skills. Students will discuss how the Navajo Code Talkers encoded messages and familiarize themselves with the Navajo Code Talker Dictionary.

The words listed from various Navajo Code Talker books and resources, and the Monument Valley Navajo Tribal Museum posters will benefit the practice of the "Skill Target" area of the Sounds of the Navajo Language which is a unit lesson from the secondary textbook entitled "Rediscovering the Navajo Language" written by Evangeline Parsons-Yazzie and Margaret Speas. This secondary to college level textbook is currently the book that I use in my classroom to teach the two courses, which are the Navajo 1 and the Navajo 2 courses at Monument Valley High School.

In the Navajo Language classes there are very few fluent speakers, most of the students come from English speaking homes. The Navajo language being the first home language spoken at home is very rare at this time. Some students can understand repeated commands but cannot respond back in the Navajo

language. In this current time period, most students are learning the Navajo language from school. The advantage for these students is that they learn how to read, write and practice speaking the language. Most of the elders are fluent speakers of the mother tongue because it's their first language.

Binary Encoding:

Students have previously learned how the Navajo Code Talkers used the Navajo Language to encode messages, e.g., encoding the letter "A" as WOL-LA-CHEE (meaning ant). Students will next learn a different way of encoding the alphabet using binary encoding. First, students will learn how computers store information in bits (binary digits) which can have the value of 0 or 1.

What is a Bit you might be saying? Youtube.com offers resources such as the 'Intro to Binary Numbers' by Pumpkin Programmer which are helpful to introduce the concept of a "bit" to a beginner like me. I have attached two types of information pertaining to the term "bits":

> "The smallest unit of data in a computer is called a Bit. The word is the shortened name for Binary Digit (Bi from Binary and the it from Digit . . . From these simple bits computers string together a large sequence of ones and zeros to represent complex data and instructions. A string of eight bits is equal to a byte). Byte is short for Binary Term (Bi from Binary and Te from Term)." (Khan Academy Computing, 2023)

> "The Binary number system works the same as a decimal system. The only difference is what each of these places represents. This is a four-digit binary number 1010. Each of these digits can also be called a bit. Since a "bit" represents zero and one. Now this four-digit number equals the decimal number ten. This first place is the one's place, just like in decimal. Now there is a zero, so that means were going to multiply zero times one, you get the very exciting value of zero. The second place that is where these get more interesting. This contains the twos place, not the tens place and there is a one here. So were going to multiply one times two. So that this number equals zero. The third place, the 3rd bit, this is zero and this is the fours place. So, we will multiply zero time four, which is once again just zero. And were still looking at the number two. The final bits place this is the eights place and there is a one here. So were going to multiply one times eight. Add that to everything else, we end up having eight plus two which equals decimal 10. But in the binary system each place represents a power of two. The first bit is two to the zero power, it's one. The second bit is two the power of one, the first power which is two. The third bit is two squared, two the power of two, which is four. And the fourth bit is two cubed, two to the power of three, that is eight. That is the only difference between decimal and binary." (Pumpkin Programmer, 2020)

Below is an illustration of the above information that also goes along with the information on the Binary number system:

Four Digit Binary Number	1	0	1	0
Each Digit is called a Bit	____	____	____	____
	8	4	2	1
	eight's place	four's place	two's place	one's place

Power 2^3 2^2 2^1 2^0

e.g. two cubed, i.e., 2 to the power of 3 equals 8

	(1 x 8)	+ (0 x 4)	+	(1 x 2)	+	(0 x 1)	
decimal	8		+	2			=10

Second, students will learn binary code and practice translating binary signals using the 5-bit binary encoding table shown below:

BINARY CODE ALPHABET REFERENCE					
1	A	00001	14	N	01110
2	B	00010	15	O	01111
3	C	00011	16	P	10000
4	D	00100	17	Q	10001
5	E	00101	18	R	10010
6	F	00110	19	S	10011
7	G	00111	20	T	10100
8	H	01000	21	U	10101
9	I	01001	22	V	10110
10	J	01010	23	W	10111
11	K	01011	24	X	11000
12	L	01100	25	Y	11001
13	M	01101	26	Z	11010

Content from the core until will be reinforced by translating the Navajo Code Talker words into binary and decoding Navajo Code Talker words which have previously encoded in binary, e.g., decoding the sequence:

10111 01111 01100 – 01100 00001 – 00011 01000 00101 00101

and realizing that this is the binary encoding for WOL-LA-CHEE which is the Navajo Code word (meaning ant) for the letter “A”.

A binary encoding worksheet has been created for the Navajo Code Talker words to encourage the students to participate in an activity using real-life Navajo terms that were used in World War II by the Navajo Code Talkers. Some historical facts and stories that were written about the Navajo Code Talkers will also be included into the curriculum. This curriculum will enhance and encourage students to become current leaders of their own learning and to begin with the terms, “I can . . .” and to focus on the learning process through the usage of the terms, “I can…”. Success is my goal for these students especially since the lessons will be focusing on their own Native history, culture, language, teachings, and stories about the Navajo people.

The students will find a new fascinating and unique style of learning to practice the Navajo language and binary encoding and learn more about the Navajo Code Talkers. By encoding/decoding messages using both the Navajo Code Talker Dictionary and a binary dictionary, students will reinforce the concept of encoding/decoding while at the same time improving their Navajo Language skills.

Students will also learn how binary encoding can be used to transmit messages with light. Using flashlights, students will use light pulses with different length (short = 0, long = 1) to send binary messages. First, students will decode simple English messages, e.g., ANT where every letter is encoded in binary signals. Later, students will decode more complex Navajo messages, where each letter of the alphabet was first encoded using the Navajo Code Talker dictionary and then in a second layer encoded using binary encoding. As an example, students will look at the light sequence:

long short long long long short long long long long short long long short short – short long long short short short short short short long – short short short long long short long short short short short short long short long short short long short long

and translate this into

10111 01111 01100 – 01100 00001 – 00011 01000 00101 00101

and then realizing as above that this is the binary encoding of WOL-LA-CHEE which is the Navajo Code word (meaning ant) for the letter 'A'.

Quantum Encoding:

Last, students will learn how quantum science can be used to encode messages in a way that allows the sender and receiver to detect if anyone was spying on them. Students will be in awe realizing that there is a connection between Navajo Code Talkers used in war time (the creation of an unbreakable code of the past) and quantum key distribution (the creation of an unbreakable code of the future).

Content Objectives

This curriculum will be targeted for students of the Navajo language II course which will consist of 10th to 12th grade students. Students will be able to recognize words and phrases that pertain to the Navajo language created and used by the Navajo Code Talkers during World War II. Navajo Code Talker terms will be introduced and discussed alongside Quantum Technology terms. Students will also be researching historical stories about World War II and reading culturally relevant stories (e.g., children's literature, biographies, etc.) about the Navajo Code Talkers. In the final assessment component piece of this curriculum unit students will create their own Encoding/Decoding activity using binary encoding with a) zeros and ones, b) with dots and dashes (long, short), or their own selected two Navajo words.

At Monument Valley High School, I use the textbook entitled "Rediscovering the Navajo Language" by Dr. Evangeline Parsons Yazzie and Dr. Margaret Speas, the history component of the Navajo Code Talkers is only three sentences in length in the textbook. The students need to learn about the Navajo Marines that helped win World War II and the sacrifice they made to keep the code a secret from the world. The Marines when they returned home were not given a welcome home parade, awards, or any type of recognition. They returned to their homeland to continue living where they left off before the war. Therefore, students need more than three sentences from the secondary-college level textbook to learn about their veterans from the Navajo Code Talker era and about the lives of these Native American heroes.

The revitalization of the Navajo language for our youth is one important issue that our elders, parents and community members wish to strengthen and to encourage our youth to become persistent in the learning process their heritage language. Lloyd L. Lee shares information about this current revitalization issue which he shares below:

> "The Diné language is vibrant, but concerns about its continuance remain. The number of monolinguals Diné speakers is relegated to the older and middle generations. It is becoming a challenge to find a young person under the age of eighteen who is a monolingual Diné speaker. By far, the majority of young Diné people speak English. Consequently, individuals and

> communities are concerned about maintaining the Diné language. They rely on schools, colleges, and the tribal government for valuable guidance." (Lee, 2020, p. 46)

Besides the revitalization of the Navajo language, the youth are told that the Navajo homeland is a vital part of their livelihood. The following is the core meaning of what it means to be a Navajo person living on the Navajo reservation as told by Lloyd L. Lee where he refers to Nihi Keyah to mean "our land", which is the same teachings shared in the past with the Marines that went to Camp Pendleton to become Navajo Code Talkers

> "Nihi Keyah is more than a commodity and property for the Diné; it is strongly connected to their identity. Nihi Keyah is a physical, emotional, psychological, and spiritual presence for the people. The land is part of the core of what it means to be human and Diné. The land's energy and power are reflected in the origin narratives and Diné philosophy."
> (Lee, 2020, p. 77)

The Navajo Language used in World War II was very difficult for the Japanese to decipher because they were unfamiliar with the language. The following is information about the Navajo dictionary that these Navajo Marines kept as a secret from 1945 to 1969.

> "When a Navajo code talker received a message, what he heard was a string of seemingly unrelated Navajo words. The code talker first had to translate each Navajo word into its English equivalent. Then he used only the first letter of the English equivalent in spelling an English word. Thus, the Navajo words "wol-la-chee" (ant), "be-la-sana (apple) and "tse-nill" (axe) all stood for the letter "a". One way to say the word "Navy" in Navajo code would be "tsah (needle) wol-la-chee (ant) ah-keh-di-glini (victor) tsah-ah-dzoh (yucca).
>
> Most letters had more than one Navajo word representing them. Not all words had to be spelled out letter by letter. The developers of the original code assigned Navajo words to represent about 450 frequently used military terms that did not exist in the Navajo language. Several examples: "besh-lo" (iron fish) meant "submarine", "dah-he-tih-hi" (hummingbird) meant "fighter plane" and "debeh-li-zine" (black street) meant "squad"."
> (Naval History and Heritage Command, 2023)

Teaching Strategies

Timeline

Students will be introduced to the history of the World War II period from 1939 – 1945. Information will come from books, internet websites, media, and children's literature. The events that were occurring in the United States and events that were happening to the young Navajo men who enlisted to become military Code Talkers will be labeled onto blank white butcher paper. A timeline (butcher paper) will be posted in the classroom (about 10-12 feet in length with placing marks that are 2-3 feet apart to mark in the years). Students will identify information/events to write onto the blank timeline sheet and visualize what events happened to the Navajo men during World War II.

Reading

Multiple types of reading materials will be distributed as appropriate for the ability level of the students to keep them engaged and to increase their reading skills. Teacher will need to create a reading level that will involve all students to stay engaged while searching for the historical events.

Classroom Activities

Activity #1: Binary Encoding/Navajo Code Talkers

Before doing this encoding worksheet, students need to be introduced to the terms "bits", "binary", "decoding", and "decipher" which appear on the worksheet. Introducing new vocabulary terms for this worksheet will enhance the knowledge and understanding of the new academic language for the subject content of the Navajo language and support finding the connection to the encoding terms all of which is needed for this curriculum to be successful.

One of the Student Classroom Activities will be to create encoding worksheets (an example worksheet is provided below). Using the worksheets, students will practice Navajo encoding/decoding and binary encoding/decoding. Below is an example of a worksheet students will use to practice deciphering a Navajo word which was encoded using four-digit binary encoding. Students will also look up the "Modern Spelling" of this Navajo word by using the internet or an English-Navajo dictionary/Navajo-English dictionary, break down the Navajo word into syllables, and practice the verbal pronunciation of the Navajo word.

Secret Key Encryption Worksheet

We would like to share a secret message with you!
To make sure only you can read our message, we have encoded it.

To decode the message, you will need to use the following encoding table

Letter (Vowel)	Bit	**Letter** (Consonant)	Bit	**Letter** (Consonant)	Bit	**Letter** (Consonant)	Bit
A	0000	B	0001	J	0010	N	0100
E	1000	D	0011	K	0101	S	1001
I	0110	G	1010	L	1100	T	0111
O	1011	H	1101	M	1110	Z	1111

Can you decode our secret message?

Word #1:

Bit	**Navajo Code Talker Word**	**Modern Spelling**	**Syllables & Pronunciation**
0011 0110 0001 1000 1101			

Word #2:

Bit	**Navajo Code Talker Word**	**Modern Spelling**	**Syllables & Pronunciation**

0111 1001 0000 1101 0000 1001 1111 0110 1101			

Word #3:

Bit	Navajo Code Talker Word	Modern Spelling	Syllables & Pronunciation
0101 1100 0110 1111 1111 0110 1000			

Word #4:

Bit	Navajo Code Talker Word	Modern Spelling	Syllables & Pronunciation
1110 1011 0000 1001 0110			

Word #5:

Bit	Navajo Code Talker Word	Modern Spelling	Syllables & Pronunciation
0001 0110 1001 1011 0011 0110 1101			

This student worksheet can be done individually or with a partner. Students will engage in a new type of decoding which combines binary encoding with Navajo Code Talker encoding. Students will learn how Navajo words were used to win World War II, work with the Navajo Code Talker's Decoding List, and also practice encoding using four-digit binary encoding.

A homework assignment for additional practice could be incorporated along with this worksheet example by providing students a similar worksheet copies but without the four-digit bits. On the internet there are many Navajo Code Talker dictionary lists or word lists that the students could use to create their own encoding worksheet.

Activity #2: Light-based binary encoding

The second classroom activity will be to incorporate a lesson on Morse code. Why the Morse code? During World War II these dots and dashes were used to send messages between war ships while they were out at sea. Naval war ships were able to communicate critical information to each other using this code. This type of encoding has each letter represented by a different sequence of long and short sounds or visual signals called dots and dashes ("di" which is a signal of about 1 second and "dahs" which is a signal of about 3 seconds in length). In this activity, students will be using the flashlights to send messages to each other as it was done during the war when signal lamps were used to communicate between ships.

In this activity the students will display a short burst of light for the dots and a longer beam of light for the dashes. Only those who can see the light can receive the transmission. Morse code also uses spaces to represent numbers and punctuation (in this activity lesson we will not be extending our codes to numbers and punctuation). While using only classical light (flashlights), this activity serves as a first introduction to Quantum Key Distribution which uses single photon lasers.

Students can use a traditional Morse Code Encoding (with short (*) and long (---)) as shown below.

A * --- Light signal: short long	H * * * * Light signal: short short short short	O --- --- --- Light signal: long long long	V * * * --- Light signal: short short short long
B --- * * * Light signal: long short short short	I * * Light signal: short short	P * --- --- * Light signal: short long long short	W * --- --- Light signal: short long long
C --- * --- * Light signal: long short long short	J * --- --- --- Light signal: Short long long long	Q --- --- * --- Light signal: long long short long	X --- * * --- Light signal: long short short long
D --- * * Light signal; long short short	K --- * ---' Light signal: long short long	R * --- * Light signal: short long short	Y --- * --- --- Light signal: long short long long
E * Light signal: short	L * --- * * Light signal: short long short short	S * * * Light signal: short short short	Z --- --- * * Light signal: Short short light
F * * --- * Light signal: short short long short	M --- --- Light signal: ong long	T --- Light signal: long	
G --- --- * Light signal: Short short long	N --- * Light signal: long short	U * * --- Light signal: Short short long	

Alternatively, students can use the binary table from a previous activity and replace 0 with short (*) and 1 with long (---) to create a different encoding.

Students will need to remember and practice the selected encoding table. A potential way is to create 26 index cards showing the encoding of each character. Students can practice by writing their first name in Morse Code. Additionally, students can try to encode other words in English. Students could also copy the codes for selected words onto index cards or sentence strips (that are cut into 5"-6" sections).

In a second step students will learn the techniques for light signaling for communication using the Morse code of letters and the basic light signals. The dot is a short and abrupt signal that expresses as the sound of "di". The signal that is three times longer than the dot is the longer sound of "dah". Students will practice listening for the differences between the dot and dash sounds and learn how to pay attention to distinct sounds. This activity will also benefit the Navajo language skills since it will teach them to carefully listen for differences between sounds.

In a third step students will use the flashlight and to practice some timing techniques of the dots and dashes ratio of 1:3 (1 second for the dot and 3 seconds for the dash). For the dot, students will turn the light on for 1 second, for the dash students will turn the light on for 3 seconds. To separate the alphabetical letters students will use a 7 second pause (/) where the light turned is off.

The following is a written example for the name of a person. The sample name here is: Betty.

--- * * * / * / --- / --- / --- * --- ---

B E T T Y

Remember that the * (dot) is 1 second in length with the flashlight on, the --- (dash) is 3 seconds in length with the light on, and the / (slash mark is in representation of the pause between the alphabetical letters) which is the pause for 7 seconds with the light off.

Students can begin by practicing with their first name to practice with the flashlight and their Morse Code card of their name. The receiver should have a piece of paper to write down the letters of the other student's first name. Students will practice the timing of the light on and light off method and the receiver can give some immediate verbal feedback by spelling the letters of the first person's name in Morse Code to the send. The receiver will do this same practice exercise to the sender. Students can share their experiences and to keep practicing the timing of the light on and light off method with each other.

As an advanced step, students could also practice sending Navajo Code with the flashlight. In this case, students would not only decode the separate letters making up Navajo words (letters were encoded using Morse Code) but also as in an additional step identify which English word was actually send, i.e., decode the Navajo Code encoding.

Activity #3: Coin encoding:

Last, the transition to quantum science can be made by introducing students to Quantum Key Distribution (QKD). In QKD, instead of using long/short signals, the polarization of light is used to encode messages in binary.

To thoroughly introduce students to QKD, students would first need to learn about polarization of light. This topic could be introduced using wave machines (Wave Machine Demonstration) and polarizers (or fishing sunglasses). Using polarizers students can send messages with Morse code, but instead of sending long and short signals, the sending student shines the flashlight through a polarizer being held in different ways to only allow transmission of specific linearly polarized light while the receiving student uses a second polarizer to check the polarization of the received light. Students will learn that polarization of light offers different ways of encoding messages, e.g., in the + basis (rectilinear basis) students can encode 'short or 0' using horizontally polarized light, and 'long or 1' using vertically polarized light (polarizer rotated by 90 degrees from first setting) and in the diagonal basis students encode 'short or 0' using 45 deg diagonal polarized light, and 'long or 1' using 135 deg diagaonl polarized light. When messages are being send and received in different bases, e.g., sending in rectilinear-basis and receiving in diagonal-basis, students will notice different light intensities. If the sender can reduce the light intensity so that only one photon (smallest quantity of light) is being send at a time and the receiver and sender use different bases, the message will have transmission errors. This is a feature of quantum science which can be used to check if someone spying on the transmission.

While a full introduction to QKD is an advanced topic and might not be a good fit for every class, students can also learn about QKD and the impact of a mismatch in sending/receiving encoding (bases) by sending messages using specifically crafted coins. In this activity, instead of using polarization of light to encode messages, students will use the Navajo and English language.

As a first basis set (analog to the rectilinear polarization basis), students will encode 0 and 1 with the Navajo words 0 = nasbaas, 1 = t'aala'i), as a second basis set (analog to the diagonal polarization basis), students will encode 0 and 1 with the English words (0 = zero, 1 = one).

The core idea of this activity is for students to experience how in QKD we can switch between different encoding bases and the impact a mismatch in basis of sender and receiver has. For this activity, four different sets of coins (A-D) need to be created.

Coin A:

Front side:

T'aala'i: N-1

ONE: E-1

Back side:

T'aala'i: N-1

ZERO: E-0

Coin B:

Front side:

Nasbaas: N-0

ONE: E-1

Back side:

Nasbaas: N-0

ZERO: E-0

Coin C:

Front side:

T'aala'i: N-1

ONE: E-1

Back side:

Nasbaas: N-0

ONE: E-1

Coin D:

Front side:

T’aala’i: N-1

ZERO: E-0

Back side:

Nasbaas: N-0

ZERO: E-0

Students will then use a poster tube to send a coin message. Before sending a message, the sending students will have to decide which language they want to send (prepare) the message in, and the receiving students need to decide in which language they want to receive (measure) the message in.

For example, the sending students might decide to send (prepare) their message in Navajo and the receiving students might decide to also receive (measure) in Navajo. To send a “1”, the senders would send coin A through the poster tube, to send a “0”, the senders would send coin B through the poster tube. The selected coin will fall out of the poster tube at the bottom and the receiving students will measure by reading the Navajo word shown on the side facing up. Since both senders and receivers are using the same language (basis), receivers will always get the correct message.

Should however, the receivers decide to receive in English, they have a 50% chance of getting the correct message since in English both coins show “ONE: E-1” on one side and “ZERO: E-0” on the other side and the outcome now depends on which side was facing up which is random.

Similarly, should the senders decide to send their message in English, they would send coin D to send a “1” and coin C to send a “0”. Again, the selected coin will fall out of the poster tube at the bottom and the receiving students will decode the message using the selected receiving language. If the receivers decide to receive in English, they will always receive the correct message, should they decide to receive in Navajo, they have a 50% chance of getting the correct message since in Navajo both coins show “T’aala’i: N-1” on one side and “Nasbaas: N-0” on the other side and so the outcome again depends on which side was facing up.

Sending students will document which language (basis) was used to encode and what message was being send (e.g., Navajo, 1). Receiving students will document which language was used to decode and which message was received (e.g., English, 0). Comparing the recordings of senders and receivers, students will realize that whenever the languages (bases) matched, the message was transmitted correctly. A mismatch in languages made the transmission not reliable. In a last step, a spy can be introduced who intercepts the message and students can verify that they can prove that a spy was present by analyzing the data.

The coin activity can also be used to play the ‘quantum coin toss’ where again the two languages are being used as the two bases instead of the two polarization bases (rectilinear, diagonal).

To relate the coin activity to the foundations of quantum science, the teacher can finish this activity by showing the youtube video on “What is a quantum coin toss?” The web link can be located below in the resource citation area. This video was created by Dianna C from the PBS Digital Studios. The video is 6 minutes in length from Season 3, Episode 5. Students when viewing this video will be introduced to tems

fundamental for quantum technologies such as wave function collapse, photon, polarization, unpolarized, polarization filter (polarizer), diagonal filter, horizontal filter, vertical filter, rectilinear measurement orientation, and diagonal measurement orientation.

Last, students will discuss the connection between the coin activity (as an accessible analog to QKD) and the Navajo Code Talkers.

Student Assessment

To assess student learning, students will be asked to create a Word Search using terms that are used in the area of quantum technology/encoding/encryption that he/she has learned from this curriculum and the classroom activities. Using the academic language in a word search can be very beneficial to the learner because he/she will be creating a list of quantum technology terms that scholars would use in their academic area (i.e., science, STEM courses, etc.). The students will also be sharing their knowledge now of the exposure to certain terms and by using them in their word search, it will enhance their knowledge of the word. As they create a Word Search, it will be an engaging activity to the student, and they might not even notice that what they are doing is creating a game that can be used as a post assessment of key terms that were learned from quantum technology.

Alignment with Standards

9th-12th Oral Navajo Language Standards
Standard III: Utilizing the Navajo language and culture, I will listen, communicate, observe, and understand appropriately.
Concept 1: I will listen and communicate effectively with logical Navajo language structure appropriate to various situations.

PO 3. I will demonstrate my understandings of oral narratives and other authentic stories.
PO 4. I will identify the vocabulary used in different contexts.

Concept 2: I will listen and communicate effectively with logical Navajo language structure appropriate to various situations.

PO 1. I will utilize the Navajo language in any setting.
PO 3. I will ask questions and apply information gained to real life situations.

9th-10th Navajo History Standards
Standard: I will understand historical/factual events, people and symbols that influence my family.
Concept 3: I will analyze and interpret major historical events of Navajo and neighboring tribes.

PO 4. I will interview and research stories of Navajo soldiers.

Concept 4: I will understand the integrity of my culture, language and values that are protected and maintained.

PO 1. I will identify and apply culturally appropriate uses of places and time.
PO 4. I will research the purpose of events in a historical timeline.

9th-12th Navajo Character Building Standards
Standard: I will develop and apply critical thinking to establish relationships with the environment.
Concept 4: I will express gratitude in everything.

PO 2. I will practice my language and culture by using it to plan and teach others.
PO 3. I will demonstrate ways to honor the Navajo culture.

Arizona World and Native Language Standards
Interpretive Reading (IR): Understand, interpret, and analyze what is read or viewed on a variety of topics. The student can:
Intermediate/High:
1. Understand the main ideas of texts related to everyday life, personal interests, and studies.
2. Sometimes follow stories and descriptions about events and experiences in various time frames.

English Language Proficiency Standards (ELPS)

Grades 9-12 English Language Proficiency Standards – Listening and Reading

Standard 1. By the end of each language proficiency level, an English learner can: construct meaning from oral presentations and literary and informational text through grade appropriate listening, reading, and viewing.

Basic: with moderate support apply a developing set of strategies to: B-2: recount a text including specific details and information.

Instructional Supports: Informational text types include but are not limited to: descriptions or accounts (e.g., scientific, historical, technical)

Literary text types include but are not limited to: stories (e.g., historical fiction).

English Language Proficiency Standards (ELPS)

Grades 6-12 Reading Foundational Skills

Considerations for Foundational Literacy Skills Instruction Based on Student Language and Literacy Characteristics

No or little spoken English proficiency: Students will need instruction in recognizing and distinguishing the sounds of English (e.g., vowels, consonants, consonant blends, syllable structures).

Spoken English proficiency: Students will need instruction in applying their knowledge of the English sound system to foundational literacy learning.

Phonological Awareness:

a. Identify phonemes in the initial, medial, and final positions of single-syllable words or individual syllables.
b. Orally produce the 44 phonemes represented in words.
c. Identify short vowel sounds in orally stated single-syllable words or individual syllables.
d. Identify long vowel sounds in orally stated single-syllable words or individual syllables.
e. Segment sentences into words.

Resources

Cowern, D. [Dianna Cowern]. (2018, March 22). What is a quantum coin toss? [Video]. *YouTube.* https://www.youtube.com/watch?v=UjFkIy1GTlk

The PBS video is very enlightening, and Dianna gives a very uplifting way to present information about quantum technology terms to her audience. Students will be engaged by watching this video not just one time but several times to understand the quantum terms. She associates the introduction of the coin toss to the quantum technology terms for making a prediction using the bits system of zeros and ones.

Hunter, S. H. (1998). The Unbreakable Code. *Rising Moon.*

This book is a children's literature featuring the grandfather as a Navajo Code Talker. The grandson does not want to leave his grandfather's homeland and his grandfather tells him the type of life he had to encounter when he was about his age in the military as a code talker. After the grandfather's story, his grandson does not feel so afraid to leave because his grandfather gave him a story of strength and pride for the mother country and that he will always feel home no matter where he moves to in America. This book contains detailed illustrations of the Navajo lifestyle, environmental surroundings, and the Navajo Code terms using the Alphabetical letters in English and the translation of the Navajo terms.

Bruchac, J. (2018). Chester Nez and the Unbreakable Code. *Albert Whitman & Company.*

This children's literature is written around the life and unforgettable journey during WWII as a Navajo Code Talker for Chester Nez. The book is unique because it contains detailed information with the actual month, date(s), and events that occurred from 1929 to 1945. There are two pages of Navajo Codes and a page of Chester Nez's Timeline.

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