LAND-BASED LEARNING IN JUNIOR HIGH SCIENCE

by

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ABSTRACT

The purpose of this paper was to create a set of 5E lesson plans using land-based learning to teach a junior high science unit on space exploration. Land-based learning uses local Indigenous knowledge and connections to the planet Earth to teach content in the context of the local community as a means of decolonizing the traditional classroom. Using land-based learning to teach space exploration poses a unique challenge as the learning is focusing on a location separate from Earth. Space exploration also has an inherently colonial history, focusing on conquering new lands and exploiting materials. This set of lessons begins by exploring Indigenous Cree constellations and mythologies, with students creating their own constellation that reflects their life experience. Students then explore traditional Indigenous means of living in extreme environments like the Canadian Arctic, which they apply to a new context in colonizing Mars. They will then build a model technology that could be used to live on Mars, for shelter, food or clothing. The lessons culminate in a debate activity in which students use the knowledge they have gained to decide if colonizing Mars would be a worthwhile endeavor.

CHAPTER ONE

INTRODUCTION & BACKGROUND

Context of the Study

Sexsmith, Alberta, Canada is a town with a population of approximately 2400 people and is located 20 kilometers north of the city of Grande Prairie, Alberta (Statistics Canada, 2021). The community has a strong tradition of farming, hunting, fishing, and other outdoor pursuits, stemming from the town's identity as the grain capital of the British empire in 1949. This name hints at the extensive British colonial history of the town. In the present day, farming continues to be a crucial industry to support the local community (Town of Sexsmith, n.d.).

Like much of modern Canada, the town of Sexsmith and the surrounding communities were founded by European colonists. Colonization was the process by which European explorers, or colonizers, arrived in Canada and imposed their values and belief systems onto the Indigenous Peoples that were already living and thriving there. This rendered the Indigenous Peoples dependent on the colonizers (Wilson, 2018). Through the process of colonization, Indigenous communities were forced off their traditional lands and moved onto comparatively small parcels of land called reservations, as outlined by the 11 Treaty agreements signed between the Canadian government and Indigenous leaders from 1871 and 1921. Sexsmith is located within the boundaries of Treaty 8, signed in 1899, with the closest reserve, Horse Lake First Nation, located approximately 70 km away (Government of Canada, 2023). Schools within the town of Sexsmith do not typically serve students that live on the reserve as there are other schools that are closer to the reserve.

As a result of the government Treaty agreements, Indigenous children were forced to live in residential schools that furthered the government's goal of destroying their native culture and language. The closest residential school to Sexsmith, St. Francois Xavier Boarding School, was located approximately 100 km away, near Sturgeon Lake, Alberta, and operated from 1905 to 1962 (National Centre for Truth and Reconciliation, n.d.). Indigenous children from the area that is now Sexsmith were removed from their families and sent to this boarding school. These children are now adults, and they, along with their descendants, still live in the community today.

Like the history of the town of Sexsmith, the educational system in Alberta has a strong colonial history, created by the provincial government from a Euro-centric perspective. There have been small steps and revisions to retro-actively implement Indigenous content and ways of knowing into the science curriculum, but in my teaching practice I have found that it is not effectively integrated. A new science curriculum for kindergarten to grade 6 is currently being piloted, with new curricula being released for grades 7 to 12 in the future. As of September 2024, there is no timeline on the process for the 7 to 12 curricula, so teachers in those grades are still working with the current, outdated curricula. For example, the current grades 7 to 12 science curricula were written in 2003, over 20 years ago. Integrating Indigenous perspectives is a requirement for the process of decolonization in Alberta, and that currently falls heavily on individual teachers to accomplish, with little support from the government.

Land-based education is a pedagogical strategy that incorporates local Indigenous knowledge into the classroom (Barnhart & Kawagley, 2005). By utilizing this form of learning, students can experience increased awareness and connection to their local environment. They are also provided with an opportunity to learn about issues that are specific to their community and develop an understanding of perspectives that differ from their own.

Focus Question

My focus question was, How can I use land-based learning to implement authentic Indigenous ways of knowing into a junior high science classroom?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Government Frameworks

The implementation of a new set of Teaching Quality Standards (TQS) by the Government of Alberta in 2020 provided an updated standard of professional practice for teachers in the province of Alberta (Appendix A). These standards include the competency to apply foundational knowledge about First Nations, Métis, and Inuit. This competency is demonstrated by understanding the implications and history of treaties and agreements the Canadian government made with First Nations and Métis, as well as the impacts and legacies of residential schools. According to the TQS, teachers are also expected to provide opportunities for all students to develop understand and appreciation for the history and cultures of First Nations, Métis, and Inuit, while also using resources that accurately represent those groups' diversity and strengths (Alberta Education, 2023). The incorporation of these standards in the new TQS is in response to recommendations made by the Truth and Reconciliation Commission of Canada.

The Truth and Reconciliation Commission (TRC) of Canada was established in 2006 as a component of the Indian Residential Schools Settlement Agreement. This agreement was made between the Government of Canada and survivors of Indian Residential Schools and their descendants. The goal of the TRC was to provide a method for the sharing of truths about the long-lasting effects of the Indian Residential Schools, and to address the continued healing that was required, despite residential schools no longer operating. This process would share the impact of residential schools with all Canadians and work towards reconciliation (Truth and Reconciliation Commission of Canada, 2015).

The TRC identified 94 calls to action, directed towards the Canadian federal government and the 13 provincial and territorial governments. Two of these calls to action focused on Aboriginal education within Canada, specifically calling on provincial Ministers of Education to implement mandatory curricula focusing on the history and contributions of Aboriginal peoples in Canada, as well as building student capacity for respect and understanding of other cultures (Truth and Reconciliation Commission of Canada, 2015). These calls to action are directly reflected in the new Alberta TQS discussed previously.

Place-Based Learning Versus Land-Based Learning

Place-based learning and land-based learning are two similar instructional techniques. Place-based learning can be described broadly as a method of using hands-on learning in the local community to explore concepts within a curriculum. By moving the learning experience outside of the classroom and into the local environment, students develop stronger ties to their community. This can result in improved academic performance and a stronger appreciation for nature (Sobel, 2004).

While land-based learning has similarities with place-based learning, land-based learning adds an extra dimension to using the local community for education. Land-based learning has foundations in Indigenous ways of knowing and addressing the effects colonization has had on human connection with the land. This can develop a greater understanding of local land issues. There are areas of overlap between Indigenous knowledge systems and Western science, but also perspectives that are unique to each. By bringing both Indigenous knowledge systems and

Western science into the classroom, teachers can provide a more holistic learning experience for students (Barnhart & Kawagley, 2005). Anti-colonialism and Indigenous knowledge are two of the key aspects of land-based learning that makes it a genuine step towards decolonization. This sets land-based learning apart from place-based learning (Webber et al., 2021).

A 10-year study in rural Alaska, the Alaska Rural Systemic Initiative, found that implementing land-based educational practices rooted in Indigenous ways of knowing resulted in increased student achievement when compared to students that did not participate in the program. This program identified curricular units that could combine local Indigenous knowledge with state standards and embed them within academic classes. Some increase in academic performance was noted as early as two years into the program, and parents also commented on the improvement in their children's writing and interest in local environmental issues (Hill et al., 2006).

Indigenous Knowledge in the Science Classroom

Western science can compartmentalize topics and subjects, without addressing the way they connect to each other or the world at large. This contrasts with Indigenous ways of understanding the universe, known as Indigenous knowledge. For example, Alaskan elders have long traditions of being able to predict weather patterns based on small details in the environment that their ancestors have observed for generations. They are aware of relationships between temperatures, clouds, precipitations, and other factors that may appear insignificant to an outside observer. This is an example of Indigenous knowledge that could compliment a unit of study on weather (Barnhardt & Kawagley, 2005).

Indigenous knowledge has been described as the knowledge and practices that are shaped by the daily experiences of people living closely with nature. Their review of a wide array of literature focusing on sustainability education support the inclusion of Indigenous knowledge to increase students' understanding of their own identities, as well as their understanding of Western science ideas. Four aspects of Indigenous knowledge were recommended for inclusion in the classroom: a) the collaborative nature of community activities; b) the dynamic nature of Indigenous knowledge; c) the holistic nature of Indigenous knowledge; and d) respect for nature, other people, and spirituality. They also noted patterns of increased positive student attitudes towards ideas of sustainability (Druker-Ibáñez and Cáceres-Jensen, 2022).

In another study, workshops were conducted in various locations in Nunavut, Canada which introduced local Inuit students to the issues of contaminated water and the effect on the local population of ringed seals. Students participated in two workshops; one workshop focused on traditional Indigenous use of ringed seals, and the other focused on water quality. The study found the workshops were successful in increasing student awareness of the presented issues, and that students had success learning from information presented from a traditional Indigenous perspective. The students also had success learning about water contaminants from information presented from a Western perspective. A criticism of the workshop was the lack of consultation with community Elders. This reinforces the importance of integrating authentic Indigenous knowledge with the Western science that is being performed in the community and presented to students (Henri et al., 2022).

The implementation of land-based learning provides an important opportunity for science teachers to integrate authentic Indigenous knowledge into their classroom. Not only does this fulfil a professional requirement for teachers in Alberta as outlined by the TQS, but it is also a recommendation made by the TRC. Land-based learning can lead to an increase in students' connection to and appreciation for their local community, ultimately taking positive steps towards decolonization (Webber et al., 2021).

CHAPTER THREE

INSTRUCTIONAL STRATEGIES

Unit of Study: Space Exploration

At first glance, space exploration is a topic that does not seem to lend itself to land-based learning. One of the reasons for this is that space is full of concepts that have no comparison on Earth. For example, black holes or stellar nuclear fusion are difficult ideas to fully comprehend just using the knowledge we have about planet Earth. Additionally, the history of space exploration is colonial in nature. It tends to focus on conquering new planets for colonization or exploiting their resources, which are ideas that run counter to the heart of land-based learning. In comparison, it is easy to imagine a land-based learning experience focusing on topics like watersheds, ecology or geology. Still, I wanted to challenge myself to develop lessons to authentically connect outer space to the land my students and I live on.

The following set of lesson plans is based on outcomes from the Alberta Science 9 Program of Studies, specifically Unit E: Space Exploration (Appendix B). Science 9 is the final year of junior high science in Alberta, completed in grade 9 by students that are typically 14 or 15 years old. It is a general science course, consisting of five units of study focusing on either biology, chemistry, physics or environmental science. The course ends with a standardized provincial exam, the Provincial Achievement Test, given by the government at the end of the school year.

Space Exploration is one of the five units covered in Science 9, usually taking six to eight weeks of class time to complete. While this set of lesson plans does not address the entire Space

Exploration unit of study, it covers several outcomes using land-based learning strategies and can easily be embedded within the unit (Appendix C). My preference is to complete this unit in November and December, when the days are short, which provides an ideal time for stargazing in the early evenings. This makes it easier for students to observe firsthand the constellations, auroras and other phenomena that they learn about throughout the unit. I believe this increases the authenticity of the unit, which is one of the principles of land-based learning.

Land-Based Learning and Space Exploration

Historical Astronomy

The Historical Astronomy Lesson focuses on traditional astronomy in ancient cultures across the globe, serving as an introduction to the Space Exploration unit (Appendix D). It begins by capturing student attention with a video describing how Polynesian wayfinders used the night sky to navigate the Pacific Ocean (TED-Ed, 2017). This video provides a detailed example of how one specific culture utilized the stars and planets in their everyday life, and how it shaped an important aspect of their life (Figure 1). A short whole-class discussion after the video will help students focus on the main ideas of the lesson. Some questions to guide this discussion include, How did their connection to their environment influence the Polynesian wayfinders? and, How would we navigate across the ocean today?

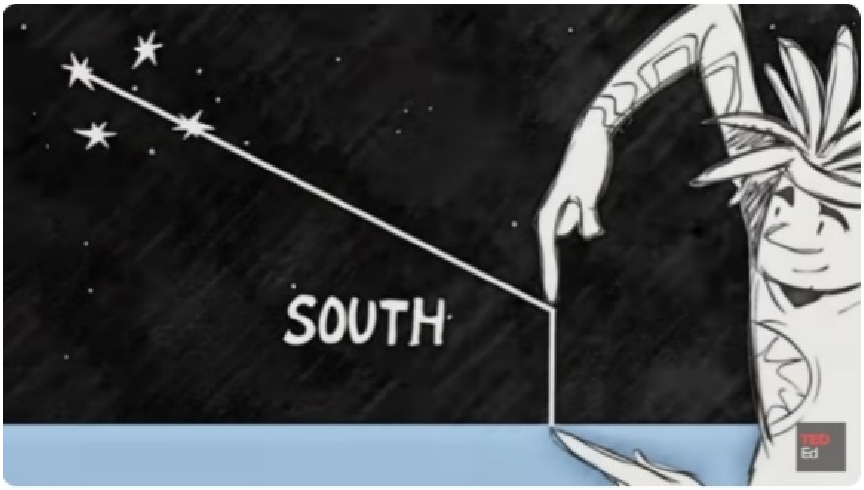

Figure 1. A screenshot of the TED-Ed video, *How did Polynesian wayfinders navigate the Pacific Ocean?* The image shows how the Polynesian people used the stars to determine which direction was southwards.

After learning about this example, students will collaborate in pairs to research other cultures that have relied on the night sky. Students can research a culture of their choosing, or select from a variety of options, such as the Mayan civilization, Incan civilization, ancient Egyptians, or ancient Greeks, based on their interest and prior knowledge. By the end of the class, students should be able to describe common reasons why people have historically used the night sky. Common usages that they should identify can include navigation, tracking the passage of time, creating cultural mythologies and storytelling. Students should also understand that connecting with the sky is a nearly universal experience for people across the globe. This sets the stage for understanding the connection between outer space, traditional Indigenous cultures in Alberta and their own personal cultures. Students will record their research in their science journals throughout the lesson, providing an opportunity for formative feedback on their records by the teacher.

<u>Ininew Mythologies</u>

The Ininew Mythologies lesson focuses on historical astronomy in Canadian Indigenous cultures, specifically the Ininew, or Cree, people of Alberta and western Canada (Appendix E). It is designed to directly follow the Historical Astronomy lesson. The lesson begins with a read-aloud story chosen from the book *Tipiskawi Kisik: Stories of the Night Sky*, written by Wilfred Buck. This book contains numerous stories sharing the mythologies connected to constellations and stars from the Ininew perspective before European contact. The teacher can choose from the many stories in the book, based on what will resonate with their students.

After hearing an Ininew myth about a constellation, students will then use StarScribe, an online activity created by Brandon Bunnie, to examine nine Ininew constellations in more detail (Figure 2). This online activity is framed as a game that takes place on the moon. The player begins in a lunar lander and can move around to explore the lunar surface. Scattered among stations providing information about the moon, are nine stations that describe various Ininew constellations. The stations provide an image of each constellation, along with the Ininew name and story, and the corresponding Western constellation. Students will visit each station in the game and will record a sketch and short description of each Ininew constellation in their science notebooks (Figure 2). After completing this activity, students should be able to explain the importance of the constellations to the Ininew people, and how it connects to their culture. For example, Makinak is a constellation of a turtle. The painted turtle is important to Ininew culture as the 13 segments around the outside of its shell represent the 13 moons of the year, and the 28 segments on the inside of its shell represent the 28 days between each full moon (Buck, 2018).

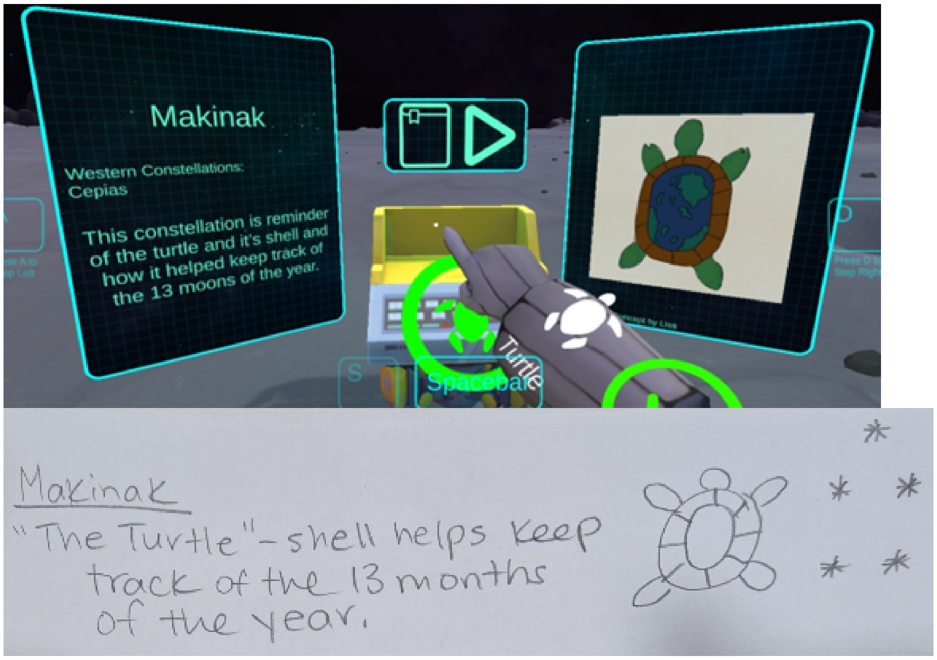

Figure 2. Top: Image from StarScribe, showing information about the Ininew constellation Makinak. Bottom: Corresponding student notes in science notebook.

The next day, students will extend what they have learned by designing their own constellations and creating mythologies based on their own lives and cultures (Figure 3) (Appendix F). This will allow students to demonstrate what they have learned in the last two lessons about the importance of the night sky and constellations to many different cultural groups. The focus of this assessment is for students to apply these ideas in a new scenario, where they are creating their own constellations and writing stories that go along with them.

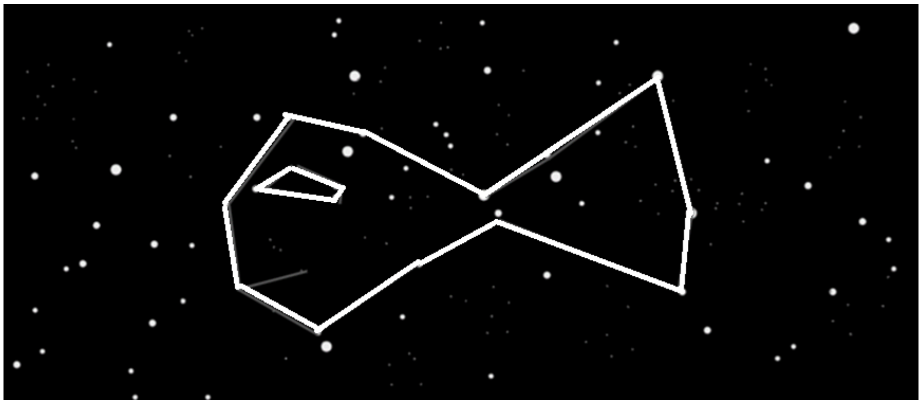

Figure 3. A sample constellation of a fish, created on Google Slides. Students will name their constellation and create a mythology explaining the importance of their constellation to their own life.

Challenges of Extreme Environments

The Challenges of Extreme Environments lesson in the first lesson in a series that focuses on the colonization of the moon or Mars, using an analogy of living in the Canadian Arctic (Appendix G). Over the course of three classes, students will research and learn about different challenges humans experience living in the Arctic, focusing on the Inuit people, and then apply that knowledge to living in environments like the moon or Mars.

The lesson begins with a brainstorming session comparing the environment of the Arctic and Mars. A photo of the Canadian Arctic and Mars are each shown on the classroom screen, and students are asked to create two lists of words on the whiteboard that they would use to describe each environment. Many of the words should be similar when describing each of the environments, for example “cold”, “no food”, or “isolated.” After completing the lists on the whiteboard, students will put those words into a Venn diagram in their notebooks, with one side representing the Arctic and the other side representing Mars (Figure 4).

Figure 4. Sample Venn diagram representing a comparison between the Arctic and Mars.

Students are then split into five home groups for a jigsaw activity. Each group is given one of the following questions to research, and record information in their science notebooks:

- Group 1: How do Indigenous or Inuit people traditionally access food in the Arctic?
- Group 2: How do Indigenous or Inuit people traditionally provide shelter in the Arctic?
- Group 3: How do Indigenous or Inuit people traditionally provide clothing in the Arctic?
- Group 4: How do Indigenous or Inuit people traditionally provide community and connection to each other in the Arctic?
- Group 5: What are the health concerns from living in an environment like the Arctic?

Groups should be given time to research information about their assigned question, writing down their findings in their science notebooks. They will be considered experts regarding their question and should be prepared to share their findings with classmates. This makes it crucial that they use reliable sources of information.

Once groups have collected information about their question, the home groups are split up into new groups with five members: one member from each home group. It then becomes the responsibility of each group member to teach the rest of their new group what they learned in their home group. At the end of this class, each student should have information in their science notebooks answering each of the five questions from the home groups, as taught to them by their group members. Students will use this information as they move forward in the next several lessons.

In the next class, students will reunite with their home groups. This time, they will be applying what they learned in the previous class to three new questions and recording their thoughts in their science notebooks. These questions have students applying the Indigenous knowledge they learned in the previous class to a novel scenario, living on Mars.

- How does this challenge (from yesterday's question) exist on Mars?
- What Inuit strategies could be adapted for surviving on Mars?
- What new technologies would be needed to survive on Mars?

The rest of the class will be given to respond to these questions and create a slideshow presentation to share their findings with the class. The information that is presented in response to these three questions will be very valuable as students move on to the next lesson.

To assess student performance in this lesson, a minute-paper can be used with the question, How can Indigenous knowledge help us adapt to future challenges, on Earth and beyond? Students can respond to this from a variety of perspectives, giving them plenty of opportunity to demonstrate what they learned.

Engineering for Extreme Environments

The Engineering for Extreme Environments lesson is designed to follow the Challenges of Extreme Environments lesson (Appendix H). It focuses on using the engineering design process to build a model technology, using the information that students have been gathering about Inuit ways of life, along with their new knowledge about Mars. Over the course of two or three classes, students will work in groups to plan, build and test a technology that would be beneficial for living on Mars.

The opening of the lesson begins by captivating student interest with the YouTube video “Why the Moon?” by NASA. This video explains NASA’s plans to build a moon base to eventually land humans on Mars. A guided conversation after the video focuses students onto the challenges and benefits of humans landing on and potentially colonizing the moon and Mars. After this conversation, students will sketch their idea of a lunar or Martian base and label the important components, such as solar panels, living quarters, or vehicles.

Before moving on in the lesson, students should be reminded about the engineering design process (Figure 5). In this lesson, the focus is on the building and testing aspect of the process. The class should already have a foundational understanding of the problem that they are trying to solve, that is living on Mars, and have developed ideas about solutions from the previous lesson.

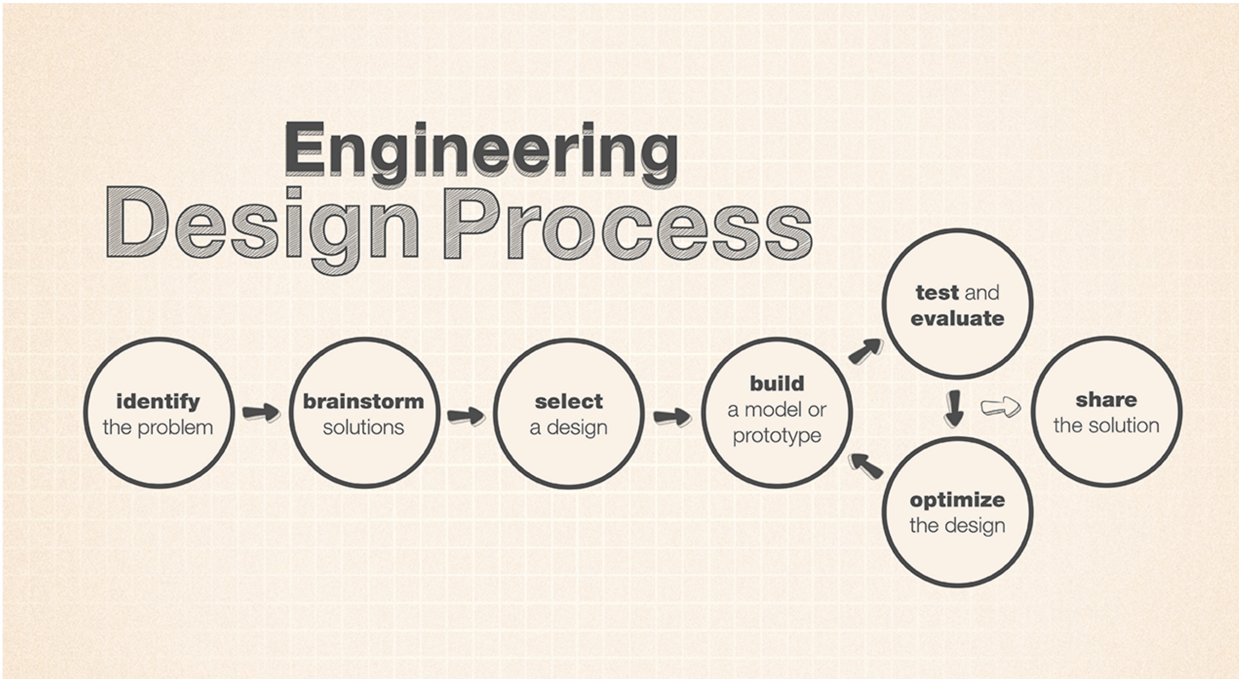

Figure 5. Flowchart demonstrating the engineering design process (NASA/JPL-Caltech).

Students will then split into groups, and be assigned one of three topics to design, build, and test a model technology for: shelter, food systems, or clothing. The groups will be given one class to research and design their model in their science notebooks (Figure 6). The design process will also include creating a list of materials they require to build their model next class, which either the teacher or students can obtain. Once groups have finalized their designs, they will decide how to test the effectiveness of their design. For example, a group building a model spacesuit could test the effectiveness of the sealing of the joints between the parts of the suit by blowing air into the suit and pressurizing it. Allowing different groups to compare their work and collaborate can help students that may struggle with the engineering design process, and can be an option for students that need more support.

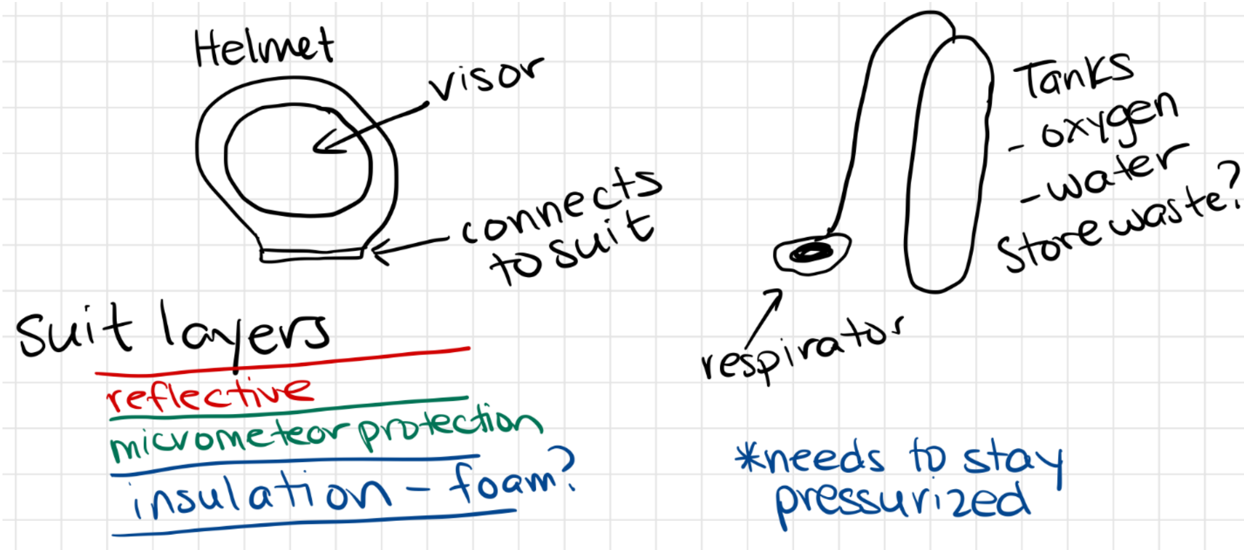

Figure 6. Sample student design of a model spacesuit

One class should be given for the planning and design of the models. Once materials are obtained, groups can be given one or two classes to complete the building of their models, based on the needs of the students. As groups finish building their model, they should move onto testing. Each group member should record the testing process and results in their science notebooks, along with a short paragraph explaining how they would improve their model in the future. Ideally, groups would be able to adjust and retest their model with improvements, but the time constraints of a typical junior high science class might not allow this.

Throughout this entire activity, the teacher should be circulating around the room making observations about how group members work together. This provides valuable formative information about how students communicate and work together. A summative assessment could be given by having groups create a formal presentation to share with the class, communicating their engineering design process and the results of testing their design (Appendix I).

Colonizing Space

The Colonizing Space lesson ties together the content the class has learned through the space exploration unit (Appendix J). Students will think critically and apply the knowledge they have learned to create an argument either in favor or against colonizing Mars. Before completing this lesson, students will cover all the outcomes in the Alberta Science 9 Space Exploration unit including, for example, topics like telescopes, space travel, characteristics of planets, the motion of objects in space, technologies to meet human needs in space, and risks of space travel. This provides students with a good foundation for participating in this lesson's debate activity.

The lesson begins by brainstorming answers to the question, If you have the opportunity to live on Mars, would you do it? Why or why not? Students will first answer in their science notebooks and then volunteer to share their responses with the class. It is likely that conversations may emerge based on their responses, and this should be encouraged. A list of ideas for and against living on Mars can be made on the whiteboard, providing a visual reminder of some of the reasons given. This will prompt students to begin thinking about the question from different perspectives, preparing them for the upcoming debate.

The class will then be split into two groups. One group will be assigned arguing in favor of colonizing Mars, and the other will be assigned arguing against it. The students' actual opinions about colonizing Mars are not important for the debate; they will be arguing their assigned perspective. This will force students to consider the issue from a perspective they may not agree with, with is a valuable skill when it comes to forming arguments and thinking critically about a topic. The groups will then be given time to research their assigned argument, including information from an economic, political, environmental and ethical perspective. Each of these perspectives should be included to ensure they are forming a robust argument. A simple planning sheet including the format of the debate could be provided during planning time to help the groups organize their information (Appendix K). Providing the assessment rubric in advance will also help students ensure they are meeting the requirements (Appendix L).

Once the groups have been given enough time to prepare their arguments, it is time to conduct the debate. The teacher plays a very important role in moderating the debate. Expectations should be clearly stated before beginning, ensuring that groups are respectful and follow the debate rules. A suggested debate format is as follows:

Opening Statements: each group presents their main arguments (2 minutes each)

Rebuttals: groups respond and challenge the opposing side's arguments (2 minutes each)

Open Debate: Guided discussion where each group can take turns asking questions and responding (20 minutes)

Closing Statements: each group summarizes their main points (2 minutes each)

This format allows each group to share their arguments and rebut the other group's arguments. Each group member should participate in the debate, as this is their opportunity to demonstrate their oral communication skills.

At the end of the debate, there does not need to be a winning team declared. Instead, students will be given an opportunity to synthesize the information and arguments shared in the debate to create their own personal response to the question, Should humans colonize Mars? Why or why not? Students can be given the freedom to choose their own means of representing their response in a way that showcases their understanding best, for example through an essay, video recording, poster, etc. Their responses can be used as a summative assessment of the knowledge they have gained through the entire space exploration unit, with the included rubric (Appendix L).

The debate and personal response activities included in this lesson serve as excellent indicators of student progress through the space exploration unit. They will use the knowledge they gained, along with information they research, to interpret data, engage in arguments from evidence, and obtain, evaluate and communicate that information to their classmates. This requires higher level thinking skills, allowing students to demonstrate their mastery of the unit's outcomes.

CHAPTER FOUR

PROFESSIONAL REFLECTION

Guidance For Implementation

This set of lesson plans assumes that students have a basic understanding of Indigenous peoples across Canada and their history with the Government of Canada. More specifically, this includes basic information about Inuit and Cree ways of life. These topics are covered extensively beginning in early elementary school, so a typical grade 9 student in Alberta should have this knowledge. Coming into this set of lessons with this basic knowledge will help students identify reliable and accurate resources when they are finding information online.

Before undertaking Lesson 4, Engineering for Extreme Environments, a basic understanding of the engineering design process would be beneficial for students. Ideally, they will have used the engineering design process previously, so they understand the process of creating a design, building it and testing it. The Engineering for Extreme Environments lesson can, however, be used to introduce the building and testing steps of the design process if it has not been taught previously. If this is the case, explicit instruction on how the design process works should be provided to ensure students have the support they need when they are building their models.

These lessons are not necessarily designed to be used in order one after another, but rather integrated into a larger space exploration unit. Lesson 1, Historical Astronomy, and Lesson 2, Ininew Mythologies, act as introductory lessons at the beginning of the unit to introduce and engage students within the topic of space exploration. After these lessons, students will then work through the unit and learn about topics like the life cycle of stars, physical characteristics of the planets, simple rocketry principles, telescopes, parallax and the Doppler effect. Lesson 3, Challenges of Extreme Environments, and Lesson 4, Engineering for Extreme Environments, would ideally take place after these topics, towards the end of the unit, once students have foundational knowledge about the solar system and the conditions people would face if they lived on another planet, like Mars. This will provide students with the background knowledge required to allow them to fully engage in the engineering process required in building their model technology in Lesson 4. Lesson 5, Colonizing Space, can be used at the end of the unit to assess student understanding of all the topics covered throughout the unit. This final lesson allows students to truly demonstrate the knowledge they have learned throughout the unit, and provide an effective performance task as a summative assessment.

The assessments included in these resources provide opportunities for formative and summative assessment. Formative assessment is embedded throughout each lesson. Observing students as they work collaboratively on each activity provides feedback on their ability to participate and work together. Minute papers and the included rubrics can also quickly provide formative feedback to both students and the teacher as the class progresses through the lessons. An excellent opportunity for summative assessment occurs after the debate activity. Allowing students to use what they have learned throughout the entire space exploration unit to respond to the question “Should humans colonize Mars?” can accurately synthesize and represent what they have learned. Rather than simply relying on a multiple-choice test, which is the format of the standardized Alberta provincial exams, letting students choose their way of demonstrating their learning is a more reliable method of assessment. Participating in the debate also provides a performance task that can be used for summative assessment, allowing students to actually demonstrate their learning.

While the included lessons are tailored to be used in the context of western Canada, they could be adapted to be used in other locations. For example, examining the constellations and night sky stories of local Indigenous culture or examining extreme environments like a desert, rather than the Arctic. Additionally, there are opportunities to expand upon the lessons. The Engineering for Extreme Environments lesson allows the teacher to tailor the depth of the engineering activity to their class's needs. A class that has extensive experience with the engineering design process can use the full process from identifying the problem, to building their model, to optimizing the model, whereas a class that is just introducing the engineering design process can focus on only the design portion.

Professional Development

The biggest change I have seen in my teaching practice because of this project is that I am much more aware of the possibilities for incorporating land-based learning in my classroom. Before this project, I did not put much conscious thought towards incorporating Indigenous knowledge in my classroom. Now, I feel much more confident in my ability to use Indigenous knowledge in an authentic and meaningful way. I also feel more empowered to seek out Indigenous knowledge from Knowledge Keepers and Elders in the local community through the relationships that were built during this project. This will no doubt impact my students in a positive way as I will provide them with a science education that is taking its first steps towards decolonization.

On a personal level, I feel much more connected to the traditional knowledge of the land that I live on and more aware of the colonial biases of the modern educational system, especially in relation to science. Land-based learning provides a much-needed framework for educators to look at the western-centric curricula they deliver from a different perspective and take steps towards decolonization.

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APPENDICES

APPENDIX A

ALBERTA TEACHING QUALITY STANDARDS

Alberta Government

Alberta Education

Teaching Quality Standard

Teaching Quality Standard

Whereas

Alberta's teachers, students, parents, educational leaders, and members of the public have a strong will to ensure all Alberta students have access to quality learning experiences that enable their achievement of the learning outcomes outlined in programs of study.

Whereas

Alberta teachers provide inclusive learning environments in which diversity is respected and members of the school community are welcomed, cared for, respected and safe.

Whereas

Alberta teachers play a fundamental role in establishing the conditions under which the learning aspirations and the potential of First Nations, Métis and Inuit students will be realized.

Whereas

quality teaching occurs best when teachers work together with other teachers in the common interest of helping all students succeed in diverse and complex learning environments.

Whereas

the *Teaching Quality Standard* provides a framework for the preparation, professional growth, supervision and evaluation of all teachers.

Whereas

students, parents and other partners in education should be confident that Alberta teachers demonstrate the *Teaching Quality Standard* throughout their careers.

1. In the context of this document:

(a) **"competency"** means an interrelated set of knowledge, skills and attitudes, developed over time and drawn upon and applied to a particular teaching context in order to support optimum student learning as required by the *Teaching Quality Standard*;

(b) **"inclusive learning environment"** means a classroom, school, on-line learning environment or other educational setting structured to anticipate, value and respond to the diverse strengths and needs of all learners;

(c) **"indicators"** means actions that are likely to lead to the achievement of a competency and which, together with the competency, are measurable and observable;

(d) **"local community"** means community members who have an interest in education and the school, including neighbouring Métis settlements, First Nations and other members of the public;

(e) **"school authority"** means a public school board, separate school board, Francophone regional authority, charter school operator or accredited private school operator;

(f) **"school community"** means students, teachers and other school staff members, parents/guardians and school council members;

(g) **"school council"** means a school council established under the *School Act*, or a parent advisory council established under the *Private Schools Regulation*;

(h) **"student"** means, for the purpose of this standard, an individual enrolled in a school or required by law to attend, and includes a child younger than 6 years of age who is enrolled in an early childhood services program;

(i) **"teacher"** means an individual who holds a certificate of qualification as a teacher issued under the *School Act*.

2. The *Teaching Quality Standard*:

Fostering Effective Relationships

1. A teacher builds positive and productive relationships with students, parents/ guardians, peers and others in the school and local community to support student learning.

Achievement of this competency is demonstrated by indicators such as:

(a) acting consistently with fairness, respect and integrity;

(b) demonstrating empathy and a genuine caring for others;

(c) providing culturally appropriate and meaningful opportunities for students and for parents/guardians, as partners in education, to support student learning;

(d) inviting First Nations, Métis and Inuit parents/ guardians, Elders/knowledge keepers, cultural advisors and local community members into the school and classroom;

(e) collaborating with community service professionals, including mental health, social services, justice, health and law enforcement; and

(f) honouring cultural diversity and promoting intercultural understanding.

Engaging in Career-Long Learning

2. A teacher engages in career-long professional learning and ongoing critical reflection to improve teaching and learning.

Achievement of this competency is demonstrated by indicators such as:

(a) collaborating with other teachers to build personal and collective professional capacities and expertise;

(b) actively seeking out feedback to enhance teaching practice;

(c) building capacity to support student success in inclusive, welcoming, caring, respectful and safe learning environments;

(d) seeking, critically reviewing and applying educational research to improve practice;

(e) enhancing understanding of First Nations, Métis and Inuit worldviews, cultural beliefs, languages and values; and

(f) maintaining an awareness of emerging technologies to enhance knowledge and inform practice.

Demonstrating a Professional Body of Knowledge

3. A teacher applies a current and comprehensive repertoire of effective planning, instruction, and assessment practices to meet the learning needs of every student.

Achievement of this competency is demonstrated by indicators such as:

(a) planning and designing learning activities that:

- address the learning outcomes outlined in programs of study;
- reflect short, medium and long range planning;
- incorporate a range of instructional strategies, including the appropriate use(s) of digital technology, according to the context, content, desired outcomes and the learning needs of students;
- ensure that all students continuously develop skills in literacy and numeracy;
- communicate high expectations for all students;
- foster student understanding of the link between the activity and the intended learning outcomes;
- consider relevant local, provincial, national and international contexts and issues;
- are varied, engaging and relevant to students;
- build student capacity for collaboration;
- incorporate digital technology and resources, as appropriate, to build student capacity for: - acquiring, applying and creating new knowledge;
  - communicating and collaborating with others,
  - critical-thinking; and
  - accessing, interpreting and evaluating information from diverse sources;
- consider student variables, including:
  - demographics, e.g. age, gender, ethnicity, religion;
  - social and economic factors;
  - maturity;
  - relationships amongst students;
  - prior knowledge and learning;
  - cultural and linguistic background;

Establishing Inclusive Learning Environments

4. A teacher establishes, promotes and sustains inclusive learning environments where diversity is embraced and every student is welcomed, cared for, respected and safe.

Achievement of this competency is demonstrated by indicators such as:

(a) fostering in the school community equality and respect with regard to rights as provided for in the *Alberta Human Rights Act* and the *Canadian Charter of Rights and Freedoms*;

(b) using appropriate universal and targeted strategies and supports to address students' strengths, learning challenges and areas for growth;

(c) communicating a philosophy of education affirming that every student can learn and be successful;

(d) being aware of and facilitating responses to the emotional and mental health needs of students;

(e) recognizing and responding to specific learning needs of individual or small groups of students and, when needed, collaborating with service providers and other specialists to design and provide targeted and specialized supports to enable achievement of the learning outcomes;

(f) employing classroom management strategies that promote positive, engaging learning environments;

(g) incorporating students' personal and cultural strengths into teaching and learning; and

(h) providing opportunities for student leadership.

Applying Foundational Knowledge about First Nations, Métis and Inuit

5. A teacher develops and applies foundational knowledge about First Nations, Métis and Inuit for the benefit of all students.

Achievement of this competency is demonstrated by indicators such as:

(a) understanding the historical, social, economic, and political implications of:

- treaties and agreements with First Nations;
- legislation and agreements negotiated with Métis; and
- residential schools and their legacy;

(b) supporting student achievement by engaging in collaborative, whole school approaches to capacity building in First Nations, Métis and Inuit education;

Adhering to Legal Frameworks and Policies

6. A teacher demonstrates an understanding of and adherence to the legal frameworks and policies that provide the foundations for the Alberta education system.

Achievement of this competency is demonstrated by indicators such as:

(a) maintaining an awareness of, and responding in accordance with, requirements authorized under the *School Act* and other relevant legislation;

(b) engaging in practices consistent with policies and procedures established by the school authority; and

(c) recognizing that the professional practice of a teacher is bound by standards of conduct expected of a caring, knowledgeable and reasonable adult entrusted with the custody, care or education of students.

Alberta Government

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Edmonton, Alberta T5J 5E6

APPENDIX B

ALBERTA SCIENCE 9 UNIT E: SPACE EXPLORATION

Unit E: Space Exploration (Science and Technology Emphasis)

Overview: Technologies have played an essential role in the study of space and in the emerging use of space environments. Our modern understanding of space has developed in conjunction with advances in techniques for viewing distant objects, for transmitting images and data through space, and for manned and unmanned space exploration. A study of space exploration provides an opportunity for students to examine how science and technology interact and to learn how one process augments the other. Students become aware that technologies developed to meet the challenges of space are applied to new purposes.

This unit builds on:
- Grade 6 Science, Topic C: Sky Science

This unit provides a background for:
- Science 30, Unit C: Electromagnetic Energy

Focusing Questions: How have humans attained a presence in space? What technologies have been developed and on what scientific ideas are they based? How has the development of these technologies contributed to the exploration, use and understanding of space and to benefits on Earth?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the outcomes below.

- technologies for space exploration and observation
- reference frames for describing position and motion in space
- satellites and orbits
- distribution of matter through space
- composition and characteristics of bodies in space
- life-support technologies
- communication technologies

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

1. Investigate and describe ways that human understanding of Earth and space has depended on technological development
   - identify different ideas about the nature of Earth and space, based on culture and science *(e.g., compare geocentric and heliocentric models [Note: knowledge of epicycles is not required]; describe Aboriginal views of space and those of other cultures; describe the role of observation in guiding scientific understanding of space)*
   - investigate and illustrate the contributions of technological advances—including optical telescopes, spectral analysis and space travel—to a scientific understanding of space
   - describe, in general terms, the distribution of matter in star systems, galaxies, nebulae and the universe as a whole
   - identify evidence for, and describe characteristics of, bodies that make up the solar system; and compare their composition and characteristics with those of Earth
   - describe and apply techniques for determining the position and motion of objects in space, including:
     - constructing and interpreting drawings and physical models that illustrate the motion of objects in space *(e.g., represent the orbit of comets around the Sun, using a looped-string model)*
     - describing in general terms how parallax and the Doppler effect are used to estimate distances of objects in space and to determine their motion

  - describing the position of objects in space, using angular coordinates *(e.g., describe the location of a spot on a wall, by identifying its angle of elevation and its bearing or azimuth; describe the location of the Sun and other stars using altitude-azimuth coordinates, also referred to as horizon coordinates or local coordinates) [Note: A description of star positions based on right ascension and declination is not required.]*
- investigate predictions about the motion, alignment and collision of bodies in space *(e.g., investigate predictions about eclipses; identify uncertainties in predicting and tracking meteor showers)*

2. Identify problems in developing technologies for space exploration, describe technologies developed for life in space, and explain the scientific principles involved
   - analyze space environments, and identify challenges that must be met in developing life-supporting systems *(e.g., analyze implications of variations in gravity, temperature, availability of water, atmospheric pressure and atmospheric composition)*
   - describe technologies for life-support systems, and interpret the scientific principles on which they are based *(e.g., investigate systems that involve the recycling of water and air)*
   - describe technologies for space transport, and interpret the scientific principles involved *(e.g., describe the development of multistage rockets, shuttles and space stations; build a model vehicle to explore a planet or moon)*
   - identify materials and processes developed to meet needs in space, and identify related applications *(e.g., medicines, remote sensing, microelectronics, polymers, medical imaging, wireless communication technologies, synthesis of fuels)*
   - describe the development of artificial satellites, and explain the major purposes for which they are used *(e.g., communication, GPS—global positioning system, weather observation)*

3. Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies
   - explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments
   - explain the role of radio and optical telescopes in determining characteristics of stars and star systems
   - describe and interpret, in general terms, the technologies used in global positioning systems and in remote sensing *(e.g., use triangulation to determine the position of an object, given information on the distance from three different points) [Note: This example involves the use of geometric approaches rather than mathematical calculations.]*

4. Identify issues and opportunities arising from the application of space technology, identify alternatives involved, and analyze implications
   - recognize risks and dangers associated with space exploration *(e.g., space junk, fuel expenditure, satellites burning up in the atmosphere, solar radiation)*
   - describe Canadian contributions to space research and development and to the astronaut program *(e.g., Canadarm)*
   - identify and analyze factors that are important to decisions regarding space exploration and development *(e.g., identify examples of costs and potential benefits that may be considered; investigate and describe political, environmental and ethical issues related to the ownership and use of resources in space)*

Skill Outcomes (focus on problem solving)

Initiating and Planning

Students will:

Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- identify practical problems *(e.g., identify problems that must be addressed in developing a life-supporting space environment)*
- propose alternative solutions to a given practical problem, select one, and develop a plan *(e.g., design and describe a model of a technology to be used in a space station)*
- state a prediction and a hypothesis based on background information or an observed pattern of events *(e.g., predict the next appearance of a comet, based on past observations; develop a hypothesis about the geologic history of a planet or its moon, based on recent data)*

Performing and Recording

Students will:

Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- research information relevant to a given problem
- select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., compile and compare information about two exploratory missions)*
- organize data, using a format that is appropriate to the task or experiment *(e.g., maintain a log of observed changes in the night sky; prepare a data table to compare various planets)*

Analyzing and Interpreting

Students will:

Analyze qualitative and quantitative data, and develop and assess possible explanations

- test the design of a constructed device or system *(e.g., create and test a model device for remote manipulation of materials)*
- identify and correct practical problems in the way a prototype or constructed device functions *(e.g., identify and correct problems in the functioning of a model "remote transportation device" that they have designed and built)*
- identify the strengths and weaknesses of different methods of collecting and displaying data *(e.g., compare Earth-based observations with those made from spacecraft)*
- identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")*

Communication and Teamwork

Students will:

Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results

- receive, understand and act on the ideas of others *(e.g., take into account advice provided by other students or individuals in designing a model space suit or space vehicle)*
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)*
- defend a given position on an issue or problem, based on their findings *(e.g., conduct appropriate research to justify their position on the economic costs or benefits of space exploration)*

Attitude Outcomes

Interest in Science

Students will be encouraged to:

Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., express interest in and describe media programs on space science and technology; take an interest in directly observing and interpreting space environments and in personal and group excursions to a space science centre)*

Mutual Respect

Students will be encouraged to:

Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., show an interest in the contributions that women and men from many cultural backgrounds have made to the development of modern science and technology)*

Scientific Inquiry

Students will be encouraged to:

Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., seek accurate data that is based on appropriate methods of investigation; consider observations and ideas from a number of sources before drawing conclusions)*

Collaboration

Students will be encouraged to:

Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*

Stewardship

Students will be encouraged to:

Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment *(e.g., consider immediate and long-term consequences of personal and group actions; objectively identify potential conflicts between responding to human wants and needs and protecting the environment)*

Safety

Students will be encouraged to:

Show concern for safety in planning, carrying out and reviewing activities *(e.g., select safe methods and tools for collecting evidence and solving problems; readily alter a procedure to ensure the safety of members of the group)*

APPENDIX C

SEP, CCC, ALBERTA EDUCATION OUTCOMES

Lesson 1: Historical Astronomy

Performance Expectation	Students will research and communicate information about the traditional use of the night sky.
Alberta Science 9 Outcomes	Students will identify different ideas about the nature of Earth and space, based on culture and science.
Science and Engineering Practices	• Planning and carrying out investigations • Obtaining, evaluating and communicating information
Crosscutting Concepts	• Patterns
Connections to Nature of Science	• Science is a way of knowing • Science is a human endeavor • Science addresses questions about the natural and material world

Lesson 2: Ininew Mythologies

Performance Expectation	Students will research and communicate information about the traditional Ininew (Cree) use of the night sky.	Students will create their own constellation and mythology, relating it to their own life/culture.
Alberta Science 9 Outcomes	Students will identify different ideas about the nature of Earth and space, based on culture and science.	
Science and Engineering Practices	• Planning and carrying out investigations • Obtaining, evaluating and communicating information	
Crosscutting Concepts	• Patterns	
Connections to Nature of Science	• Science is a way of knowing • Science is a human endeavor • Science addresses questions about the natural and material world	

Lesson 3: Challenges of Extreme Environments

Performance Expectation	Students will research the extreme arctic environments of Northern Alberta/Canada and the extreme environments of space.	Students will compare environments (Arctic and space), looking for similarities and differences. Students will identify challenges of meeting basic needs in both environments.
Alberta Science 9 Outcomes	Students will analyze space environments and identify challenges that must be met in developing life-supporting systems. Students will recognize risks and dangers associated with space exploration. Students will research information relevant to a given problem.	Students will identify practical problems. Students will organize data, using a format that is appropriate to the task or experiment.
Science and Engineering Practices	• Planning and carrying out investigations • Analyzing and interpreting data • Obtaining, evaluating and communicating information • Engaging in argument from evidence	
Crosscutting Concepts	• Patterns • Systems and System Models • Energy and Matter	
Connections to Nature of Science	• Scientific investigations use a variety of methods • Scientific knowledge assumes an order and consistency in natural systems • Science addresses questions about the natural and material world	

Lesson 4: Engineering for Extreme Environments

Performance Expectation	Students will use the engineering design process to build a model technology for living on Mars.
Alberta Science 9 Outcomes	Students will analyze space environments, and identify challenges that must be met in developing life-supporting systems Students will describe technologies for life-support systems, and interpret the scientific principles on which they are based Students will identify materials and processes developed to meet needs in space, and identify related applications Students will recognize risks and dangers associated with space exploration Students will identify practical problems Students will propose alternative solutions to a given practical problem, select one, and develop a plan Students will test the design of a constructed device or system Students will identify and correct practical problems in the way a prototype or constructed device functions Students will identify new questions and problems that arise from what was learned Students will work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise
Science and Engineering Practices	• Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Constructing explanations and designing solutions
Crosscutting Concepts	• Systems and system models • Energy and matter • Structure and function • Stability and change

Connections to Nature of Science	• Scientific investigations use a variety of methods • Scientific knowledge is open to revision in light of new evidence

Lesson 5: Colonizing Space

Performance Expectation	Students will prepare and engage in a debate about human colonization of Mars.	Students will create a personal response to the question “Should humans colonize Mars?”
Alberta Science 9 Outcomes	Students will recognize risks and dangers associated with space exploration Students will identify and analyze factors that are important to decisions regarding space exploration and development Students will research information relevant to a given problem Students will select and integrate information from various print and electronic sources or from several parts of the same source Students will identify the strengths and weaknesses of different methods of collecting and displaying data Students will receive, understand and act on the ideas of others Students will work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise Students will defend a given position on an issue or problem, based on their findings	
Science and Engineering Practices	• Analyzing and interpreting data • Using mathematics and computational thinking • Constructing explanations and designing solutions • Engaging in argument from evidence • Obtaining, evaluating, and communicating information	

Crosscutting Concepts	• Patterns • Cause and effect
Connections to Nature of Science	• Science models, laws, mechanisms and theories explain natural phenomena • Science is a human endeavor • Science addresses questions about the natural and material world

APPENDIX D

LESSON #1 HISTORICAL ASTRONOMY

Historical Astronomy Lesson Plan
Unit Topic: Space Exploration
Lesson Science Content: Historical astronomy, solstice, equinox, constellations, moon phases
Length: 55 minutes
Performance Expectation: Explore historical examples of the importance of astronomy to cultures across the world.
Materials Needed: Teacher: Polynesian Wayfinders video (https://www.youtube.com/watch?v=m8bDCaPhOek)
Student Materials: science notebooks, Chromebooks (or other internet access)
Background: Humans have been curious about the night sky for thousands of years. This includes storytelling and recording histories through legends, as well as keeping track of the seasons and passage of time. This lesson is designed to introduce the Space Exploration unit and show students that the night sky is a common and important connection between people across the globe.
Alberta Program of Studies Outcomes, NGSS SEPs & CCCs: Appendix A

Engage

Opening: This lesson introduces the Space Exploration unit by showing the historical connection between humans and the night sky. Begin by showing the video "How did Polynesian wayfinders navigate the Pacific Ocean? - Alan Tamayose and Shantell De Silva" from TED-Ed on YouTube: https://www.youtube.com/watch?v=m8bDCaPhOek .

While they watch, students should record three ways the Polynesian wayfinders used the sky in their notebooks. After the video, ask the students to share their notes with the class (10 minutes). Guide a short conversation with the following questions:

- What do you think were the most important skills or techniques that Polynesian wayfinders relied on while navigating the Pacific Ocean?
- How did their connection to their environment influence the Polynesian wayfinders?
- How would we navigate across the ocean today?

Explore

Pair students up to work together. Each group should choose one cultural group (modern or ancient) and use the internet to research how the sky was/is important to them. If students cannot decide on a cultural group themselves, they can choose from the following: the Mayan civilization, Incan civilization, ancient Egyptians, or ancient Greeks. Students should record the information they learn about their chosen cultural group in their science notebooks.

After 15 minutes of researching their selected cultural group, each pair should find another group to match up with and share their information. Repeat this twice so each pair shares with at least two other groups. They should try to match up with groups that choose a different cultural group so they can hear about a variety of cultures (30 minutes).

Explain

Reiterate to the class that the night sky has had important roles in cultures across the world and throughout time. Ask students, “Were there any common patterns in what people have used the night sky for?” and “Was there anything unique about how your chosen cultural group used the night sky?” They should realize that most cultural groups have used the night sky for similar purposes throughout time (i.e., navigation, telling time with sundials, and keeping track of seasons).

Discuss the impact it has on our own culture in modern Canada. While we do not necessarily use the night sky for navigation anymore, it is still part of our lives. For example, the solstices and equinoxes mark the changing of our seasons. This is especially important in Alberta due to the prevalence of agriculture in the province. The fall equinox in September lines up roughly with harvest time, and Canadian Thanksgiving. Additionally, we are fortunate to be able to see the Northern Lights very often. This is an exciting phenomenon that we get to experience in the winter. Ask students if they have any other experience observing the night sky in their own life. Many students will probably relate to seeing the Big Dipper, the planets, the moon, and other major constellations (15 minutes).

Evaluate

As students are working on researching their cultural group, the teacher should circulate and make notes of the information students are writing in their notebooks. Ensure they are on the right track with the information they are finding. Additionally, students can submit their notebooks at the end of class for formative assessment of their findings.

Conclusion: At the end of class, students will complete an exit slip on a piece of blank paper asking them to write down one common reason people have historically used the night sky.

Extend

In the next class, we will extend this process to look specifically at the importance of the night sky to the Indigenous Peoples of Alberta.

APPENDIX E

LESSON #2 ININEW MYTHOLOGIES

Ininew (Cree) Mythology Lesson Plan
Unit Topic: Space Exploration
Lesson Science Content: solstice, equinox, constellations, moon phases, stars
Length: Two classes of 55 minutes
Performance Expectation: Explore local Indigenous Ininew traditions relating to the night sky
Materials Needed: Teacher: *Tipiskawi Kisik: Stories of the Night Sky*, by Wilfred Buck
Student Materials: science notebooks, Chromebooks (or other internet access) to access the StarScribe activity (https://pinnguaq.com/learn/canadian-space-agency-game/), and to complete the "Create a Constellation" activity
Background: Humans have been curious about the night sky for thousands of years. This includes storytelling and recording histories through legends, as well as keeping track of the seasons and passage of time. This lesson is designed to dive into local Indigenous traditions, focusing on the Ininew people of western Canada.
Alberta Program of Studies Outcomes, NGSS SEPs & CCCs: Appendix A

Engage

Opening: This lesson dives deeper into the cultural importance of astronomy historically within the context of local Indigenous culture. Begin by choosing a story to read from the book *Tipiskawi Nisik: Stories of the Night Sky* by Wilfred Buck. This book contains many stories about traditional Ininew (Cree) constellations and mythologies, so the teacher can choose one that will connect best with their class. In their science notebooks, students can respond to the question, Why was this constellation important to the Ininew people? A discussion can be help afterwards where students are encouraged to share their thoughts of the story (20 minutes).

Explore

Students will access the StarScribe game through the website: https://pinnguaq.com/learn/canadian-space-agency-game/. This is best accessed through a Chromebook or laptop as a cell phone screen will be more difficult to navigate with. This game leads students through nine Ininew constellations, providing information about the Cree name and the story connected to it. In their science notebooks, students should create a chart to record the Cree name, story and a diagram of each of the nine constellations.

As students work through the online activity, the teacher should circulate to ensure students are finding the correct information and recording it in their science notebooks (30 minutes).

Explain

As a class, nine students can volunteer to share the information they collected about each constellation. Allow the class to compare their information and add or change as necessary so their notes are accurate. As a class, connect the Ininew constellation stories to the video about the Polynesian wayfinders, and other cultural groups, from the previous lesson. Ask students, What are the similarities between how the Polynesian people (or other cultural group) and the Ininew people used the stars? What are the differences between how they used the stars? (5 minutes)

Evaluate

In the next class, students will be assessed on the “Create a Constellation” activity using the included rubric (Appendix D). The focus of this assessment is on students applying what they have learned in the previous classes to demonstrate their understanding of the historical and cultural significance of constellations to Indigenous cultures.

Extend

The next class will be spent working on the “Create a Constellation” assignment (Appendix D). Using the information they have now collected and observed about several different cultural groups, students will create a constellation of their own that connects to their own life or culture. They will need to write a short story or mythology explaining the significance of the constellation, in a manner like the case studies they have spent the previous classes examining (55 minutes).

APPENDIX F

CREATE A CONSTELLATION ASSIGNMENT & RUBRIC

The following slides are provided to students in a Google Slide presentation to directly access and edit. They can be assigned to students through Google Classroom or another digital learning platform.

Slide 1: Introduction

Introduction: What are constellations?

People have created constellations for thousands of years by grouping visible stars into patterns that resemble familiar shapes, animals, mythological figures, or objects. This process often reflects cultural stories, mythology, and beliefs, giving each constellation unique meaning within its cultural context. Ancient civilizations, such as the Greeks, Egyptians, and Chinese, created their own sets of constellations, often using them for navigation, marking seasonal changes, and telling stories that were passed down through generations.

The significance of constellations lies in their practical and symbolic roles. They served as early calendars, helping societies determine the timing of agricultural activities, rituals, and festivals. Constellations also provided a way to navigate by identifying stars and patterns that guide direction at night. Symbolically, constellations connect human beings with the cosmos, reflecting humanity's curiosity about the universe and its desire to understand the world beyond Earth. Today, constellations continue to inspire, serving as both a cultural legacy and a way to spark interest in astronomy.

Slide 2: Assignment Information

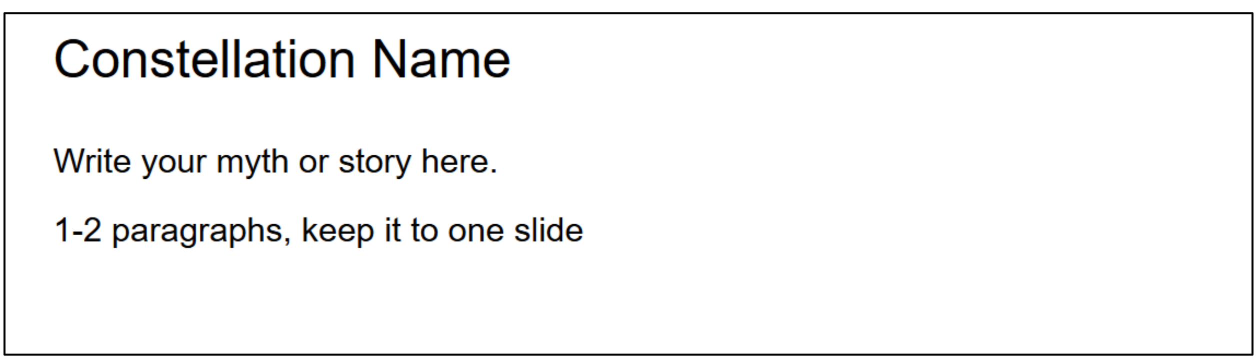
Your Task!

Imagine you could create your own constellation in the night sky! Think of something meaningful to you – it could be a story, an animal, an object, a person, or a symbol that reflects your personality or interests. Using the stars on the next slide, add lines to connect the stars to form your chosen shape.

Give your constellation a unique name, and write a short story or myth explaining its origin and significance (1-2 paragraphs). How would people interpret this constellation if they saw it in the sky? Consider how it might help them navigate, or what time of year it would appear. Let your creativity shine as you craft a new story in the stars!

Slide 3: Night sky template to design a constellation.

Slide 4: Students name their constellation and write their mythology or story.



Create a Constellation Rubric

Standard	Mastery is demonstrated by:
Students will create a well-organized constellation that features distinct stars and visible connections, forming an easily recognizable shape.	○ The constellation design is clear and coherent, with distinguishable points and logical connections between them. ○ The shape of the constellation is easy to identify and imaginative. ○ The student demonstrates a thoughtful approach to spacing, placement, and the aesthetic appeal of the constellation.
Students will develop a thoughtful story that gives meaning to their constellation, with a clear connection between the constellation's shape and its narrative.	○ The constellation's story is creative, imaginative, and well-developed. ○ The story ties back to the shape and design of the constellation in a meaningful way (e.g., a mythological or historical narrative that explains the arrangement of stars). ○ The student demonstrates originality in the creation of their constellation's narrative, showing personal or cultural relevance.
Students will explain how their constellation can guide or inspire people, demonstrating an understanding of its historical, cultural, or symbolic significance.	○ The student provides a clear explanation of how the constellation could be used for navigation, inspiration, or guidance in the context of human history or culture. ○ The student integrates an understanding of how constellations have historically guided societies (e.g., used for navigation, storytelling, or cultural practices). ○ The explanation connects the design of the constellation with its potential cultural or historical significance, reflecting a deep understanding of the topic.
Students will present their constellation and its story in a clear, organized, and engaging way.	○ The student's presentation is clear, organized, and engaging, making it easy for the audience to understand both the constellation's design and its story. ○ The student uses appropriate visuals (e.g., diagrams, drawings) to enhance their explanation and make the constellation's connections and shape easily recognizable. ○ The student communicates the historical and cultural relevance of their constellation in a way that is accessible to others.

Level 5 100%: All standards met and exceeded.

Level 4 95%: All standards met.

Level 3 85%: Two or three elements are missing or incomplete.

Level 2 75%: Four or five elements are missing or incomplete.

Level 1 65%: Five or more elements are missing or incomplete.

APPENDIX G

LESSON #3 CHALLENGES OF EXTREME ENVIRONMENTS

Challenges of Extreme Environments Lesson Plan
Unit Topic: Space Exploration Lesson Science Content: basic human needs, environment, solar system, Arctic environment, climate/weather Length: Three classes of 55 minutes Performance Expectation: Investigate the challenges of living in extreme environments, including the Canadian Arctic and space. Materials Needed: Teacher: images of the Arctic and Mars Student Materials: science notebooks, Chromebooks (or other internet access) Background: NASA is currently working on the Artemis program, which has the eventual goal of building a base on the moon. This is the first step in humans getting to Mars. Using the Canadian Arctic as an analogy, students will investigate the requirements to survive in extreme environments. Alberta Program of Studies Outcomes, NGSS SEPs & CCCs: Appendix A

Engage

Opening: On the whiteboard, create a chart with two columns labelled "Arctic" and "Mars". Show an image of the Canadian Arctic in the winter on the screen. Ask students to turn to their neighbour and describe the environment they see to them. After two minutes, allow volunteers to share their descriptions. Descriptions may include "cold", "snow", "remote", "isolated", "no food", etc. As students share their descriptions, add them to the chart on the whiteboard under "Arctic".

Show an image of the surface of Mars and repeat the activity. Responses should be similar to the descriptions of the Arctic. Record the students' responses on the whiteboard under "Mars".

Students should draw a Venn diagram in their notebooks. Label one side "Arctic" and one side "Mars". Students should work with their neighbour to complete the Venn diagram using the information on the whiteboard. Information that is shared goes in the middle of the Venn diagram, while information that is unique to each goes on the appropriate side (15 minutes).

Explore

Group students into five groups, which will be their "home groups". Assign each group one of the following topics to research and collect information in their notebooks. Provide approximately 15 minutes for students to complete this activity. Remind students that they will be sharing this information with classmates in small groups, so it is important that they find accurate information.

- Group 1: How do Indigenous or Inuit people traditionally access food in the Arctic?
- Group 2: How do Indigenous or Inuit people traditionally provide shelter in the Arctic?
- Group 3: How do Indigenous or Inuit people traditionally provide clothing in the Arctic?
- Group 4: How do Indigenous or Inuit people traditionally provide community and connection to each other in the Arctic?
- Group 5: What are the health concerns from living in an environment like the Arctic?

Remind students to use authentic, reliable resources like government and university websites. Some resources can include:

- Inuit Tapiriit Kanatami (https://www.itk.ca/)
- https://www.thecanadianencyclopedia.ca/en/article/country-food-inuit-food-in-canada
- Nunavut Department of Health (https://livehealthy.gov.nu.ca/)

- Government of Nunavut Nutrition Food Fact Sheet (https://livehealthy.gov.nu.ca/sites/default/files/resource_attachments/EN_WEB_itf--nutrition-fact-sheet-series.pdf)
- The Inuit Way (https://www.relations-inuit.chaire.ulaval.ca/sites/relations-inuit.chaire.ulaval.ca/files/InuitWay_e.pdf)

(20 minutes)

Explain

Students will complete a “jigsaw” activity to teach their classmates about their research question. Split each original home group up into new groups with one student from each home group. Each group will consist of one student each from group 1, group 2, group 3, group 4 and group 5. Each student is now the “expert” for their original question, and should take five to ten minutes to teach their group members what they learned. Students should add relevant information about each of the questions in their science notebook (20 minutes).

Extend

In the next class, students will begin back with their home groups. They will be assigned three new questions to examine, based on their question from last class. Students should record their thoughts and information in their notebooks on the next page after the last class’s jigsaw activity. Students may use knowledge they already have about Mars, but they should confirm the accuracy of it using the internet to prevent misinformation or misconceptions from spreading through the class.

- How does this challenge (from yesterday’s question) exist on Mars?
- What Inuit strategies could be adapted for surviving on Mars?
- What new technologies would be needed to survive on Mars?

One class of 55 minutes will be given to collect this information and put it into a short presentation of no more than five minutes, using Google Slides or a similar platform. Groups should be encouraged to include images in their presentation and should be reminded that it is required to include sources for any information or images included. At the beginning of the next class, they will present their findings to their classmates.

Evaluate

Students will complete a formative minute-paper after presentations are completed, answering the question "How can Indigenous knowledge help us adapt to future challenges – on Earth and beyond?". They are given one minute to respond to the question on a piece of paper, which is collected to be assessed by the teacher.

Students can also be evaluated on their communication skills from their presentation.

APPENDIX H

LESSON #4 ENGINEERING FOR EXTREME ENVIRONMENTS

Engineering for Extreme Environments Lesson Plan
Unit Topic: Space Exploration
Lesson Science Content: planets, technology, engineering design process
Length: Two or three classes of 55 minutes
Performance Expectation: Use the engineering design process to build a model technology for living on Mars.
Materials Needed: Teacher: YouTube Video "Why the Moon", NASA (https://www.youtube.com/watch?v=bmC-FwibsZg), Student Materials: science notebooks, Chromebooks (or other internet access), materials for building models (dependent on student needs)
Background: NASA is currently working on the Artemis program, which has the eventual goal of building a base on the moon. This is the first step in humans getting to Mars. Students will use their knowledge of extreme environments and the engineer design process to build a model technology to use in colonizing Mars.
Alberta Program of Studies Outcomes, NGSS SEPs & CCCs: Appendix A

Engage

Opening: Begin by showing the video "Why the Moon?" by NASA on Youtube: https://www.youtube.com/watch?v=bmC-FwibsZg

While they watch, students should answer the question "Why does NASA want to go to the moon?" in their notebooks. Guide a short conversation summarizing the videos with the following questions:

- Why does NASA want to go to the moon? (Student answers could include building a base to launch to Mars, investigating frozen water, learning how to survive on another planet, testing technology that will take us to Mars.)
- What are some things that might make it difficult to get to the moon (or Mars)? (Student answers could include the danger of space flight, lack of water/air/food/resources, distance and the time it takes to travel, etc.)
- What will the benefit be to humans if we build a base on the moon? (Student answers could include mining/other natural resources, developing new technologies, stepping stone to Mars or other locations)

Give students five minutes to sketch what they think a moon or Mars base would look like in their notebooks. Ask them to label the different components of their base (i.e. living quarters, research station, solar panels, batteries, vehicles). (15 minutes)

Explore

Divide students into groups of three or four. Assign each group one of the following requirements to live on Mars: shelter, food systems or clothing. Each group will work through the engineering process to create a model technology to address their topic. Students should be encouraged to use the information they have learned about how Indigenous people traditionally have lived in extreme environments to help them with their design.

Groups should take some time to brainstorm and examine real-world technologies that are being used for future travel to Mars. Some sources of information could be NASA, Canadian Space Agency, SpaceX, etc. After approximately 20 minutes, groups should have an initial rough sketch of their idea.

Explain

Go through the engineering process with the class.

Groups should refine their initial sketches and can collaborate with other groups to compare models. At the end of this class, each group should have a list of materials that they require. It may be necessary to put restrictions on the materials that will be provided (i.e. materials that are found at the grocery store or dollar store). Ensure the materials are obtained for the next class.

Groups will also need to decide how they will test their model to ensure that it is working effectively. Each group may decide to test their model differently. Some ideas for testing could include testing the insulation of a spacesuit by recording how well it keeps water warm, testing the water cycling of a hydroponics model, or testing the strength of a material used for a shelter. They will record the results of their testing in their science notebooks.

Extend

Groups can be given one or two classes to build their model. The teacher should rotate through the classroom to observe how groups are working, encouraging all students to be active participants. Once their model is built, each group must carry out their testing, and each group member must document their testing process in their science notebooks. They should also include a short paragraph explaining how they would improve their model in the future and what they learned from the process of building the model.

Evaluate

Formative evaluation can be done on students' records in their science notebook, as well as the model their group built. An option for summative assessment is groups can create a formal presentation to share their model, testing and results with the class.

APPENDIX I

MARS ENGINEERING RUBRIC

Mars Engineering Rubric

Standard	Mastery is demonstrated by:
Students will research and plan in response to a problem	○ Identifies key environmental challenges of living on Mars ○ Identifies the problem their model will solve ○ Incorporates accurate scientific and engineering information
Students will use the engineering design process	○ Clearly identifies the problem the model is solving ○ Brainstorms and records multiple design ideas ○ Develops and revises a plan ○ Tests components or design features ○ Reflects on testing and improves design
Students will build a model technology	○ Model is complete ○ Materials are used effectively and safely ○ Model demonstrates a clear attempt at solving the identified problem
Students will apply creative and innovative thinking	○ Model is original or adapted in a unique way ○ Integrates unexpected materials or design features ○ Shows initiative and novel thinking in approaching the challenge
Students will collaborate and work as a team	○ All team members are actively involved in the design and building process ○ Team members communicate effectively ○ Evidence of planning/assigning roles within the group
Students will document and reflect on the engineering design process	○ Includes clear records of design steps (notes, sketches, test results) ○ Reflects on challenges faced through the engineering process ○ Identifies what worked and what can be improved ○ Shows growth or learning from the design process

Level 5 100%: All standards met and exceeded.

Level 4 95%: All standards met.

Level 3 85%: Two, three or four elements are missing or incomplete.

Level 2 75%: Five or six elements are missing or incomplete.

Level 1 65%: Six or more elements are missing or incomplete.

APPENDIX J

LESSON #5 COLONIZING SPACE

Colonizing Space Lesson Plan
Unit Topic: Space Exploration Lesson Science Content: technology for exploring space, colonizing space Length: three classes of 55 minutes Performance Expectation: Students will analyze the challenges of living in space, construct arguments for and against it, and communicate their arguments to their classmates. Materials Needed: Teacher: whiteboard, stopwatch or timing device Student Materials: Science notebooks, Chromebooks (or other internet access) Background: This culminating activity brings together the entire Space Exploration unit. Students will apply what they have learned through the unit to construct and communicate an argument in favor or against colonizing Mars. Alberta Program of Studies Outcomes, NGSS SEPs & CCCs: Appendix A

Engage

Opening: Students should now have a good understanding of some of the requirements and challenges of colonizing Mars. Begin the class by posing the question “If you had the opportunity to live on Mars, would you do it? Why or why not?”. Give students three minutes to record their answer to the question in their science notebooks. Ask volunteers to share their reasons for either answer. As students share their information, create lists on the whiteboard of reasons why they would or would not live on Mars. This will serve as a brainstorm to help later in the lesson. (10 minutes)

Explore

Split students into two groups and assign them either in favour or against colonizing Mars. It will be their responsibility to research and prepare an argument with that point of view, regardless if they personally agree with it. Within the groups, students should split up to research their arguments from an economic, political, environmental and ethical perspective. They will need to include each perspective in their argument. Students should be given one class to complete their research and prepare their arguments. This timeline can be adjusted based on the needs of the class. (45 minutes)

Explain

In the next class, conduct the debate. The teacher will act as moderator, guiding the students through the debate and ensuring that the arguments remain respectful. A suggested format for the debate is:

Opening Statements: each group presents their main arguments (2 minutes each)

Rebuttals: groups respond and challenge the opposing side's arguments (2 minutes each)

Open Debate: Guided discussion where each group can take turns asking questions and responding (20 minutes)

Closing Statements: each group summarizes their main points (2 minutes each)

Short breaks can be used between each section to allow groups to form their arguments. Each group member must speak at least once, and interruptions are not permitted. Groups must wait until their designed time to speak. The timing of each section can be adjusted based on the length of the class period.

Extend

Students will use the experience with the debate to create their own personal opinion about whether humans should colonize Mars. They will create a response to the question "Should humans colonize Mars? Why or why not?" They can choose a method to create their response, for example through a short essay, video recording or poster. They will need to use the factual information they have learned throughout the space exploration unit and the debate activity to support and justify their response.

Evaluate

This debate activity can be used as a summative assessment for the entire space exploration unit. Students should be using the content covered through the unit to create their arguments for the debate, and their personal response afterwards.

Assess students based on their ability to create their arguments, as well as communicate them during the debate. The teacher can decide if they wish to use the debate and/or the personal response as their summative assessment. The personal response portion can be used to assess the students' knowledge and understanding, whereas the debate portion can be used to assess the students' ability to communicate information effectively and work as team (Appendix L).

APPENDIX K

DEBATE PLANNING SHEET

Colonizing Mars Debate Planning Sheet

My group's topic: ____

Political Perspective
Economic Perspective
Environmental Perspective
Ethical Perspective
Other Information

APPENDIX L

DEBATE AND PERSONAL RESPONSE RUBRICS

Colonizing Mars Debate Rubric

Standard	Mastery is demonstrated by:
Students will develop arguments in support of a given point of view	○ Clear, well-developed arguments that are easy to follow ○ Arguments are relevant to the topic ○ Demonstrates a deep understanding of the issue ○ Arguments demonstrate economic, political, environmental and ethical perspectives
Students will use evidence in support of their arguments	○ Each argument is supported with factual evidence ○ Sources of evidence are current, relevant and credible ○ Uses more than one type of evidence (data, quotes, examples)
Students will communicate their ideas effectively and appropriately	○ Speaks clearly and confidently ○ Maintains eye contact with audience ○ Treats all debate participants with respect
Students will work with their teammates effectively and appropriately	○ Shares speaking time fairly between group members ○ Preparation is completed as a cohesive group with everyone contributing ○ Supports and encourages teammates throughout the debate process

Level 5 100%: All standards met and exceeded.

Level 4 95%: All standards met.

Level 3 85%: Two or three elements are missing or incomplete.

Level 2 75%: Four or five elements are missing or incomplete.

Level 1 65%: Five or more elements are missing or incomplete.

Colonizing Mars Personal Response Rubric

Standard	Mastery is demonstrated by:
Students will develop a personal response to the question "Should humans colonize Mars? Why or why not?"	○ States a clear opinion on the question ○ Position is consistent and clear throughout the response ○ Arguments demonstrate economic, political, environmental and ethical perspectives
Students will use evidence to support their position.	○ Includes specific facts or evidence to support the argument ○ Evidence is accurate and reliable ○ Connects evidence to key arguments, avoiding listing facts without explanation
Students will demonstrate personal reflection on the topic.	○ Shows personal connection to the topic ○ Includes thoughtful reflection on ethical implications ○ Demonstrates deep understanding of the topic
Students will present their argument in a clear, organized, and engaging way.	○ Choose an appropriate medium for communicating their response ○ Has a clear structure and flow ○ Writing contains no spelling or grammatical errors

Level 5 100%: All standards met and exceeded.

Level 4 95%: All standards met.

Level 3 85%: Two or three elements are missing or incomplete.

Level 2 75%: Four or five elements are missing or incomplete.

Level 1 65%: Five or more elements are missing or incomplete.