Ethical Colonization?

In this lesson, students will analyze an informational text intended to support reading in the content area. The article discusses ethical issues that may arise when humans eventually travel to and colonize other planets, especially Mars. The article anticipates many of the concerns that will need to be addressed as space colonization becomes more of a reality. This lesson includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric.

**Prior Knowledge:** What prior knowledge should students have for this lesson?
For science, students should have:

**LESSON CONTENT**

**Learning Objectives:** What should students know and be able to do as a result of this lesson?
- Identify the ethical questions that exist concerning future travel to, and colonization of, other planets.
- Explain why the introduction of foreign microbes could be catastrophic to other planets.
- Cite specific and relevant text to support analysis of the text.
- Use various vocabulary strategies to define academic and domain-specific words in a text.
- Construct a written response that clearly establishes a main point(s), contains relevant textual evidence to support the main point, utilizes transitions to maintain flow, effectively uses domain-specific vocabulary, and provides an appropriate conclusion.

**Subject(s):** Science, English Language Arts

**Grade Level(s):** 9, 10

**Intended Audience:** Educators

**Instructional Time:** 3 Hour(s)

**Resource supports reading in content area:** Yes

**Keywords:** Mars, Mars exploration, colonization, ethics, space, space travel, lesson plan, text complexity, microbes, perchlorate

**Instructional Component Type(s):** Lesson Plan, Worksheet, Assessment, Video/Audio/Animation, Text

**Resource Collection:** FCR-STEMLearn Literacy in STEM 2017

**ATTACHMENTS**
- Article_MarsMicrobes.pdf
- Article_HumansColonization.pdf
- Note-takingGuide_Humans.docx
- Text-Dependent_Questions_Humans.docx
- Writing_Rubric_Humans.docx
- Pyramid.pdf
- Pyramid_Answers.pdf
- Final_Recommendation_Placement_EthicalColonization.pdf
- Qualitative_Rubric_EthicalColonization.pdf
A general understanding of who “owns” space

- In order for students to fully understand the ethical issues that may arise, they need to understand that there is not one specific governing body in space. A great introduction to this point is the 4-minute video Who Owns Space? (uploaded by YouTube user SciShow Space)

A general understanding of the implications of introducing Earth-born organisms to Mars or other planets.
- Students may need a review of limiting factors and invasive species in order to understand the potential devastating impacts of introducing a new species to an environment that is not equipped to limit or prevent its growth. This TED-Ed video titled “The Threat of Invasive Species - Jennifer Klos” (4:45) explains these concepts and helps students to relate them to topics they may already know.

- A general familiarity with the history of Mars exploration.
  - Teachers may wish to discuss some of the past missions and explorations conducted regarding the planet Mars. This timeline from NASA provides a synopsis of this information.
  - General information about the planets in our solar system.
  - Teachers may wish to discuss some of the characteristics of the various planets. The following NASA site provides information to be used as needed.
  - General information about the domain Archaea.
  - Teachers may wish to discuss some of the characteristics of the domain Archaea. These microbial organisms are referred to as extremophiles because of the conditions they live in, leading scientists to believe they might be able to survive on the planet Mars.

For literacy:
- Students should have prior experience utilizing various vocabulary strategies to determine the meaning of unknown words in a text. For this lesson, prior experience in using context clues to determine the meaning of words in a text would be beneficial. In addition, students should have some dictionary skills that will enable them to look up words with multiple meanings and determine the most appropriate meaning based on how a word is used in a text.

- Students should be aware of text features that can help them locate and learn information when reading a text. The text features in “When Humans Begin Colonizing Other Planets, Who Should Be in Charge?” include the title, images, and captions.

- Based on the provided writing rubric, students should be able to respond to a writing prompt in a clear, organized manner that includes the use of transition words or phrases can help a piece of writing flow smoothly from one point or idea to the next. This site provides transitions teachers might provide.

Guiding Questions: What are the guiding questions for this lesson?

1. What ethical questions may arise due to interplanetary travel?
   - Many ethical questions may arise when humans begin to travel beyond our planet. One issue is the potential introduction of Earth-born life to another planet and how we would handle it if it were to happen. Another issue is the lack of a governing body regarding our solar system. Who dictates laws, policies, procedures and their enforcement? How would humans produce the energy needed for support on another planet? Would humans consume all of the natural resources of the host planet? Would rules from one planet extend to another despite compositional and atmospheric differences? These are all questions and concerns being raised as the possibility of space colonization becomes more real in the next several decades.

2. Is it likely that foreign microbes can be introduced to other planets?
   - If planets have harsh climates and high surface UV radiation like Mars, it is likely that many microbes would not survive. However, if microbes are suited to these conditions, they may be able to thrive and reproduce.

3. What are the implications of introducing foreign microbes to other planets?
   - Without natural limiting factors in place, foreign microbes that are able to successfully live on those planets may grow exponentially. This growth could interfere with existing life (if there is any) and consume natural resources on the planets.

4. How can lessons from past space travel influence future space travel?
   - Due to our limited knowledge of the conditions that exist on other planets, we may run into serious problems regarding visitation and colonization of said planets. Referencing moon missions from the past, scientists have expressed their concern when discussing future space travel.

Teaching Phase: How will the teacher present the concept or skill to students?

1. Begin the lesson by showing the brief video about NASA's journey to Mars (2:21, uploaded by YouTube user NASA's Marshall Center).
2. Next, ask students: “As space colonization becomes more of a possibility, what issues may arise when we travel to other planets to colonize them?”
   - Students may bring up points regarding expense of the programs, sources of fuel and energy, the mental and physical health of the space colonists, and who would be involved in the colonization.
3. Next, ask: “What type of ethical issues may arise when we travel to other planets to colonize them?”
   - Students may point out ownership issues regarding planets and asteroids. They may also discuss depriving people of their families when leaving. Also, they may speculate on the mental issues that may arise when humans are away from Earth from extended periods of time.

4. Next, ask: “Do you think by colonizing other planets, we might cause harm to them?”
   - Students may respond that other planets do not have the requisite conditions to support life, so we wouldn't be able to “hurt” anything. Inform them although we have not found life forms, it does not mean there is not life out there.
5. Ask students: “Who will be deciding and making decisions on a planet if it was colonized?”
   - Students may reply that whichever country gets to the planet first should be able to make the laws and enforce them. Other replies may be to institute a council representing global interests to protect the planet.

6. Inform students these are some of the major questions that need to be answered as we continue to explore the possibility of space colonization. Let students know there are no easy answers to these questions because no one knows exactly how we should behave as interplanetary colonists.

7. Tell students that they will be reading two articles from Smithsonian.com and NASA that discuss some of the concerns about space colonization and what problems colonists may encounter if it were to become a reality.

Guided Practice: What activities or exercises will the students complete with teacher guidance?

1. Provide each student with a printed copy of the article “When Humans Begin Colonizing Other Planets, Who Should Be in Charge?”
   - For class discussions that will follow, it may be beneficial to have students number the paragraphs.
2. Provide each student with a pyramid note-taking guide and a vocabulary note-taking guide.
3. Before students begin reading, direct them to pay attention to the text features of the article to help them learn and locate information:
   - Title: “When Humans Begin Colonizing Other Planets, Who Should Be in Charge?”
   - Subtitle: The biggest threat humans pose to other worlds is what we don’t know—or what we think we know, but don’t.

4. Have students fill out the note-taking guides as they read the text. This can be done individually, in pairs, or in small groups. The teacher should monitor students as they work and provide support and guidance as needed.
   - For academic vocabulary, students will likely be able to use a variety of strategies to define the meaning of the words. For domain-specific (in other words, subject-specific) vocabulary, students will typically need to draw on prior knowledge and use a dictionary to define those words.

How will you check for student understanding? (Formative Assessment):

- Teachers can check for understanding by collecting the completed note-taking guides, checking them, and providing feedback as appropriate.
- Teachers may use this sample answer key for the pyramid and this sample answer key for the vocabulary (just scroll down) to help assess student responses.
- For discussion of students’ answers to the defined vocabulary words, teachers are encouraged to not only ask students to explain the meaning they determined for a word, but the strategy they used to arrive at that meaning. This will allow the teacher to provide alternative suggestions as to how the student could have arrived at the correct meaning of the word.
- Because the article brings up many different ethical concerns about space colonization, have students text mark areas they consider an ethical dilemma with an “E” and mark areas they consider solutions to these concerns with an “S.” Teachers may choose more areas to text-mark if they want to.

Common errors/misconceptions to anticipate and how to respond:

- Students often believe that the United States “owns” the rights to celestial bodies in space. Students should be instructed on the global collaboration that has existed and still exists regarding space exploration.
- Students may believe that organisms from Earth will not be able to survive on other planets due to harsh environments. Students should be shown examples of extremophiles like halophiles and thermophiles.

**I Independent Practice: What activities or exercises will students complete to reinforce the concepts and skills developed in the lesson?**

Provide each student with a copy of the text-dependent questions to complete. Students should be reminded to continually refer back to the text and to use relevant and specific evidence from the text to support their answers.

**How will you check for student understanding? (Formative Assessment):**

1. Teachers can check students’ understanding by collecting their answers to the text-dependent questions, checking their work, providing written feedback, and maybe grading the assignment. Or, teachers can have students share out their responses and the teacher can provide verbal corrective feedback, allowing students to make corrections to their work during the discussion.
2. Teachers should use the sample answer key provided at the end of the document to help them assess students’ answers.

**Common errors/misconceptions to anticipate and how to respond:** Please see the text-dependent questions sample answer key.

**Closure: How will the teacher assist students in organizing the knowledge gained in the lesson?**

For literacy:

1. Before students complete the writing prompt, be sure to review their responses to the other text-dependent questions as a class, including covering the misconceptions and key points described in the sample answer key.
   - If you feel your students need more information on why the colonization of Mars will be a huge human endeavor and achievement, watch this 7-minute video from The Verge titled “SpaceX’s Plan to Colonize Mars, Explained” that breaks down Elon Musk’s ambitious plan.
   - While the video is not specifically focused on the ethics of interplanetary travel, it does highlight some of the issues humans will face as we travel through our solar system.

2. Before assigning the students the final writing prompt, have them read aloud, as a class, “Nineteen Miles Up, Experiment Reveals Earth Microbes’ Likely Fate on Mars.” The information in this article will be integrated into their response to the writing prompt.
   - If you feel your students need more information on why the colonization of Mars will be a huge human endeavor and achievement, watch this 7-minute video from The Verge titled “SpaceX’s Plan to Colonize Mars, Explained” that breaks down Elon Musk’s ambitious plan.
   - While the video is not specifically focused on the ethics of interplanetary travel, it does highlight some of the issues humans will face as we travel through our solar system.

3. After students’ written responses have been graded and returned with feedback, teachers might wish to use the provided sample response with the class. The teacher could show the sample response on an overhead or with an LCD projector and discuss:
   - How the topic is introduced in the opening sentences of the introductory paragraph; have students identify the main point of the piece. Brainstorm with students other ways the writer could have opened the piece.
   - Have students examine each of the body paragraphs and explain how each supports the main point of the piece.
   - Have students identify where the writer effectively uses textual evidence from the article for support of his or her points.
   - Have students identify the use of transition words or phrases that make the ideas flow.
   - Ask students to identify where domain-specific vocabulary is used accurately and effectively.
   - Have students read the final paragraph to see how the writer wrapped up the piece and connected back to the main point established in the introduction.

4. Teachers may have students use the rubric to provide a score for the sample written response and have them justify the score they gave, possibly providing revision suggestions for any categories they scored lower than a 4.

For science:

1. Whole group: ask students what ethical concerns they believe are the most prominent regarding human colonization of other worlds. Write responses on board.
2. Put students (or allow them to arrange themselves) into small groups and have them rank the choices from the whole group discussion (that are on the board) and provide justification to the class as to why they ranked them that way.

**Summative Assessment**

1. Students will individually respond to the writing prompt. They should be directed to respond with a multi-paragraph response with a clear introduction, body section, and conclusion. They must refer back to both texts as they construct their response.
2. Provide students with a copy of the rubric and go over it with them so they will know how their written response will be assessed.
3. Go over the writing prompt with students and make sure students understand what the prompt is asking them to address. Encourage students to underline key parts of the prompt as the teacher goes over it so they will remember to answer all the required parts.
You have been elected to serve on COSPAR (The Committee on Space Research) in the year 2050 as humans are about to embark on the first journey to colonize Mars. You must prepare a protocol regarding the protection of Mars from invasive human impact including the following:

- The need for the mission to be sanitary
- The implications of inadvertently bringing microbes from Earth to Mars
- What colonists should do in the event of contamination
- Using evidence from the texts “When Humans Begin Colonizing Other Planets, Who Should Be in Charge?” and “Nineteen Miles Up, Experiment Reveals Earth Microbes’ Likely Fate on Mars,” craft the protocol you will submit to COSPAR.

4. Teachers will use the rubric to assess students’ written responses.

Formative Assessment
Specific suggestions for conducting Formative Assessment can be found in the Guided Practice and Independent Practice phases of the lesson where it says, “How will you check for student understanding?”

Feedback to Students
Specific suggestions for conducting Feedback to Students can be found in the Guided Practice and Independent Practice phases of the lesson where it says, “How will you check for student understanding?”

ACCOMMODATIONS & RECOMMENDATIONS

Accommodations:
For students struggling with the science content:
- The video “Who Owns Space? A Primer on Space Law!” is an informative video that explains the history of space law as it began during the Space Race (U.S. and Soviets) through the present.
- Have students read about NASA’s analog missions so they have context about how we are trying to prepare for life in space using extreme habitats on Earth.
For students struggling with the note-taking guide:
- Emphasize that there are no “incorrect answers”; however, students are expected to fill in each line in the vocabulary pyramid. Giving a student a word from the answer key may be appropriate modeling.
For students struggling to read the text:
- It might benefit students to chunk the text. Have students independently read section one, then have several strong readers read section one aloud.
- Then, have students highlight selected vocabulary for section one on the article. Work with students to model ways to define a few of the academic vocabulary words to get them started. The teacher can think aloud as he or she decides which vocabulary strategy or strategies to use to define a word, and think aloud while deciding which meaning from a dictionary entry with multiple meanings would be the best fit for how the word is used in the context of the article.
- When students are ready, have them share their answers and provide corrective verbal feedback as needed, allowing students to make corrections to their work. Then repeat this process for the other sections of the text if needed. Or, at least have students complete the graphic organizer for the next section and receive feedback on their work before they move on.
For struggling writers:
- It might help struggling writers to provide them with an outline to help them structure their response. The outline might include places for them to record:
  - Introduction paragraph
    - Ideas on how to introduce the topic
    - A few specifics from the text they might want to use to support or explain the topic
    - A place to write down their main point(s)
  - Body paragraphs:
    - Topic sentences (the first sentence of each body paragraph that will reveal the point of the paragraph and will connect to the paper’s overall main point)
    - Specific evidence from the text for support in each body paragraph
    - Ideas for transition words
    - Ideas for use of selected vocabulary
  - Conclusion:
    - Ideas on how to wrap up their piece and connect back to the main point(s)

Extensions:
- In groups, have students create a set of laws and consequences applying to interplanetary travel and colonization. They must provide justifications for their choices.
  - Some criteria to have them consider:
    - Humaneness
    - Cost
    - Efficacy of enforcement
- The teacher may wish to use one of the activities from NASA’s Mars survival kit. There are several activities for grades 6-12.

Suggested Technology: Computer for Presenter, Internet Connection, LCD Projector, Overhead Projector, Microsoft Office, Computer Media Player

Further Recommendations:
For teachers who would like more support in understanding and implementing Reading Standards for Literacy in Science and Technical Subjects into their science curriculum, please see the teacher tutorials featured in the section of this lesson’s CPALMS resource page labeled “Attached Resources.”
### Related Standards

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<th>Description</th>
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<tbody>
<tr>
<td>LAFS.910.RST.1.1:</td>
<td>Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.</td>
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<tr>
<td>LAFS.910.RST.2.4:</td>
<td>Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.</td>
</tr>
<tr>
<td>LAFS.910.RST.4.10:</td>
<td>By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.</td>
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| LAFS.910.WHST.1.2:          | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.  
  a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.  
  b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.  
  c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.  
  d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.  
  e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.  
  f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic). |
| LAFS.910.WHST.3.9:          | Draw evidence from informational texts to support analysis, reflection, and research. |
| SC.912.E.5.7:               | Relate the history of and explain the justification for future space exploration and continuing technology development. |

### Remarks/Examples:

**Identify examples of historical space exploration (e.g. telescopes, high altitude balloons, lunar landers, deep-space probes, space station) that had significant impact on current space exploration and recognize the importance of continued exploration in space.**

### Attached Resources

**Tutorial**

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<tr>
<td>Infectious Evidence:</td>
<td><strong>Click “View Site” to open a full-screen version.</strong> This tutorial is designed to help secondary science teachers learn how to integrate literacy skills within their science curriculum. This tutorial focuses on using specific textual evidence to support students’ responses as they analyze science texts. The focus on literacy across content areas is designed to help students independently build knowledge in different disciplines through reading and writing.</td>
</tr>
<tr>
<td>Words in the Wild: Vocabulary Strategies:</td>
<td><strong>Click “View Site” to open a full-screen version.</strong> This tutorial is designed to help secondary science teachers learn how to integrate literacy skills into their science curriculum. This tutorial will demonstrate a number of strategies teachers can impart to students to help them use context clues to determine the meaning of unfamiliar words within science texts. It will also help them teach students how to select the appropriate definition from reference materials. The focus on literacy across content areas is intended to help foster students’ reading, writing, and thinking skills in multiple disciplines.</td>
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