A. Introduction
Habitability, a.k.a. habitat suitability, is a topic typically discussed in Biology class. We present here a curriculum unit that introduces the topic of global-scale planetary habitability in a Physics class, allowing students to emulate the process of doing cutting-edge science and re-framing an otherwise “typical” physics unit in a more engaging and interactive way.

At its core, habitability is a temperature-dependency parameter that is introduced and explored during the Energy unit. Students conduct a research project with the goal of determining the habitability state for a chosen exoplanet.

Classroom implementation was modeled after the CCRI scientist-mentor’s actual research plan. Students first discussed 4 basic habitability factors and explored these variables through climate modeling software. Students then chose an exoplanet to evaluate using these habitability factors, an activity that required them to perform authentic research on the exoplanet and its host star.

Research and Methods: The research project that inspired the unit plan described here involved the exploration of various factors that can influence an Earth-like planet’s habitability state. A planet is considered potentially habitable for life as we know it if the planet receives enough energy from its host star to maintain liquid water on its surface (0˚C < tsurf < 100˚C).

Students also developed hypotheses about factors beyond currently available mission data, such as atmospheric composition and surface albedo of their exoplanet. They then used the modeling software to collect data, test hypothesizes, and draw conclusions. Lastly, students communicated their findings in a poster session and presentation at the high school’s annual science symposium.

By bringing actual science and research practices to the classroom, the students were not only more actively engaged with the required physics course content, but also gained a better understanding of how scientific research is done.

B. CCRI Program

Program Overview: The NASA GISS Climate Change Research Initiative (CCRI) provides an opportunity for STEM educators to work directly with NASA scientists, lead research teams, and develop STEM curricula for their current classes.

Students are engaged in a project-based Energy unit that directly mimics CCRI research project and progression.

Day 1: Habitability & Exoplanet Selection

1. Students complete habitability concept web
2. Students explore Exoplanet catalog
3. Students record relevant habitability data for chosen exoplanet

Day 2: Climate Simulation

1. Students explore each habitability factor individually using the Mini-GEEBIT B3 model
2. Students create graphs of trends in temperature in response to varying each respective factor
3. Students discuss and determine model inputs for their specific exoplanet
4. Students analyze model output to determine habitability for their exoplanet
5. Students discuss and determine one habitability factor to change to increase habitability
6. Students input new data into the Mini-GEEBIT B3 model
7. Students analyze model output
8. Students share model outcomes with the class
9. Students compare exoplanet outputs with the Earth-Sun system

C. Unit Overview

Day Topic Activity
1. Habitability: definition, factors and exoplanets
   - Climate simulation: Introduction of Mini-GEEBIT B3 model
   - Exoplanet habitability: model exoplanet using Mini-GEEBIT B3 model
   - Exoplanet habitability (continued): manipulate exoplanet data for new model inputs
   - Habitability: comparison of exoplanet data and manipulation with Earth-Sun system
   - Students complete habitability concept web
   - Students explore Exoplanet catalog
   - Students record relevant habitability data for chosen exoplanet

D. Classroom Implementation

Day 1: Habitability & Exoplanet Selection

1. Students learn about habitability & the characteristics of the exoplanet they have selected

Day 2: Climate Simulation

1. Students use toy climate model to explore habitability factors

Day 3/4: Exoplanet Habitability Using Climate Simulation

1. Students use toy climate model to explore habitability factors

E. Summary

The CCRI collaboration between NASA scientist, Dr. Linda Sohl, and STEM educator, Mary Anne Woody, served as an impactful partnership. The scientist provided inspiration, content and resources for lessons, bringing actual scientific content and research practices to the high school classroom. As a result, the students were able to engage with an exciting and relevant topic, while expanding on the typical science content of a unit on conservation of energy.

Lastly, the project provided a genuine snapshot of a career in scientific research, one where the “right” answer is not always readily available, and informed interpretations are made. The students reported positive feedback for the project and recommended it for rising Physics classes. They were not only engaged in the subject material, but also enjoyed using the online simulations to be “experts” on their chosen exoplanet.

References

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