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Educational Web Application for Exoplanet and Habitable Zone Modeling

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Understanding the concept of the habitable zone (HZ) is one of the core principles of astronomy, yet existing tools for modeling it remain largely inaccessible at the K–12 level. Most platforms require coding skills, professional software, or are too abstract for meaningful engagement. Despite the HZ being part of many national science curricula, there is a lack of interactive media designed specifically to support conceptual understanding and visualization in the classroom.

To address this gap, we developed a browser-based educational tool to help students visualize and explore planetary habitability. Designed to support project-based learning in the Solar System, Habitable Zone, and Exoplanet units of the Earth and Space Science curriculum, the platform enables students to investigate how stellar and planetary parameters influence whether a planet can support life.

Students can explore over 4,000 confirmed exoplanetary systems, identify potentially Earth-like planets, and analyze their placement within the habitable zone. A Hertzsprung–Russell diagram provides stellar context, while simulation tools let students create custom systems and observe how changing stellar or planetary inputs alters habitability outcomes.

The application sources data from the NASA Exoplanet Archive using the Table Access Protocol (TAP) and calculates HZ boundaries using the Kopparapu et al. (2014) climate model. The inner and outer limits are defined using the conservative thresholds of the runaway greenhouse and maximum greenhouse criteria, respectively.

Visuals are rendered using Matplotlib and D3.js and delivered through modern web technologies including Next.js and TailwindCSS—all via a fully browser-based platform that requires no installation or specialized software, allowing students to access it from any device or operating system.

The platform is currently used by tens of thousands of users worldwide and has shown strong potential as an educational tool for student-led projects in astronomy classrooms. It is freely accessible at www.exoplanetvisualizer.com.

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