

# Advancing Astronomy Education through Immersive Learning and Enacted Astronomy

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## Abstract

Immersive learning technologies have revolutionized education and transformed public outreach. In astronomy education, traditional learning methods (textbooks and lectures) cannot convey the vastness and complexity of the universe and its contents. In the concept of "enacted astronomy", students learn through interactive and experiential engagement with astronomical concepts using advanced technologies and role-playing activities. Using immersive learning techniques, the students can engage in interactive, three-dimensional experiences that bring astronomical concepts to life, enhancing comprehension and helping to retain the knowledge for future reference. Immersive learning techniques include, among others, simulations of celestial phenomena, virtual tours of the observed universe, interactive models of astronomical objects, or a human Orrery. These provide students with a sense of scale that is important for understanding concepts such as planetary orbits, the structure of galaxies, or a sense of time and presence which can help in gaining perspectives of celestial phenomena such as the life cycle of stars or the vicinity of a black hole. It is also possible to combine these techniques, for instance a Virtual Reality Orrery experience, in which case the users interact with an advanced, dynamic model of the solar system that incorporates real-time simulations of the motions of celestial bodies. This can apply to both classroom settings and public educational programs. In conclusion, immersive learning environments and experiential learning leverage the power of embodiment and active learning and entail cognitive and motivational benefits, stimulating curiosity and enthusiasm among students and making astronomy more accessible, engaging, and comprehensible to audiences at all levels of education.

## Introduction

This contribution explores how immersive learning and enacted astronomy are revolutionizing the way we teach and learn about the universe. By leveraging advanced technologies and interactive methodologies, these approaches offer transformative educational experiences that enhance engagement, retention, and understanding. We cover the concepts of immersive learning and enacted astronomy, their benefits, and real-world examples of their application in astronomy education.

# Immersive Learning and Enacted Astronomy

Immersive learning utilizes technology to create engaging and interactive environments, often through virtual reality (VR), augmented reality (AR), or simulations. This approach enhances engagement, retention, and understanding by providing hands-on experiences that simulate real-world scenarios. Enacted astronomy involves students in the active process of discovery and exploration through simulations, role-playing, and interactive activities. This educational approach promotes active learning, critical thinking, and a deeper understanding of astronomical concepts.

## 1. Immersive Astronomy

**Virtual Reality (VR)** allows users to experience astronomical environments in three dimensions, creating a sense of presence and immersion.

- **Adler Planetarium (Chicago IL, U.S.):** Offers VR tours of planetary surfaces, enabling students to explore Mars or the Moon as if they were there.

**SkyRider Theater** (Richmond BC, Canada)

- : Projects fantastic virtual-reality images onto a screen hung from the dome, with audience controls allowing participation.
- **Space Engine:** A VR software that lets users travel through the universe, exploring stars, planets, and galaxies.

**Augmented Reality (AR)** overlays digital information onto the real world, enhancing real-world experiences and providing educational content in context.

- **SkyView:** An AR app that helps users identify stars, constellations, and satellites by pointing their device at the sky.
- **Star Walk:** An AR app that provides detailed information about celestial objects and events when viewed through a smartphone.

**Planetarium Shows with Advanced Technology:** Modern planetariums use digital projectors and 3D simulations to create immersive star shows.

- **Hayden Planetarium (New York NY, U.S.):** Uses cutting-edge technology to provide immersive star shows and cosmic simulations.
- **Morrison Planetarium (San Francisco CA, U.S.):** Features a 75-foot digital dome offering an immersive experience of the night sky and beyond.

**The Overview Effect** is a profound cognitive shift reported by astronauts viewing Earth from space, characterized by a sudden recognition of the planet's fragility, interconnectedness, and the oneness of all life. This transformative experience often leads to a heightened sense of responsibility towards environmental stewardship and global cooperation. Examples of Immersive Astronomy Replicating the Overview Effect:

- **"Overview" by SpaceVR:** Uses footage from the International Space Station to provide a 360-degree view of Earth, aiming to evoke the same emotional and psychological impact.

- **"SpaceBuzz"**: Initiated by Dutch astronaut André Kuipers, this project employs VR to take children on simulated space journeys, fostering environmental awareness and global consciousness.

## 2. Enacted Astronomy

Enacted astronomy is grounded in the theory of enaction, which claims that mental model building is interconnected with our perception of the external world through all our senses. Cognition arises through the dynamic interplay of brain, bodily action, and perception, necessitating that new abstractions be grounded in physical reality to be fully understood.

**Interactive Simulations:** Software that simulates astronomical phenomena, allowing students to manipulate variables and observe outcomes.

- **Universe Sandbox:** A physics-based space simulator merging gravity, climate, collision, and material interactions.
- **Stellarium:** An open-source planetarium software that lets users explore the night sky in real-time.

**Role-Playing and Active Learning:** Activities where students take on roles to solve problems or conduct missions.

- **AstroCamp:** An educational program where students simulate space missions, solving real-world challenges and contributing to NASA science missions.
- **Mission X: Train Like an Astronaut:** A global educational challenge encouraging students to learn about space exploration through physical activities and problem-solving tasks, part of NASA's Commercial Crew Program.

### Real-World Examples of Enacted Astronomy

- **AstroPi:** A project by the European Space Agency that sends Raspberry Pi computers to the International Space Station for student experiments, combining coding, data analysis, and space science.
- **Goldstone Apple Valley Radio Telescope (GAVRT):** Allows students to use a decommissioned NASA radio telescope for scientific research, engaging in authentic scientific inquiry and data analysis.

**Human Orrery:** Provides a kinesthetic learning experience, allowing participants to physically embody the movements of planets and other celestial objects.

- **Armagh Observatory and Planetarium (Armagh, Ireland):** Features a permanent outdoor human orrery for educational programs.
- **Cité de l'Espace (Toulouse, France):** Offers an outdoor human orrery where visitors can experience planetary movements firsthand.
- **Royal Greenwich Observatory (London, England):** Sets up temporary human orreries during educational events.
- **DIY Human Orrery Projects:** Schools and community groups create their own human orreries for classroom learning.
- **Aristarchus Project (Greece, France, Cyprus, Germany):** An educational initiative that uses a large-scale human orrery to make astronomy accessible and engaging.

# The Future of Immersive Learning and Enacted Astronomy

## Emerging Technologies

- **AI and Machine Learning:** Potential applications in personalized learning experiences and data analysis.
- **Holographic Displays:** Potential for creating even more immersive and interactive astronomical experiences.

## Expanding Access

- **Online Platforms:** Increasing accessibility of immersive learning tools through online resources and virtual classrooms.
- **Global Collaboration:** Encouraging international cooperation in developing and sharing educational resources.

## Conclusion

Immersive learning and enacted astronomy are transforming astronomy education by making complex concepts tangible and engaging. As technology continues to advance, these innovative approaches will play an increasingly crucial role in inspiring the next generation of astronomers and fostering a deeper understanding of the universe.

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