

BRINGING ACTIVE FIELD-BASED LEARNING TO SCALE IN ASTROBIOLOGY: VIRTUAL FIELD TRIPS AND ADAPTIVE COURSEWARE. D. D. Bratton, III^{1,2}, J. Hayes¹, D. Sarno³, G. Bruce², L. Horodyskyj², C. Mead², D. Ben-Naim^{1,2} and A. D. Anbar², ¹Smart Sparrow, LLC, 375 Alabama St Suite 440, San Francisco, CA, 94110, donald.bratton@smartsparrow.com, jacqui@smartsparrow.com, dror@smartsparrow.com ²Center for Education through eXploration, ASU School of Earth and Space Exploration, PO Box 871404, Tempe, AZ 85287-1404; gbruce@asu.edu, cjmead1@asu.edu, levh@asu.edu, anbar@asu.edu. ³ Lighthaus, Inc., 877 S. Van Ness Ave, San Francisco, CA, 94110, david@lighthaus.us

Introduction: Active learning and field-based learning are two pedagogical practices with significant bodies of work indicating high levels of effectiveness in science education [1, 2], however, these practices have been difficult to implement in large enrollment courses, at scale, and online. We present our work producing high-quality adaptive place-based science education online at scale and the results of research into effectiveness.

Immersive Virtual Field Trips (iVFTs): Our initial foray into field-based education began with the development of immersive Virtual Field Trips, or iVFTs, in remote locations of astrobiological, geological and paleobiological significance, including North Pole Dome in Australia and Grand Canyon, USA, among many other locations. We present recent improvements and new features to the iVFT suite we have developed, and recent results on effectiveness of iVFTs.

Habitable Worlds: Habitable Worlds is the first adaptive general education science course developed by our team and includes several examples of field-based learning centered around concepts of exoplanets, astrobiology, and biological habitability. We present a case where place-based education was integrated into Habitable Worlds and preliminary data on its use and effectiveness.

BioBeyond: BioBeyond is our first attempt to bring the principles of iVFTs and Habitable Worlds to a first-year non-majors science course, general biology, based on the search for life in the Universe. BioBeyond takes advantage of field-based education to help students develop concepts of past and present life on Earth to aid their search for life elsewhere. We present the techniques and preliminary data on effectiveness of the course as a whole.

Virtual Reality: In summer 2016, we developed a prototype virtual reality simulation of a three-dimensional dynamic animal cell to be run on a high-end PC with HTC Vive hardware. That experience and the Nilpena iVFT were further developed into low-cost VR experiences delivered through Google Expeditions. We are still developing this new medium and present initial experiences and anecdotal data on its use and effectiveness as well as plans for future development.

References: [1] Freeman et al. (2014) *PNAS*. [2] Mogk & Goodwin (2012) *GSA Special Papers*.