**Advances in assessments of Astrobiology learning outcomes and data-driven student support.** C. Mead[1], L. Horodyskyj[1], S. Buxner[2], S. Semken[1], A. Anbar[1], [1]Center for Education Through eXploration, Arizona State University, Tempe, AZ 85287. [2]Department of Teaching, Learning, and Sociocultural Studies, University of Arizona, Tucson, AZ 85721.

**Introduction.** The Center for Education Through eXploration (ETX) at Arizona State University has developed several innovative digital learning experiences, centered on astrobiology, ranging from fully-online college sciences courses such as *Habitable Worlds* and *BioBeyond* to stand-alone immersive virtual field trips and individual activities for formal or informal education settings. From this foundation of novel learning experiences, ETX has conducted exploratory research into how student learning outcomes might be measured differently and more effectively by analyzing student data from these same digital learning experiences. We have also studied, in formal education settings, how student data may be used proactively to reduce failure rates in these and other courses.

**Assessing Complex Learning Objectives through Analytics.** A significant obstacle to improving the quality of education is the lack of easy-to-use assessments of higher-order thinking. Most existing assessments focus on recall and understanding questions, which demonstrate lower-order thinking. Traditionally, higher-order thinking is assessed with practical tests and written responses, which are time-consuming to analyze and are not easily scalable. Computer-based learning environments offer the possibility of assessing such learning outcomes based on analysis of students' actions within an adaptive learning environment.

*Habitable Worlds*, a fully-online college science course, uses an intelligent tutoring system that collects and responds to a range of behavioral data. Among these, the data for the final project provide insight into how students solve a large, multi-step problem in science. The challenge is to discover a habitable planet from among hundreds of candidate stars. In this challenge, students may use virtual currency to check their work and "unlock" convenience features. Results show that high-achieving students ("A" grade) spend close to the minimum amount required to reach these goals, indicating a high-level of concept mastery and efficient methodology. Average students ("B" or "C" grade) spend more, indicating effort, but lower mastery. Low-achieving students ("D" or "E" grade) were most likely to spend very little, which indicates low effort. Differences on these metrics were statistically significant between all three of these populations. We interpret this as evidence that high-achieving students develop and apply efficient problem-solving skills as compared to lower-achieving student who use more brute-force approaches.

**Measuring scientific reasoning through behavioral analysis in a computer-based problem solving exercise.** Developing scientific reasoning skills is a common learning objective for introductory science courses. Yet, as with higher-order thinking, assessments of reasoning are typically open-ended, require hand-scoring, and may not be usable online. Using computer learning environments, reasoning could be assessed automatically by analyzing student actions within the learning environment. We are working to develop such an assessment, in which students "solve" the question of why the Earth has seasons through data collection and analysis.

Initial results from approximately 400 undergraduates show both promise and challenges, from an assessment standpoint. We do indeed observe a range of strategies in using data to answer the seasons question, meaning that students could be classified based on the quality of their decisions. However, by examining short answer responses, we also see that some students make the correct decision for the wrong reasons or else simply do make an effort to use the data in drawing conclusions.

**Different behavioral patterns of success for men and women in an online introductory science course.** Some evidence exists pointing to lower course grades or exam scores for women in some science courses [1, 2]. Because *Habitable Worlds* provides such detail about student behavior, we hoped to add to this literature by examining how, if at all, men and women differ in their behavior and success in this class. Using more than 1000 student records from four semester of *Habitable Worlds* performed a logistic regression to see which variables within our database were most predictive of passing/failing. Of these, which include both demographic, academic, and in-course data, we see a significant difference in the predictors for men and women. Chief among these differences is that a male student's likelihood of failure is predicted similarly by the completion-graded exercises and the quizzes, whereas for female students, the completion-graded exercises are far and away the strongest predictor. These results may stem from unique factors related to non-traditional, fully-online students.

**References:** [1] Miyake et al. (2010 *Science*. [2] Wright et al. (2016) *CBE Life Sci. Educ.*