ASSESSING STEM LEARNING AND ENGAGEMENT THROUGH VIRTUAL FIELD TRIPS AND EXPERIENCE BOXES. W.L. Taylor1,2, M.E. Minitti3, S. Buxner1, G. Bruce2, M. Hufford2 and A.D. Anbar2
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**Project Background:** Virtual Field Trips (VFTs) are immersive digital experiences that allow students to explore important, remote sites that they would not otherwise have access to. VFTs developed by Arizona State University have been used for over five years to engage students in the exploration of significant geologic sites all over the world (http://vft.asu.edu). Students, educators and the members of the general public are transported to such sites through web-based virtual environments (linked spherical panoramas) with embedded high resolution Gigapan images and videos for visitors to explore. VFTs have been used as lab components for both in-person and online undergraduate science courses as well as in K-12 classrooms to supplement instruction.

Object-based learning is a hands-on way to hone higher-level skills of observation and perception; to enhance creative thinking and problem solving ability; and to build on and apply different ways of communicating. [1] demonstrates that it is not science that puts students off following careers in science, but rather their lack of personal identity with it. The personalized and investigative nature of object-based learning activities overcomes these obstacles and nurtures student interest in science.

The motivation for this project is the idea that educational tools that combine digital learning and object-based learning have the potential to be powerful aids in capturing student interest and improving student skills in STEM disciplines. The goals of this project were to build VFTs to engage student interest; develop embedded labs within the VFTs to teach students STEM topics; and create “Experience Boxes” filled with hands-on objects to bring the VFT site and topic to life. To help realize our goals, we presented a series of workshops to train educators on the use of the VFTs, labs and Experience Boxes; gained feedback from educators to improve the VFTs and labs; and worked with them to evaluate the use of the VFTs, labs and Experience Boxes in their classrooms.

**Virtual Field Trips and Labs:** This project developed interactive labs for one pre-existing VFT and built a second, original VFT with interactive labs. The labs were created with the adaptive learning platform Smart Sparrow (https://www.smartsparrow.com). The labs were embedded within their respective VFT, allowing students to move back and forth between the virtual environments and lab exercises.

**Bizarre Animals - Nilpena.** The ASU NASA Astrobiology node produced a VFT to the Nilpena fossil site in the Flinders Ranges, South Australia near the area where the first Ediacaran fossils were identified in 1946. The VFT features three fossil bed locations and a stop at the Ediacaran gallery in the South Australia Museum, Adelaide. Detailed images of fossils, virtual 3D fossil models and videos with experts on the Ediacaran biota are embedded within the VFT to support student learning.

We developed five interactive Smart Sparrow labs for the Nilpena VFT focusing on deep time, the rock types and structures found at Nilpena, identifying the fossil taxa, reconstructing an Ediacaran ecosystem, and the extinction of the Ediacaran biota. These labs paint a picture of what the first complex life was like on Earth over 560 million years ago.

**Upheaval Dome.** Found in Canyonlands National Park in southern Utah, Upheaval Dome is an ~5 km-diameter feature exhibiting complex structure quite unlike the flat lying Colorado Plateau rocks surrounding it. The competing hypotheses for the formation of Upheaval Dome (meteorite impact vs. pinched off salt dome) make the site ideal for encouraging debate and critical thinking as students investigate the structure through the VFT. The VFT contains images, graphics, animations and videos from experts on both the impact and salt dome hypotheses that support student learning.

We created six interactive Smart Sparrow labs that introduce the rocks observed at Upheaval Dome, the concepts of weathering and erosion, age dating, rock deformation, meteorites and impacts, and allow students to explore and engage in the debate about how Upheaval Dome formed.

**Experience Boxes:** Each lendable Experience Box is filled with hands-on materials supportive of the content of its corresponding VFT. The Upheaval Dome Experience Box contains meteorites, sedimentary rocks either present within or representative of those found at Upheaval Dome (including salt), and posters and DVDs related to impacts and meteorites. The Nilpena Experience Box contains Ediacaran fossil casts, two fossil kits, sedimentary rock samples, DVD, posters, fossil flash cards, playdough and magnifiers. Each Experience Box also contains educator guides supporting their use and their linkage to the VFT.

**Teacher Workshops:** During the summer of 2014, nineteen formal and informal educators attended a
three-day training workshop at ASU. The goals of the workshop were to introduce the VFT and Experience Box concepts to educators, step through an example lab in one of the VFTs and provide background lectures on the VFT topics.

During the summer of 2015, after a subset of the educators from the first workshop had employed the VFTs and Experience Boxes in their classrooms, thirteen formal and informal educators attended a one-day training workshop. The purpose of the workshop was to update educators about the innovations in the VFT technology, and to solicit their feedback based on their use of the VFTs, labs, and Experience Boxes with their students and/or audiences.

**Evaluation Tools:** Educators who participated in the summer professional development workshops were asked to complete formative workshop evaluation surveys at the end of each day (2014) and summative evaluation surveys at the end of the workshop (2014 and 2015). Additionally, the external evaluator conducted a structured focus group in 2015 to collect feedback on teachers’ experiences with the VFTs, labs, and Experience Boxes. The subset of educators from the professional development workshops that implemented the VFTs and Experience Boxes were asked to complete a post school year teacher survey (2014-2015). This survey collected data on their experience with the materials, their beliefs about the instructional value of the materials, and the efficacy of the materials for student content learning and nature of science understanding. Students who engaged with the VFTs, labs and/or Experience Boxes completed pre- and post-surveys designed to measure changes in their content knowledge, including both declarative and procedural (scientific inquiry skill) knowledge, as well as their basic understanding of the nature of science. On the post-survey, students were also asked about how engaging the VFTs and boxes (when applicable) were and how each contributed to their learning.

**Evaluation Results:**

*Educators:* Teachers reported highly variable implementations, ranging from less than an hour to more than a week. Overall, teachers reported that the sphericals, scientists’ videos, animations and labs were easy to use, engaging for students, and supported student learning. The teachers who used the Experience Boxes reported that the specimens and guides were engaging for students and supported their learning. Those two teachers rated the Experience Boxes slightly higher in value for the classroom than the VFTs. All of these respondents reported that they would possibly or definitely use the VFTs in the future. For the teachers who reported that they might not use the VFTs in the future, technology and technology integration were the reasons. Teachers reported that they liked the VFT content but old computers, slow Internet, and problems using the VFTs on iPads might prevent them from using the VFTs with students in the future.

*Students:* For both the Upheaval Dome (UD) and Nilpena (N) VFTs, comparison of scores from content pre- and post-tests demonstrates that students made statistically significant gains in knowledge after using the VFT and/or Experience Boxes. The data do not indicate that use of the Experience Boxes was better or worse for learning content than no use because no controls were used in the assessment including students’ background, and the type or length of the instruction.

Feedback from students on their perception about how the tools helped them learn was acquired through surveys where students rated each statement on a scale from “1” (strongly disagree) to “10” (strongly agree). Over half the students (UD: 62%, N: 57%) reported that the immersive experience of the VFTs helped them understand the geology better. A large percentage of students (UD: 77%, N: 84%) reported that they learned new things about rocks by completing the labs. A majority of respondents (UD: 75%, N: 71%) reported that the VFTs helped them understand that scientists can have different explanations for a single geologic feature. The Experience Boxes were variably perceived, as 67% of the students (n=95) who used the Upheaval Dome Experience Box reported that touching and studying real rocks helped them understand geologic processes better, compared to only 49% of the students (n=65) who used the Nilpena Experience Box.

Feedback on engagement and use was also obtained from the students. More students (UD: 62%, N: 69%) reported that they enjoyed the VFTs than did not; fewer than a third of students reported that they had trouble using either of the VFTs. Well less than half of respondents (UD: 41%, N: 30%) reported that the scientists in the VFTs were hard to understand.

**Availability:** The VFTs and labs developed for this project are accessible at the Virtual Field Trip website portal http://vft.asu.edu. In cooperation with the Ron Greeley Center for Planetary Sciences within the Arizona State University School of Earth and Space Exploration, the Experience Boxes that accompany the Upheaval Dome VFT are available to educators for check out in central Arizona. The Experience Boxes that accompany the Nilpena VFT are available for check out from the Arizona Museum of Natural History (http://arizonamuseumofnaturalhistory.org).