Project Description

Pathways: **Outdoor Learning Clouds: Interactive Informal Science Education Within the Environment** is an interdisciplinary free-choice educational project that uses mobile networking technology to enable *objects* in the outdoors to become the educator of science concepts. The use of mobile learning interfaces, geospatial information technology and outdoor high bandwidth communication networks coupled to curated, digital science content will support self-directed, customized and extendable informal science learning experiences throughout the natural and built environments.

Introduction

"There was a child, went forth every day, And the first object he look'd upon, that object he became, And that object became part of him for the day or a certain part of the day, Or for many years or stretching cycles of years". (Walt Whitman)

"I like to play indoors better 'cause that's where all the electrical outlets are". (Fourth-grader in San Diego)

The two dichotomous quotes are from Richard Louv's *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*. In his book, Louv presents a compelling argument for the increasing division between the modern world in which children dwell and their exposure to and experiences in the natural world. Specifically, he draws correlations between the "wired generation" and disturbing trends in our nation's youth, including obesity, attention deficit disorders and depression. The argument presented in the book resonated with so many in the United States that it stimulated a national movement entitled No Child Left Inside. The goal of the No Child Left Inside movement is to reconnect our youth with the environment while concurrently building an environmentally literate citizenry.

As a result, several environmentally focused organizations are stepping forward to realign or create new educational activities to support the No Child Left Inside movement. However not all activities are grounded in sound educational research and pedagogy, nor utilize applications of technology which are an attractant to members of the "wired generation".

Imagine that same fourth grader exploring the outdoor landscape and wanting to learn more about the nature of things. Walking through the environment, utilizing portable technology to help understand what is being observed, through virtual lessons available from the tree or under the water. Technology allows the outdoor objects to become teachers in a novel and compelling way.

Project Rationale

Learning and discovery is an essential human behavior, not confined to classrooms, workshops, or conferences, and is not just for students, or workers pursuing professional skills. Free-choice learning is the most common type of learning in which people engage, controlling what to learn; when to learn; where to learn; and with whom to learn. Layering on the exciting possibilities of new media and technological developments (National Research Council, 2009) creates new and fertile informal science education research and learning opportunities.

Contrary to what national and international science test scores may indicate, Falk and Dierking (2006) led a study where the overwhelming majority of interviewees, regardless of age, ethnicity or gender, claimed to have an interest in science. Most people claimed that the **motivation** behind their knowledge was simply interest and curiosity. And one half of the participants learned their science, during their leisure time, through some kind of free-choice learning experience. In addition, Horrigan (2006) reports that a Pew Internet and American Life Project survey revealed that many Americans rely on internet resources for science news, science research and verification of scientific claims.

Brown and Duguid (2000) argue that "society is just beginning to realize the transformative power of web-based technologies, which ultimately will be on par with the generation and use of electricity, permeating and redefining society. There are important features of the web that may support science learning in ways that other media do not. Unlike print media, the web allows users to both receive and send information. Through user-selected and designed interfaces, the web can honor **diverse ways of knowing and learning**, so that users can interact with content and with one another in ways that they deem valuable.

As an expansive network of users and resources, individuals can leverage resources to communicate with huge numbers of people. Furthermore, these characteristics of the web—dialogic structure, user direction and organization, expansive networking of people and resources, and increasingly user created media—resonate with learning science and informal environments (NRC, 2009).

The 2008 report produced by the National Science Foundation, *Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge*, specifically calls for the need to **advance seamless cyberlearning**. **"**Education tends to be intentionally designed and provided either inside formal institutions like schools or as informal education inside science museums or afterschool centers. This can and should change, given the enormous changes in the digital resources, web browsers, and other ICT platforms now available and increasingly used for learning outside formal designs. Advancing seamless cyberlearning across formal and informal settings is a large-scale opportunity where NSF investment could make a tremendous difference. Users are in motion, but supports for their extended learning and education are not—to the detriment of the Nation and greater learning for all. The use of mobile learning devices, geospatial information technology and high bandwidth outdoor network connectivity will support self-directed, customized and extendable outdoor mobile learning experiences."

Technology holds great potential to support inquiry practices in designed spaces (Ansbacher, 1997). It has proven to be an effective scaffolding tool that helps users engage in domain-specific inquiry (Linn, Davis, and Bell, 2004). While no clear understanding of its contribution to learning is currently evident, novel technology may have a special appeal and unique potential. Visitors tend to use technology-based exhibits more frequently and for longer periods of time than traditional exhibits (Serrell and Raphling, 1992; Sandifer, 2003), a result that has been attributed to "technological novelty" (Sandifer, 2003). In an analysis of 47 visitors and 61 instances of visits to interactive exhibits, Sandifer sought to determine the characteristics of exhibits that sustained visitors' attention the longest. In a regression analysis, "technological novelty"—the presence of visible state-of-the-art devices or illustrating, through the use of technology, phenomena that would otherwise be impossible or laborious for visitors to explore on their own—was a significant factor in the variance of visitor holding time (NRC, 2009).

Leveraging mobile learning projects and research conducted by the Exploratorium in San Francisco, CA (Fleck et al., 2002; Hsi, 2003), the Tech Museum of Innovation in San Jose, CA (Eberbach, 2006), and others (NRC, 2009), this project will move informal learning experiences from the science center floor to the outdoor environment. The use of mobile learning devices will support self-directed, customized and extendable outdoor mobile learning experiences.

Response to Need

The Outdoor Learning Cloud is an example of the natural environment becoming an infrastructure and focus for learning. Science is learned in relation to the interdependencies of natural systems and the influence of humans on the environment, while the material world, with GIS tagged (place specific) features and processes, become the focus of inquiry and learning. A long-term goal of the proposed efforts is to create outdoor places for enculturation (Bruner, 1996; Martin and Toon, 2005; Pearce, 1994), providing multiple environmentally based opportunities for participants to develop their identity as a part of a community (e.g., social affiliation around nature and neighborhood), and influence people's identities as science users (Ivanova, 2003), where personal identity is viewed as the cluster of knowledge, dispositions, and activities, therefore creating a more science and environmentally literate population (NCR, 2009).

Education Goals:

1. To determine what scaffolding systems are necessary to support learning in distributed learning environments (Pea, 2004).
2. To demonstrate that digital assets can support learners in free-choice learning environments.
3. To investigate the Outdoor Learning Cloud user's acceptance of the learning object as teacher.
4. To demonstrate that use of the OLC leads to engagement with the STEM knowledge domains at each site.
5. To demonstrate that use of the OLC leads to increased awareness, knowledge, and understanding of the specific STEM knowledge domains at each site.

A key and applicable finding from the informal education field is that users are engaged by experiences that offer interactivity, which is defined by McLean (1993) in terms of reciprocity: “The visitor acts upon the exhibit, and the exhibit does something that acts upon the visitor”. Apart from supporting interaction with the physical world, interactive exhibits may also create a broader temporal space in which additional learning can transpire, including stimulating constructive exchanges between users (Blud, 1990).

Outdoor Learning Cloud- *Definition*
The cloud is the convergence of location aware mobile devices with outdoor high bandwidth communication networks and geographical information systems and enables objects within a coverage area to present multimedia learning information to a user within the cloud.

The cloud is a *shift* in the structure of science education both formally and informally. From a formal perspective the cloud allows the augmentation of a learning environment beyond the brick and mortar setting. In essence the cloud helps to *shift* learning science from formal to informal or to a hybrid of formal/informal. From an informal perspective, the cloud permits the expansion of the learning experience beyond contrived settings in museums, exhibit, public buildings and homes.

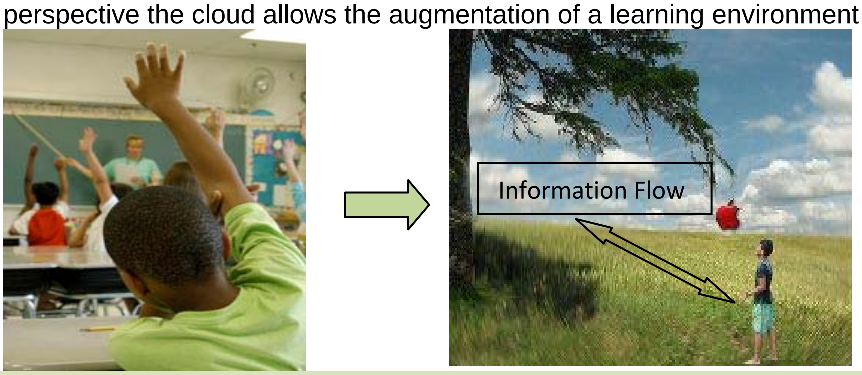


Figure 1. The shift in information flow and availability which occurs with outdoors learning clouds. In the Outdoor Cloud the object becomes the teacher/instructor, This shift is the significant innovation of this proposal.

Outdoor Learning Cloud (OLC) - *Technical Approach*
The mobile revolution is here, and these platforms will develop and expand for the foreseeable future. The current estimate is that the mobile device will be the primary tool for accessing the internet by 2020. Wherever one looks, the evidence of mobile device adoption is irrefutable. Anderson and Blackwood (2004), reviewed the use of both mobile phone and PDA technologies in education and identified key factors in the uptake of these technologies: (1) widespread adoption of mobile devices, (2) changing strategic demands of the educational environment - an increasing emphasis on lifelong learning and widening participation, and (3) developments in pedagogy moving toward active learning using constructivist teaching models that emphasize user autonomy. The use of PDA-based performance tools to facilitate classroom instruction and on-the-job training has been utilized for a number of years, particularly in the fields of medicine and allied health, business, and journalism.

Only NASA and one company (Ucompass) provide tools for mobile education. Ucompass allows users to tie activities and resources to specific locations by allowing insertion of Google Maps into an educator’s classroom module, not a true outdoor educational network. No one currently offers an integrated system that enables **real time multimedia learning content to be delivered outdoors.** Another developed mobile learning platform is Whereigo (http://whereigo.com/), an interesting use of GPS handheld standalone systems (e.g. Garmin units) which are specialty items unlike the cell phone/laptop approach by the project lead in this project, N21 (http://www.n21discovery.com). The number of mobile PCs and cell phones is vast and we believe that the path taken by N21 has the greatest potential for the largest number of subscribers.

Outdoor Learning Clouds arise from the convergence and integration of outdoor networking technology, content, geographical information systems, and mobile devices.

The innovative aspect of this proposal is in the systems integration of these elements into a coordinated, integrated network system capable of providing multimedia education to a user within the Outdoor Learning Cloud.

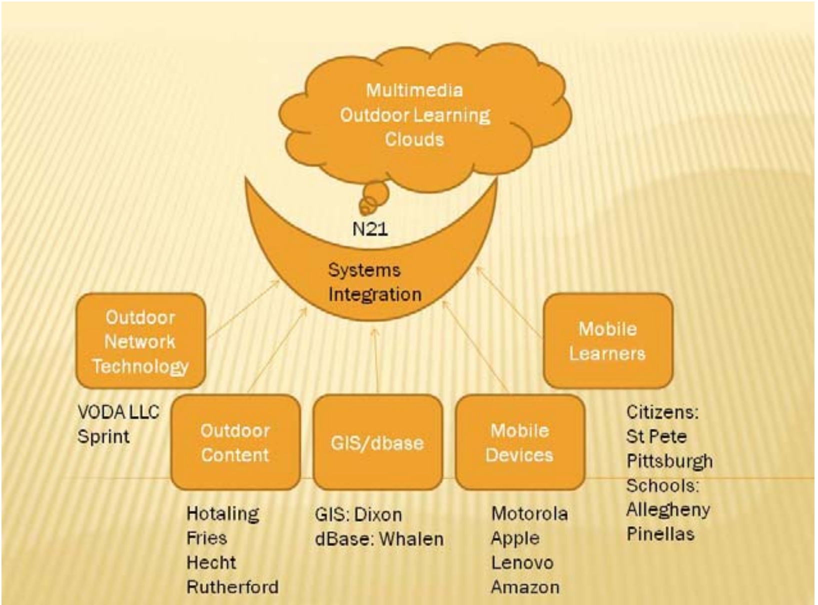


Figure 2. Summary Image of Sub Topics that will be integrated by N21 for enabling Multimedia Outdoor Learning Clouds.

Each element of the integrated systems technology serves a particular purpose (see Figure 3 below):

- 1. Outdoor Network Technology: *Connectivity* and internet (vast information storehouse access)
- 2. Content: Aggregated, *Indexed Information* for Learning
- 3. GIS: Geospatial *Location* positioning and indexing
- 4. Mobile Devices: *Translators* of information about and from the object to the user
- 5. Massive Local Storage: For S*torage* of information such as electronic textbooks

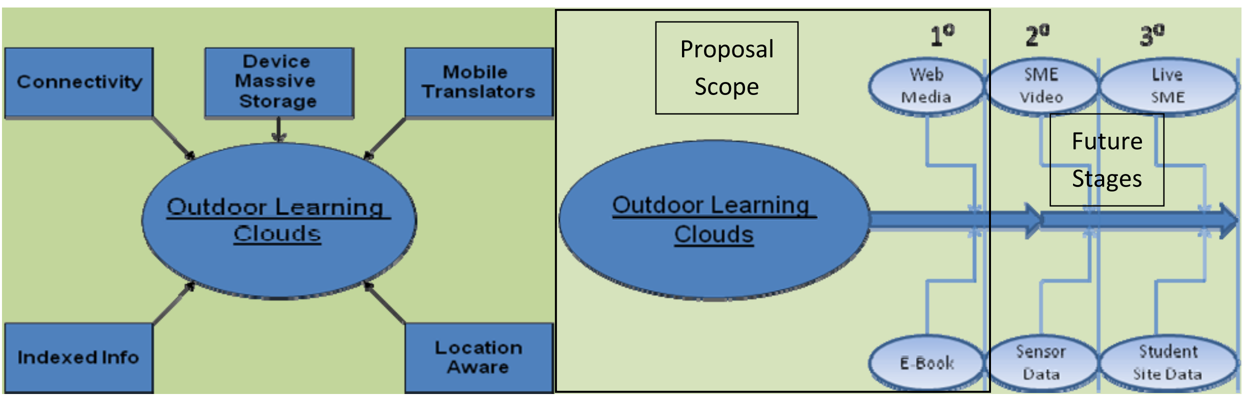


Figure 3. (Left) The innovation is the integration of these elements into a cohesive "educator" system. (Right) The evolution of the OLC to include more functionality over time includes live instruction to augment recorded information, real time sensor streams to augment static data, and student/citizen data generators to help expand the type and quantity of information within the cloud.

<u>(1) Low-Cost High-Bandwidth Outdoor Network Technology</u>

In university-related research, project team member Fries has demonstrated sophisticated, small, rugged sensors at strategic points in (open water environment) in Tampa Bay to monitor the environment for chemical, biological and physical parameters to determine the health of the waters. Think environmental domain awareness through technology (Fries 2007). The broadband wireless coastal sensor network can monitor biological, chemical, and physical targets while sending real-time information from the sensors back to shore. High bandwidth wireless communication links provide major improvements to integrated environmental observatory systems. The enabling potential of broadband wireless networks opens up numerous application scenarios for environmental monitoring, research, security and mobile learning. The broadband nature of high bandwidth networks in low infrastructure environments allows the incorporation of bandwidth-hogging video/voice application in conjunction with mobile devices. The wireless networks used in the past were designed using modified 802.11b (up to 11Mb/sec) technology, and currently in the process of transitioning to 802.11n (54 Mb/sec) which is more than enough bandwidth to handle multimedia transfer. Dual radio access point/routers are the basis for the system and give the system higher throughput and ease of deployment over multiple single radio access points. Network power management supervisory modules are part of the network nodes to extend the duration of deployment and provide backup power in cabled situations. <u>This previous experience serves as key credibility for the ability to deliver a functioning, low cost outdoor network product to this Outdoor Learning Cloud effort.</u>

Figure 4. 802.11b miniature wireless sensor system with battery (30mmx30mmx8mm) (left), and ultra low cost mini sensor node buoy for deploying the sensors (middle,) wireless video of mangroves in pitch black nighttime scene using a wireless night vision camera connected to network to demo high bandwidth transmissions The prior work demonstrates the ability to generate multimedia content across a distributed network in the outdoor setting.

The wireless sensor network platform is built around the Lantronix WiPort development kit, as it supports both Ad-hoc and infrastructure modes of communication. The nodes offer an alternative configuration based on a mesh router/bridge/gateway/access point that allow for large area coverage over adaptive terrains.

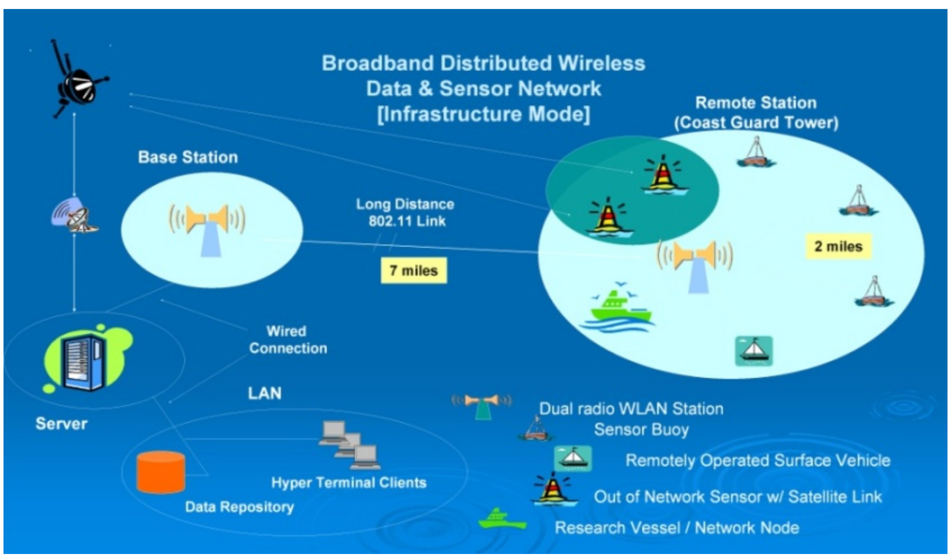


Figure 5. 802.11b wireless network topology in past demonstrations for a machine to machine sensor network in a low infrastructure environment. **This same mature core technology will be applied to the mobile learning clouds.**

Combining the sensor and telemetry modules with an <u>inexpensive</u> environmental housing yields wireless system nodes capable of scaling into networks. Network management software is complete (as demonstrated through prior work) and the development of the educational information management software is described in the GIS section (3) below. In the past a network was deployed with streaming video, a microbial biodetector, a small network of five CTDs (measuring conductivity, temperature and depth), collecting and transmitting real-time data *over several days* as a demonstration of a drop in network to characterize biological hotspots in the environment. <u>*This technology, experience and ability will be applied to create the Outdoor Learning Cloud.*</u>

<u>(2) Content</u>
Content connects people with objects and products. The Outdoor Learning Cloud is a programmable tool for any content; however this project will focus on users exploring outdoor examples of natural and manmade systems. Our goal is for a visitor to create a customized learning experience about natural and manmade systems with multimedia information collected while walking through the Outdoor Learning

Cloud. This approach yields a transition from pure online learning environments to hybrid physical-digital environments in mobile settings. The tools to encode, protect, stream, and playback content enables easy assembly of components to create the multimedia experience.

People visit environmental sites where they feel comfortable and with the intent to learn. The value in the site for the visitor is the site itself, and what they learn may not be the conservation message intended by the site staff or mission; however personal insight gained is still meaningful. Jarvis (1987) suggested that any one experience may be meaningful to one user and meaningless for another. An experience can be either attended to and reflected on, or not attended to (nonlearning); if the experience is attended to, the learning can be nonsignificant or not subjectively valued and hence be short term at best, or the experience can be significant, one in which personal value is highly supported by the experience and thus increases the cognitive impact of the information (Hilton, 1999; Falk et al, 2009). As Falk notes, "Free choice environmental education practice has been diminished by a one-size-fits-all approach. From the perspective to practice, if free choice environmental learning is primarily shaped by user's identity-related motivations, and only secondarily influences by situational motivations such as compelling exhibition or programs, then what and how we offer educational programming in free choice environmental settings needs to reflect this reality" (Falk et al, 2009).

The Outdoor Learning Clouds (OLC) model is a significant shift away from the prevalent one-size-fits all approach and directly addresses Falk's challenge. The outdoor educational network system suite will present users with a variety of learning options, creating a very flexible learning experience which can be tailored to the individual preferences of the mobile learner. In addition to the onsite experience, mobile users will walk away with links and electronic resources to promote learning beyond the experience both spatially and temporally.

<u>Pilot Project Locations (Areas of Place-Based Knowledge Building)</u>

The Outdoor Learning Cloud is more than accessing the internet for information, or following prescribed content through an audio tour, and it is more than simply a downloadable application, it is information curation. Information (data, images, video, etc.) harvested and placed into a database, presented in a flexible format for OLC users to either follow a more prescribed tour of the cloud, or launch into independent discovery of the objects in the cloud.

Marrying the learning theory mentioned above with the philosophy of Louis Bloomfield presented in his book, "*How Everything Works: Making Physics out of the Ordinary*," we intend to create a placed-based mobile learning experience, allowing visitors to investigate individual objects at each site. The two sites represent two different types of learning places: 1) free space, an open access city park with minimal existing educational signage or waypoints, and 2) space attached to an existing informal science education institution, an aquarium, with more and highly structured educational signage.

Site One – Through Time – Schenley Plaza, Pittsburgh, PA

Schenley Plaza is a public park within Pittsburgh city limits. The park is surrounded by the University of Pittsburgh, Carnegie Mellon University, Carnegie Museum of Natural History, and the Carnegie Museum of Art. Schenley Plaza recently underwent a $10 million dollar, 10 year long restoration effort, representing a tremendous collaboration between the Pittsburgh Parks Conservancy, the Oakland community, corporations, foundations, and government. Schenley Plaza, located in the academic, cultural, and healthcare center of the City of Pittsburgh, just hosted its one millionth visitor. The Plaza provides relaxation, recreation, food, and entertainment to Pittsburghers of all ages.

Partnering with the Pittsburgh Parks Conservancy and Councilman Peduto representing the City of Pittsburgh, the Schenley Outdoor Learning Cloud will explore the history, science, natural history, and environmental impacts associated with the objects in the Plaza. Objects are webbed to general themes of information and the user can explore the topics "through time" and over the space. Visitors to Schenley Plaza will use mobile devices (smart phones, laptops, tablets) to explore the Plaza. Objects on the Plaza will "light up" with information, links and media describing the object or the area in which the object dwells; these in turn become the "instructor." The OLC enables people to explore, discover and interact with the environment: A person's desire to learn is intimately linked with interactivity, a link utilized within the OLC.

Imagine standing in the present day Plaza and the image and timeline below appears on the screen of your mobile device. Click on any stop along the timeline and the image will change to an image representative of the Cathedral of Learning (University of Pittsburgh) or of Schenley Plaza area during that time. In general, the user would simply need to navigate over the Plaza image to reveal the objects that are active with information, links and media associated with that space, and choose a selected time.

TIMELINE

Cambrian Period	Cenozoic Era	1500	1600	1700	1800	1900	1950	2000	Present	Future

Figure 6. Cathedral of Learning object example: the user can select a time period to explore science, cultural, historical or sustainable topics and the subsequent display of information, both static and dynamic, in an educating and entertaining fashion.

In addition to serving as an OLC pilot site, the Pittsburgh Parks Conservancy will feature the OLC in a lecture series held regularly in a nearby Visitors Center. The OLC lecture will incorporate a visit to the Plaza so people will have an opportunity to interact with the OLC during the event. Liesl Hotaling (PI), Marijke Hecht (Co-PI) and David Fries (Co-PI) will lead the discussion.

Site Two – Through Water - The Pier Aquarium, St. Petersburg, FL

The mission of The Pier Aquarium (www.pieraquarium.org) is to enhance the public's understanding of the value and fragility of the local and global marine environment through research, education and personal experiences. The Pier Aquarium highlights and showcases the major marine research conducted in the Tampa Bay region, which holds the highest concentration of marine scientists in the Southeast U.S. The Pier Aquarium is the most visited tourist site in Pinellas County and is located on Tampa Bay. The Pier Aquarium’s strategic plan to become the major resource for marine science education in west central Florida calls for a move to a larger “Marine Discovery Center” facility. This “Marine Discovery Center” will incorporate cutting edge technologies, such as Outdoor Learning Clouds, with living exhibits and other interactive experiences.

Since the Aquarium is able to offer the existing infrastructure of staff and methods for distributing and loaning equipment to visitors, a hand-held loaner program will be established. Visitors who do not possess a personal hand-held device capable of synching with the OLC will have the ability to borrow one from the Aquarium for the duration of their visit.

The content of the Pier Aquarium pilot project will focus on Tampa Bay and the flora and fauna that dwell within, and the environmental pressures that the bay currently faces. Users of the Pier Aquarium OLC will stand outside of the Aquarium and point their mobile device toward the water (aligned with waypoint markers) to begin. Imagine a reverse periscope; the OLC will allow the user to “see to unseen” underwater.

Figure 7. Simple Multimedia example for “seeing the unseen”, a sea science tourism example. The proximal user at the Pier can select one of several distances and depths in a view, which then present up alternative interactive scenarios for exploration of science topics The left view (bird’s eye view) allows for a traditional GIS overlay (not shown) while the right views show water level views (which are essentially GIS “level” perspectives). This approach can yield creative opportunities to present both traditional overhead GIS info and “new”-level plane- multimedia “GIS” of images.

Content from existing Pier Aquarium exhibits will be integrated into the OLC Pier Aquarium experience, including sound clips from *A Sea of Sound*, content and images from *Counting on Fish,* which focuses on the importance of sport and commercial fish to the region and ecosystem, and general information on species in the region collected and produced by the Pier Aquarium.

In addition to serving as an OLC pilot site, the Pier Aquarium will feature the OLC in their SciCafe series hosted in St. Petersburg, FL area. The purpose of the SciCafe series is to present scientific content in a casual meeting place and generate plain language and inclusive conversation for people with no science background. The OLC SciCafe will occur at the Aquarium so people will have an opportunity to interact with the OLC during the event. Hotaling (PI), Rutherford (Co-PI) and Fries (Co-PI) will lead the discussion.

(3) Geographic Information System

In the context of this project, GIS will provide a framework to attach and organize developed multimedia educational content in a way that allows the user to access and interact with the educational content from the real-world object or environment of study. Once a GIS platform is established (ARCGIS, Autodesk, GeoMedia), the GIS Specialist/Programmer will take the multimedia educational content developed within the project (data) and link it to the existing real world entities being studied within the GIS modeled environment (map) and will create shareable, interactive map(s) that are accessible from the object or environment.

A relational database will act as a central repository for the content. It will keep the associations between the location information and the object details. These details can include text, pictures, audio, video or pointers to object details kept remotely. Relationships between the objects themselves can also be kept. The most likely candidate for our dBase needs will be Oracle, which along with proven scalability and platform independence, has free basic GIS capabilities within both the standard and enterprise editions. Known as Oracle Locator, it provides the core location-based functionality needed for GIS applications. In addition to the basic built-in GIS functionally, Oracle also provides Oracle Spatial as pay-extra option for the Oracle Enterprise Edition that extends the functionality of Oracle Locator, and provides a robust foundation for any future complex GIS applications.

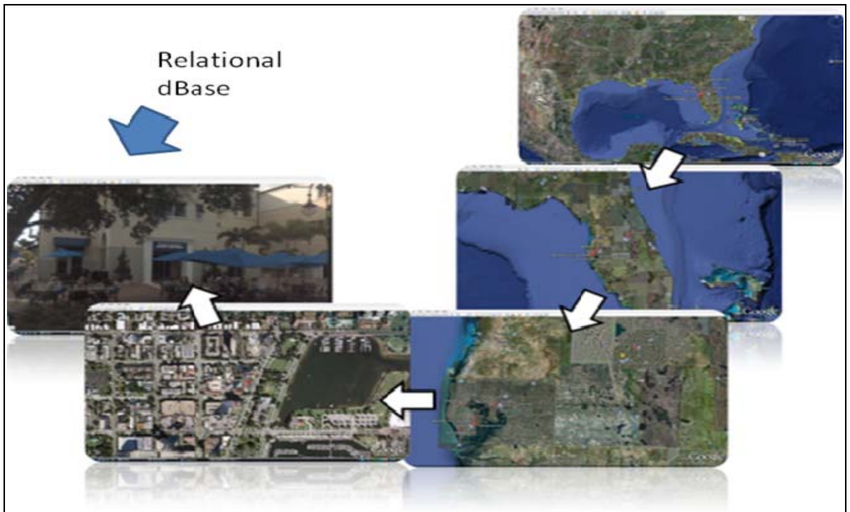
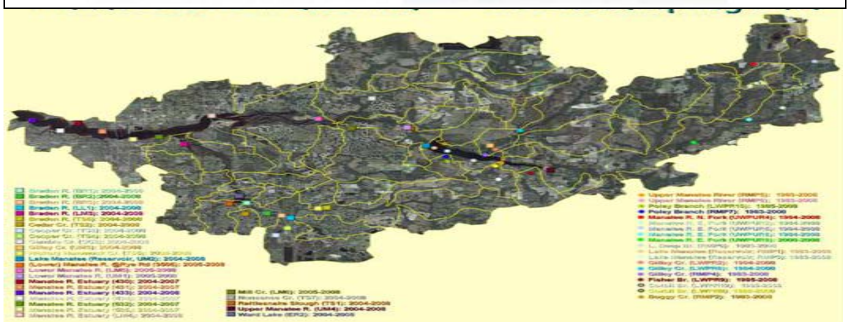


Figure 8. Upper Image: the access sequence for users with the cloud geospatial information system. The *aerial view* of a location transitions into a *street view* and the spatial objects within the image view are linked to a (correlated image) linked relational dBase.

The relational database once integrated with a front end image (Google Maps image or N21 provided scene image) and the objects completes the operational flow of information from located object to located information consumer.



Lower Image: GIS produced *aerial view* of location, in this example, exhibiting nutrient levels and positions within the cloud region. A user would be able to further explore individual points for historical and current levels of nutrients. Additional instructional material can be coupled into the data sites. The aerial view provides a larger scale of engagement for the user and an alternative "birds eye" view of the location.

How it works: In its simplest form, a user walks into the park and is aware of the parks ability to interact by presenting information coupled to objects in the park. The user turns on the Wi-Fi device (laptop or handheld or tablet), then looks for the OLC signal, and connects. The user launches a web browser and signs up, at N21discovery.com/olc. The network knows the location of the mobile device and user. Approximate street level images of the site are presented and one is selected by the user. The user optimizes the image on the augmented image is presented on the screen for the user information experience and exploration to begin.

Figure 9 (below) shows potential output from an OLC and the key innovation of the proposal. Outdoor and proximal images are added with digital information to generate an augmented reality image infused with selectable learning information. This augmented reality technology is not high technology novelty and is being used in other areas of communications and marketing but the image suggests a different way to view and deliver educational information.

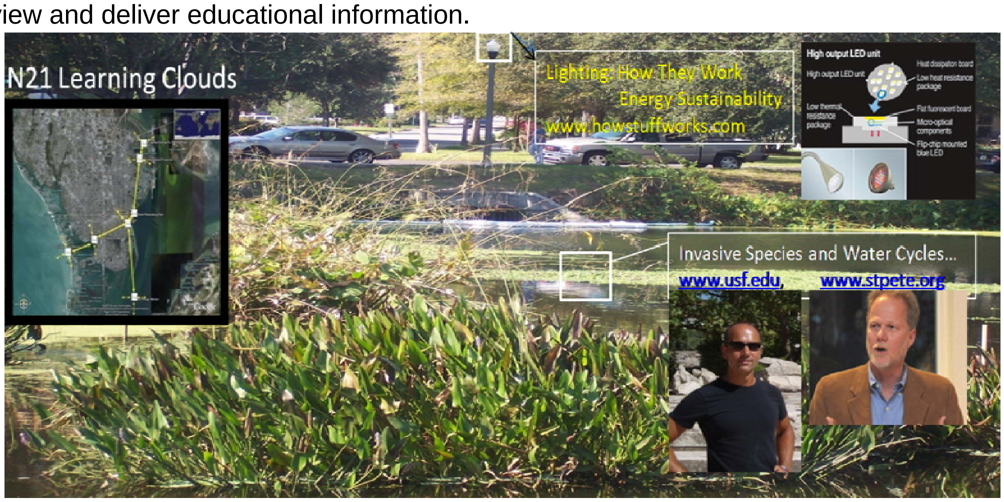


Figure 9. An example of a linked image-relational dBase will provide web resource links, graphics, illustrations, video and audio information to the objects within the image and the objects within the field of view become "alive" with static and dynamic learning information.

4) Mobile Devices

The mobile device, today is a camera, diary, navigator, and social secretary rolled into one, it also can act as a connectivity source, translator of the information embedded in the object within proximity, and local massive storage for augmenting multimedia information. Currently smartphones are emerging as a competitor to outdoor signage as well as a complement to it. Most mobile devices come with a location aware algorithm based on position within an IP network or with GPS and also come as dual mode 3G/WiFi communicator. The Outdoor Learning Cloud is based on WiFi and also 3G/4G and GPS so we will rely on phones and netbooks from commercial suppliers (Motorola, Apple, ATT, Amazon, Lenovo) supplied by the volunteer participants for the mobile hardware. At the Pier Aquarium, as noted above, the devices will be loaned to visitors.

Currently 2 billion people have access to the internet and a 500 million people accessed mobile internet worldwide in 2009, with usage expected to double within five years as mobile overtakes the PC as the most popular way to get on the Web. Just as user convenience led voice telephony to migrate from fixed wires to wireless units, mobile internet access will follow the same evolutionary path. The mobile device also offers an opportunity for electronic textbooks to infuse information into the location. Furthermore, the concerns of a small screen experience are being alleviated with the convergence of netbooks and smartphones. Large screen cell phones, and netbooks have converged into mobile tablets which have received wide adoption and are highly suitable for the mobile learning experience. Of note in our project is that an advisor to our project (Lodato) is head of mobile education development at Motorola Moblility and access and support to the Motorola Droid Platform for insertion into this project has been initiated. Motorola is (EE Times 12/2/10) releasing a tablet also within the next 6 months.

(5) Mobile Learners

Outdoor Learning Clouds (OLC) proposes short and long term educational goals which are rooted in educational theory and utilize a novel application of technology – mobile learning or mLearning. Mobile learning is the term applied to learning that can occur in diverse or multiple locations while utilizing portable technologies. Mobile Learning is portable, malleable, individual and more engaging for digital natives and supporting autodidacts with new modes of exploration. This approach enables users to learn while moving within and connecting to nature. Using sensory coupling experiences may create an ontological scaffold for development of intrapersonal and interpersonal conceptual and metaphorical knowledge (Ackerman, 2010) as well as a springboard for the application of knowledge. Mobile Learning is also representative of 21st century education, striving for a transformation from learning “what” to learning “how.” Looking upon, learning about and becoming an object in the natural environment using mobile technology will assist the “wired generation” student in the proposal introduction to converge with the child described by Whitman and build a more environmentally literate generation of learners. Doing what comes naturally for users, inspired by found objects and natural elements, the outdoor learning could becomes an exercise in creativity.

Project Design

Year 1

The first year of the project activities will focus on the implementation of the OLC in Schenley Plaza. First year project activities will include:

1) Creation of database and inventory of interactive objects for pilot location in Pittsburgh. Project team members will develop a template for the information describing all organisms and objects identified and transcribed into the database. The template will not only serve as an organizational mechanism for team members, but also give the mobile learners structure and context when retrieving information.

2) Creation of location-based educational experiences. mLearning applications should strive to use technology to advance learning, not just strive to use technology for technology’s sake. In order to move the technology past an outdoor, gee whiz encounter, educational experiences will be developed to support the mobile learning experience development cycle (details in next section).

In addition to offering participants a robust place-based learning experience, the information and suggestions generated by the mobile learners (e.g. suggestions for future sensor development, database expansions) will inform the development of the next phases of the project to not only improve the product, but also to better serve the user audience.

Year 2
The second year of the project will include expanded work in St. Petersburg, FL with the Pier Aquarium.

Instructional Design Model
The free choice perspective on learning will frame the proposed educational activities. The “Best Practices for Free Choice Learning and the Environment” published in Falk et al’s *Free-Choice Learning and the Environment* book, combined with the *scaffolded knowledge integration framework* (SKI) (Linn, et. al, 1999; Linn et. al, 2004), will inform the instructional approach for conveying information in the Outdoor Learning Cloud environment.

Experience design is an approach to the design of products, services and environments based on a holistic consideration of the users' experience. Experience design is therefore driven by consideration of the 'moments' of engagement between people and products, and the memories and learning these moments create. The actual workings of the technology itself, from broadcast network, content development, to interaction with the user will be developed and evaluated from a user experience perspective. In order to properly apply the elements of this development and evaluation process for the OLC we have enlisted the originator of the systematic approach into our Advisory Panel, Franco Lodato. Lodato is the originator of this experience development process and has implemented this methodology into developments for his iconic designs for Motorola (Razr cellphone) and Gillette (Oral B Toothbrush) and Herman Miller, amongst others. We will evaluate the technology suite with his guidance along three lines: 1) Awareness and knowledge building 2) Engagement and 3) Extended Engagement; The description and metrics for the technology component will mirror the elements described for the learning experience, below. With this process and the guidance from Lodato the experience design element will be addressed to maximize engagement and learning.

Key features include selecting goals that build on user intuitions, encourage knowledge integration, and foster learning as a continuous process. This approach advocates activities that build on everyday experiences, encourage autonomous learning, and provide social supports as needed. The proposed activities are designed to move individuals through a development cycle, either through free-form interaction or a more structured progressive learning experience of: awareness, engagement, and extended engagement:

Awareness: Users will initiate the learning task by exploring the outdoor learning cloud. Measurable indicators of success include, users successfully access content within the learning cloud and users exhibit basic knowledge of objects in their location.

Engagement: Users will further exploration of objects and their connections to the environmental and human systems. Measurable indicators of success include, users increase their interaction time with learning objects (signage versus no signage), users successfully answer embedded assessments/questions of the data/information provided through the OLC, and users formulate questions about the objects and systems and look for answers (either onsite of later, through the backend infrastructure).

Extended Engagement: After leaving the OLC, users will continue to explore resources provided through the OLC experience. Measurable indicators of success include, users continue to access information provided in the OLC, users make a return visit to the location in order to access the OLC (through backend), and users urge others to visit.

Project Evaluation
The evaluation of the OLC project will take the form of a comparative case study of the two learning environments, with a combined usability study and engagement/knowledge-building study for each. Although both environments are free-choice, the sites represent two of the most likely future sets of conditions, constraints, and opportunities, as follows:

	The Pier Aquarium	Schenley Plaza
Type of space	Museum/aquarium	Public plaza
Educational Goals of space	Aquarium has specific goal to teach about marine habitats and the environment	Plaza has no goals in terms of purveying information
Type of information	Specific to Aquarium's goals	Related to objects found in the plaza
Timeframe of information	Current	Historical over time through present day
Type of science knowledge	Environmental science	Geology; architecture; history; environmental science
Type of visitor	Purposeful (visitors plan ahead)	Not purposeful (visitors wander in)
Access to technology	Provided by Aquarium to all	Bring your own

As noted earlier (Jarvis,1987; Hilton,1999; Falk et al, 2009), a visitor to any museum-type site can either attend to an object or not, so the first step is to get their attention or engage them. For those who do attend to an object, the learning can be non-significant/not subjectively valued and therefore have at best short-term impact or significant/personally valued, which is likely to have a longer term impact. Using the progression from awareness/knowledge building to engagement to extended engagement, the evaluation will address the following questions at each stage:

1) Awareness and knowledge building

- Are visitors able to access content within the OLC? (Goals 1, 2)
- Do visitors find the software usable? (Goals 1, 2)
- Do visitors add to their personal STEM knowledge base about the objects at the site? (Goals 3,4)

2) Engagement

- Do visitors spend more time with learning objects than without (including when signage is used compared to using the OLC)? (Goals 3, 4)
- Is the visitors' curiosity stimulated by what they see? Do they formulate questions about the objects and systems in the OLC and look for answers (at the time)? (Goals 4, 5)

3) Extended Engagement

- Do visitors continue to access information provided in the OLC? (Goals 4, 5)
- Do visitors formulate questions about the objects and systems in the OLC and look for answers when they return home? (Goals 4, 5)
- Do visitors make return visits to the site to explore other objects in the OLC? (Goals 4, 5)
- Do visitors refer others to the site to use the OLC? (Goals 4, 5)

<u>Methodology and data sources</u>

In earlier studies of museum exhibits, evaluators have used "walk-alongs" (following groups of visitors, see Ma 2004) and "noticing" studies (watching where and when visitors stop and look at an exhibit; see Melch 2009). With OLC, much of this can be done through the back-end data collection system, which can analyze when and where visitors stop and look at an object, how long they spend there, what they do in terms of querying the database, hard stops (participants leaving the cloud), progressions and bifurcations (choices), "hit" data by activity, downloads, return visits, etc. Upon exiting the OLC, the user will receive a link to an online survey containing questions about the user experience with the OLC. In addition, at each site we will conduct two sets of week-long observations, using very short post-visit interviews to assess usability, as well as to assess engagement, knowledge-building, and the possibility of extended engagement by asking a random selection of visitors to respond to a set of questions about what they noticed or had not noticed before, such as the following:

- “What did you learn today that you didn’t know before?”
- “What was most memorable about what you learned about today?”
- “Is there anything that sparked your curiosity and that you might want to explore further as a result of what you learned about today?”

Intensive one-week observation sessions will be conducted at each site. The data from the online survey and the first set of interviews at each site will be considered formative and used to improve the experience. The data from the online survey and the second set of interviews (see timeline below) will be considered summative and used to evaluate the success of the site. Modifications and refinement of the OLC in each location will be made based on user feedback.

Extended engagement will be evaluated through three-month follow-up surveys (with those who have volunteered during the site-leaving interviews), as well as through the back-end data. To capture referrals, we will ask visitors on the second visit how they learned about the site and ask visitors in the follow-up surveys if they have told anyone about the OLC.

Timeline

Project Year 1 (June 2011 – May 2012)													
Task	**Resource**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**
Creation of database and an inventory of learning objects	N21	X	X										
Fuse GIS and Learning Resources	N21, PPC - Pittsburgh Parks Conserv.				X	X	X	X	X	X			
Creation Pittsburgh based educational experiences	N21, PPC	X	X	X	X	X							
Test with users	N21, PPC, evaluator					X						X	
Refinement of Pittsburgh based educational experiences based on user feedback	N21, PPC, evaluator						X	X	X	X	X	X	X
Project Year 2 (June 2012 – May 2013)													
Task	**Resource**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**
Test with users in Pittsburgh	N21, PPC	X											
Set Up High Bandwidth Outdoor Bandwidth Networks (with Voda LLC) at The Pier Aquarium	N21	X	X										
Creation of database for aquarium	N21, Pier	X	X										
Fuse GIS (Google Earth) and Learning Resources	N21				X	X	X						
Creation of aquarium based educational experiences	N21, Pier		X	X	X	X	X						
Test with users	N21, Pier, evaluator							X	X	X	X		
Refinement of aquarium based educational experiences based on user feedback	N21, Pier, evaluator										X	X	
Report Results	N21, evaluator											X	X

Advisory Committee

The Advisory Committee members selected for this project have extensive experience in informal science education research, user engagement design and applications of mobile devices and new media. The Advisory Committee will meet remotely through videoconferencing twice annually to offer guidance on project goals, tasks and direction. The following people were contacted and accepted the invitation to join the Advisory Committee:

Dr. Philip Bell is an Associate Professor of Learning Sciences, and a Co-PI for the Learning in Informal and Formal Environments (LIFE) Center, an NSF Science of Learning Center at the University of Washington, and co-editor of the National Research Council's 2009 study, *Learning Science in Informal Environments: People, Places, and Pursuits*.

Mr. Peter Kagayama is the co-founder and producer of the Creative Cities Summit, an interdisciplinary event that brings together practitioners around the big idea of the creative dynamic city. Peter is the former President of Creative Tampa Bay and a frequent collaborator with Richard Florida's Creative Class Group and with Charles Landry from the UK's Comedia. In 2009 he produced and directed a documentary film "Charles Landry and the Art of City Making." In Feb 2011, his book, *For the Love of Cities: The Love Affair Between People & Their Places* will be published.

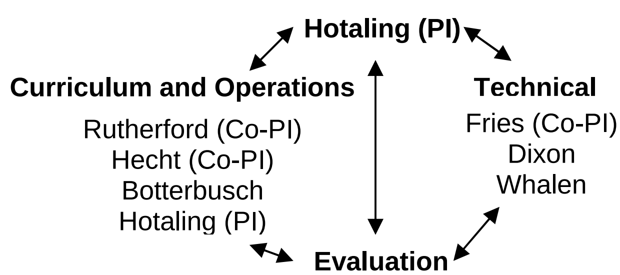
Mr. Franco Lodato, Industrial Designers Society of America, Head, R&D Division, North American Region, Pininfarina Extra USA, is experienced in the world of wireless communications, wearable technologies, and consumer markets for 18 years, In his book, *Bionics in Action,* he explores these principles. He has worked at DuPont, Gillette, Motorola, Herman Miller and Pininfarina, worked with the MIT Media Lab and taught design methodologies and innovative design at conferences worldwide. Mr Lodato is one of the world's recognized leaders in experience design of products for consumer use.

Results of Prior Funding

Although this project has not received funding to date, the project PIs are simultaneously involved with other NSF funded efforts or have been asked to help define future objectives for NSF in outdoor networks. Projects and associated national networks, the Centers for Ocean Sciences Education Excellence (COSEE) and the Innovative Technology Experiences for Students and Teachers (ITEST) would have great interest in the proposed project and results. Team member Hotaling would lead the networking and dissemination efforts of this project to the above educational communities through the COSEE Network, *NSF 07-30719: Collaborative Research of COSEE-NOW*, ***Janice McDonnell***, PI, ***Liesl Hotaling***, *Senior Personnel, $2,600,000, 2007-12*; **Gail Scowcroft** PI, **Liesl Hotaling** Co-PI, *$500,000, 2009 – 13, NSF OCE 0943472*; and through the *NSF ESI-08-33440: SENSE IT,* ***James Bonner****, PI,* ***Liesl Hotaling****, Co-PI, $1,400,000, 2008 – 11* ITEST program. Team Member Fries has been *Co-Chair* ***David Fries*** for *Sensors of Environmental Observatories*, *NSF Sponsored Workshop,* December 2004, and *Executive Committee Member* ***David Fries*** for Review Panel of *National Ecological Observatory Network*, an NSF nationwide outdoor ecological observation network. Experience from both NSF project activities should inform the development of the project and will help with the evolution of the Learning Cloud into a sensor augmented Learning Cloud at a later stage.

Project Management

Project Partners - The multi-disciplinary project investigators create a collective team that is highly qualified to respond to the needs associated with the creation of an outdoor learning cloud. The team includes:



Liesl Hotaling (PI) is Curriculum Design Consultant, holds a B.A. in Marine Science, a M.A.T. in Science Teaching, and a M.S. in Maritime Systems (ocean engineering). She is a partner in NSF's Centers for Ocean Science Education Excellence - Networked Ocean World (COSEE-NOW), serves as the Collaborations and Partnerships Coordinator for the COSEE National Network, is a Co-PI and Project Manager for an ITEST project (SENSE IT) and specializes in real time data education projects and hands-on STEM educational projects supporting environmental observing networks.

David Fries (Co-PI) holds multiple appointments, currently is a Technology Partner at N21 LLC, and is Head of the Ecosystems Technology Group at USF Marine Sciences. He is also President of a non-profit

SciFlies, the Peoples Science Foundation. He was original member of the Center for Ocean Technology at USF. He is the original author of USF's MEMS Program and the National Forensic Science Technology Center. He is founder of two companies, Intelligent Micro Patterning (2002) and Voda (2007). He has 23 Patents Issued: 13 pending, licensed 12 technologies while at the University and is the lead at USF in both number of patents and number of licensed technologies. He has over 60 publications in oceanography, analytical chemistry, medical technology, biotechnology, chemistry, microtechnology, electronics and robotics. He has held a past appointment at Sandia National Laboratories/Lockheed Martin. He holds a B.S. in Chemistry, Univ. of Pittsburgh and M.S. in Chemistry, Univ. of South Florida.

Marijke Hecht (Co-PI), is the Director of Education for the Pittsburgh Parks Conservancy where she leads the organization's efforts to utilize the parks as classrooms for people of all ages and backgrounds. This includes the redevelopment of the Environmental Center at Frick Park and the design and installation of over a dozen outdoor learning spaces for families. She is also responsible for managing the Parks Conservancy's volunteer activities. Prior to joining the Parks Conservancy, Marijke was the Director of TreeVitalize Pittsburgh with the Western Pennsylvania Conservancy. She also served as the Executive Director of the Nine Mile Run Watershed Association where she led the organization's community forestry and rain barrel programs and advocated for the $7.7 million Nine Mile Run stream restoration project. Marijke has been recognized as a regional leader by Pittsburgh Magazine and PUMP's "40 Under 40", as well as an environmental leader by the Pennsylvania Environmental Council's "40 Under 40" award. She received a Master of Science in Botany from the Field Naturalist Program at the University of Vermont and a Bachelor of Arts in Nutritional Anthropology from Hampshire College.

E. Howard Rutherford (Co-PI), is the President/CEO of The Pier Aquarium. Mr. Rutherford is responsible for insuring optimum organizational performance through people and facility management. He is also responsible for the procurement of funding from local, state and federal granting agencies, as well as private corporations and individual donors, and actively seeks out collaborative partnerships that further the mission of The Pier Aquarium- To enhance the public's understanding of the value and fragility of the local and global marine environment through research, education and personal experiences. Currently, Mr. Rutherford is a Director on the following Boards: National Marine Educators Association, Florida Marine Science Educators Association, the St. Petersburg Downtown Business Association and the Pinellas County Environmental Forum. Mr. Rutherford represents The Pier Aquarium on the St. Petersburg Ocean Team, St. Pete Cultural Arts and the St. Petersburg Public Arts Commission. Mr. Rutherford previously served as the informal science education Co-PI for COSEE-FL.

Dr. Susan Lowes (Project Evaluator) is the Director of Research and Evaluation at the Institute for Learning Technologies, Teachers College, Columbia University and will serve as the Project Evaluator. Dr. Lowes has conducted evaluations of projects that develop, test, and implement new pedagogical approaches in the university, K-12, and community/afterschool environments, including those funded by NSF (ITEST, GK-12, IGERT, REU, CCLI, BPC, C-PATH, STEP), the Department of Education (FIPSE, PT-3, TICG, 21st CCLC, TAH), the National Institutes of Health, private foundations (Chase, Goldman-Sachs, National Geographic Education Fund, Arthur Vining Davis), and state and city departments of education.

Dr. Barnali Dixon (GIS) is a professor at the Geospatial Analytics Lab at University of South Florida.

Russell Whalen (Database Engineer) holds a B.S., Business Information Systems and is an Oracle trained Database engineer.

Hope Roland Botterbusch (Education) is a career educator with teaching and administrative experience in K-12, college and university settings.

Collaboration Process - N21/USF/Consultants will meet monthly with Televideo status updates, using the tasks outlined above as metrics to assess the timely progression of the project. Team members will meet in person prior to and after each intervention as described in the evaluation section. Evaluation data collected during each intervention will be used as an iterative guide and quality check for the milestones and developed materials which will be discussed and acted upon by team member.