Student-Generated Data Informing Student-Generated Inquiries

The DOTS program engages both youth and adults in digital literacies, and "connects the dots" from data collection to inquiry and analysis.

A Water Summit participant passes out tools to collect water and atmospheric data. Photo credit: DOTS participant.

How do we train educators to successfully interface technologies with the outdoor experiences that they provide their students?

by R. Justin Hougham, Marc Nutter, Megan Gilbertson, Quinn Bukouricz - University of Wisconsin - Extension

Technology in education (ed tech) is constantly changing and growing in impact in classrooms across the globe. While ed tech holds great promise for closing achievement gaps in sectors of the education community, it remains yet to be seen how this will truly live up to its potential ("Brain Gains", 2017, July 22). Ed tech is anticipated to grow to a $120 billion market by 2019, which will largely be spent in software and web services. How might we hope to see this show up in out-of-classroom field experiences?

Unaddressed in these articles and what we explore here are the specific impacts that the conversation of technology in environmental education brings as well as a case study that shares strategies we have found to be effective when an education considers the merging of hardware (inquiry tools), technology application in professional development, and web-based collaboration tools. Important questions for environmental education to ask include:

- How does this scale for education for the environment?
- What considerations need to be taken to ensure that investment works?
- How would we know if it does?
- How do we train educators to successfully interface technologies with the outdoor experiences that they provide their students?

In an article published in CLEARING in 2012, we explored the instructional framework for merging field based science education with mobile pedagogies in the framework entitled Adventure Learning @ (Hougham, Eitel, and Miller, 2012). In the years since, this model has informed a collection of hardware kits that support the concepts in AL@ as well as an examination of the questions outlined above. These hardware kits are called Digital Observation Technology Skills (DOTS) kits.

In the middle fork of the Salmon River in Idaho you'll see steelhead, rushing rapids and hot springs that all tell the story of the landscape. Similarly, along the Wisconsin River, you will see towns, forests and fields that have a link to the industries that have shaped the state over the last 150 years. If you're in the right spot at the right time, you can find inquisitive young people and bright yellow cases filled with gadgets taking data points and crafting Scientific Stories about the watersheds in their state. Regardless of whether it is a wild river or a small tributary outside a schoolyard- scientific stories wait to be told in these places and technology that is appropriately considered helps unlock and share these experiences.

In a world where technology is almighty, wielding digital literacy is practically a requirement in our understanding of just about everything. The students of today are able to navigate through web pages and apps with ease, information at their fingertips like never before. Here, we can find ourselves removed from that information, disconnected from those data sources and collections, stifling our desire to wonder and inquire more. By investing in digital tools that can enhance inquiry of the natural world, educators can bridge this divide of both information and the ability to be a primary data collector. In equipping students with touchscreens and interfaces familiar to youth of today, they are able to partake in not only real world application of scientific observation, but also experimental design and efforts moving toward the future.

Young people in Wisconsin have been contributing to the development of this idea of digital data collection and inquiry, through DOTS. The DOTS program has been developing in Wisconsin since 2014, engaging both youth and adult demographics in digital literacies, and connecting the dots from data collection to inquiry and analysis. By involving youth in the visualization and comparison of their data collections, they are able to begin to accomplish higher order learning such as developing their own hypotheses and synthesize the meaning of their findings. DOTS has been developed for students in 4th through 8th grades but has been modified for audiences in 2nd through high school, including adult learners, continuing education, and professional development.

A naturalist assists youth with a water quality test while on a canoe trip. Photo credit: DOTS participant.

Case studies of this application vary widely in scale, location and content. Currently DOTS kits are used in Idaho and in Wisconsin by youth to examine water quality. A full-scale implementation is underway currently in Wisconsin to connect youth from many different watersheds. Held this past August,

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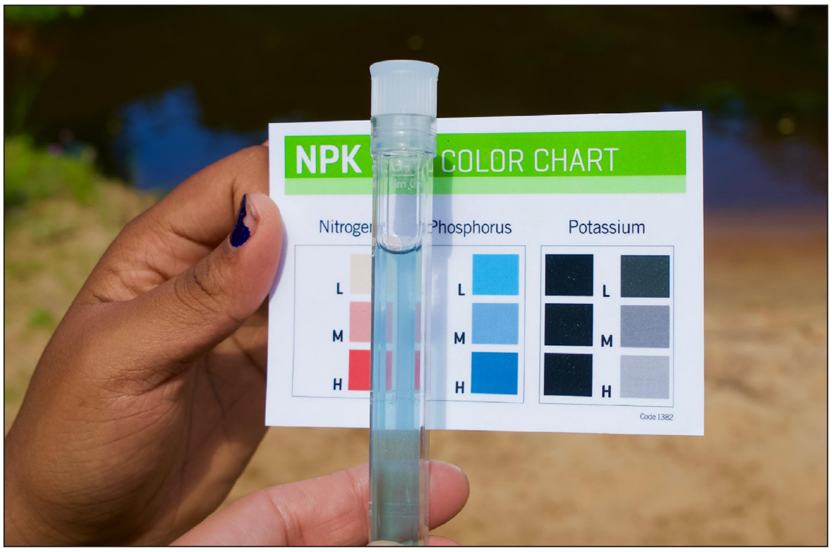
the Wisconsin Water Youth Stories Summit brought together students from across the state of Wisconsin who are interested in not only environment and ecosystems, but also water quality and sharing their "water stories". Supported by an EPA grant, this Summit was a culminating experience for many of the youth, getting to collect and share their findings over their 3 day period at Upham Woods Outdoor Learning Center (Grant Number: EPA-00E02045). This two year grant has trained and equipped educators with DOTS tool with an emphasis on water quality monitoring. Throughout the year, youth from around Wisconsin collect data and share their findings with others in real time on the web. At the Water Stories Summit, each group brought their DOTS kit to explore the environment and compare collected data sets. This experience not only brought together young scientists with a vested interest in the future of water, but also allowed students to share stories of local water quality that affects their own communities around the state.

Many shared stories about urban run-off pollution, such as lawn fertilizers and road salt, E. coli contamination, and they discussed the ways in which humans alter natural waterways. At the end of their experience one student said they learned that, "science is being precise and unbiased about nature and numbers." Another student said of a different Upham experience, "We went to Blackhawk Island for our project. The tools helped us take photos of what was under the rock. The tools help to see what animals were living there. We came up with a lot of new questions after we did our research and we can't wait to find out things like, if the temperature affects what animals we will find living under a rock, and what animals live at different depths." Through these collaborations of student generated data, participants were able to make connections between each other and drive further inquiry questions such as how to improve water use and consumption, and how the water affects all other life.



A student uses a water quality test to find the amount of phosphorus at a Wisconsin River location. Photo credit: DOTS participant.

While the kits themselves are certainly an enhancement to a variety of curriculum, the training that accompanies the deployment is just as important as the tools themselves. Educators that partner on DOTS projects are supported with (1) Equipment, (2) Training and (3) a Web platform for collaboration. It is the interrelationship between the inquiry tools, inquiry methods and inquiry artifacts that provide the support for transformative outdoor science experiences.

A DOTS kit consists of a select set of digital tools to equip youth and educators with everything they need to take a basic data set of an ecosystem and microclimate. Contained in a waterproof, heavy-duty case, the tools selected are chosen for their utility, cost effectiveness, and ease of use. Any suite of tools can be selected for an individual's classroom purposes, this is first and foremost, a framework to scaffold inquiry and observational skills. DOTS users gain field experience with hand held weather stations, thermal imagers, digital field microscopes, GPS units, and cameras to contribute to local citizen science monitoring (Hougham and Kerlin, 2016). A DOTS program training is facilitated by program staff and has evolved over time to include these six goals. While these are used in DOTS, nearly any technology implementation would benefit from these goals being outlined.

1. Establish functional and technical familiarity with DOTS Kit hardware
2. Orientation to DOTS Kit web interface, data uploading, and site visualizations
3. Examination of mobile, digital pedagogies in historical as well as applied contexts
4. Advance instructional capacities in application of observation and inquiry facilitation applicable to experiences outside the classroom
5. Production of digital artifacts that contribute to Scientific Storytelling
6. Facilitation of initial curricular design considerations for integrating kits into existing programs

After the training, educators have access to a suite of tools that can be lent out for deeper science connections in outdoor spaces. Further, trained educators can use grab-and-go lessons from the project website to launch the concepts with their students and watch videos produced and hosted on the site that provide further instruction on applications of the tools.

Lastly, a web-based collaboration platform is hosted to support the development of additional inquiry. To continue this mission of enhancing student inquiry and promoting collaboration, data sets can be uploaded to an online public access platform. As users enter their data online, the map displays in real time the coordinates and information of each data point. Viewers can easily navigate a Google map with their and other's data points for comparison and post-experience observation. This immediate viewership not only falls in line with today's student's understanding of a fast-paced, immediately available world, but also allows no stagnation in the learning process as inquiry can continue instantaneously. Through engagement by use of digital tools collecting data in the field, reflection on process and methods through data entry into the web-based model, and through analysis and refinement of hypothesis for further inquiry, students take ownership of their data and have a voice in sharing their discoveries with others. These inquiries have been qualified in the DOTS programming through use of a "scientific story".

The scientific story helps to build connection between qualitative and quantitative data and their respective ways of understanding. As humans we have told stories for millennia to entertain, educate, and remember. Combining these elements of storytelling with the scientific method of developing hypotheses and data collection, a story is created to share. These stories are generally 3-5 sentences and include photos taken by camera and tools such as the handheld microscope and thermal imager. In taking a closer look with digital tools, a deeper appreciation is gained and honed in on through these scientific stories and it is through these words that we can harness stories in what they do best: share. They can be digitized and easily shared across social media platforms, creating interest in the environment and science in family and community members.


A naturalist teaches an Escuela Verde student how to take a water quality reading.
Photo credit: DOTS participant.

This story was written while at Upham woods during the aforementioned Water Stories Summit, and describes the location and inquiries the youth had:

> *We investigated two different locations as a part of the water study blitz at Upham Woods. The first location was the Fishing shore on the Wisconsin River, and the second location was a stagnant inlet only 100 feet away. We noticed several differences between the two locations. We wanted to know more about the animal life in both locations. What kind of animals live in these habitats that we couldn't see during the blitz? What would we find if we studied the location where the Fishing Shore and Inlet connect?*

This story highlights the questions students wanted to investigate further and spurred their desire to continue comparing locations in the context of animal life. Another story from the Water Stories Summit illustrates a group of high school students making connections between ideas and places:

> *When doing the data blitz at camp, we tested water for all kinds of factors (pH, Conductivity, Salinity and others). The cool thing we noticed was the differences in PH levels of the water that equaled a 9.49 level that makes water a base. This reminded us of what would happen if water had a unbalanced and non neutral PH level, that was out of control… One example of this is a sulphur pit, like in Yellowstone national park. The pH of this water is as low as 1.2, which is almost equivalent to battery acid.*

By encouraging students to develop their own scientific story, they create a deeper connection with that place and nature in general. This connection evolves to a jumping off point for further inquiry and hypothesis development which can be fleshed out into full empirical science studies or harnessed into environmental service projects. Additionally, as data sets can be shared, these students in Wisconsin can use the data collected in Idaho to further their hypotheses and promote scientific collaboration.

Throughout the use of this approach research suggests that digital tools should be adopted in environmental education whenever possible (Hougham et al., 2016). To assess participant perspectives, DOTS uses a modified Common Measures instrument (National 4-H Council, 2017) to examine student attitudes towards technology and towards nature. In a 2015 study conducted by the DOTS project research team (Hougham et al., 2016), students where engaged in two iterations of an environmental studies curriculum- one was with traditional analogue toolsets and one was with digital toolsets. In an analysis of pre/post-test evaluation responses (n= 135), students showed statistically significant and positive shifts in attitudes towards technology, the use of technology outdoors, and towards investigating nature. In a review of the data from DOTS users for both profession development and youth workshops (n=71), it was found that 97% of participants of all ages agreed or strongly agreed that they "better understand how science, technology, or engineering can solve problems after using the DOTS tools", and 89% said they agreed or strongly agreed that they "liked learning about this subject".

This survey data provides insight on scaffolding and curiosity building techniques. In this way, it was found that lessons on observation were most useful when they began with broad scale observations and students were invited to make more focused observations. This system allows for students to explore a part of the world that they find interesting, making them more invested in a narrative authentic to them. The practice of up close observation is nothing new in environmental education, notably

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Adventures with a Hand Lens was published in 1962, advancing outdoor science instruction to engage the learner in their own investigations of the world up close. Today, this observation scaffolds easily onto data collection, with students studying parts of the ecosystem that they find interesting with encouragement to find how these seemingly individual pieces coalesce into a larger system.

In moving environmental education into the digital age, educators should look to empower youth with the tools and responsibility to examine their surroundings, and in encouraging youth to take and use technology outside, educators can capitalize on students collecting their own data sets to develop deeper, more meaningful inquiry questions. And when they can begin developing their own questions that they want to answer rather than following a worksheet or handout, the exploration becomes that much more desirable and satiating. Those young people wielding handheld weather stations and thermal imagers on the Salmon River or on the Wisconsin may appear to be kids collecting some information for science project, but don't be fooled, the next generation of scientists and scientific thinkers is out there, already developing their inquiries into the natural world. ❑

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