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TERC

HANDS ON!

02

SPECIAL INTERFACE FOR SPECIAL STUDENTS

Excerpt from 1983 Hands On! *by Bob Tinker shows that educational technology to improve access for all learners is ongoing at TERC.*

07

YOUNG PEOPLE DESIGNING GAMES ABOUT CLIMATE CHANGE

At a summer workshop, young people design games around the issue of climate change and learn systems thinking, mathematics, and model-building.

10

WHATS THE WEATHER? eBOOK

Teacher's Guide and separate Student Packet that run on computers, iPads, and mobile devices, optimize teaching and learning for all students.

14

ZOO LEARNING COMES TO LIFE

Action research from a collaboration between informal science education researchers and educators from zoos and aquariums.

03

FOCUS ON ENERGY

Addressing the challenges of the abstract nature of energy and the need for an innovative curriculum with teacher preparation.

Technical Education Research Centers, Inc. Summer, 1983 Vol. 6 No. 2

HANDS ON!

Microcomputers in Education — Innovations and Issues A nonprofit, public service corporation

We include this excerpt from an article in the Summer 1983 edition of Hands On! as an example of Bob Tinker's dedication to the use of technology to make STEM education accessible to all learners. The original article contains detailed descriptions of pioneering adaptations, such as voice typing and keyboards activated by a head-mounted laser pointer.

Special Interfaces for Special Students

It is now possible to make all software accessible to physically handicapped individuals. The seminal idea that makes this possible involves the use of an intelligent interface between the handicapped individual and the computer running the applications software. The trick performed by the interface is to make the handicapped individual's responses mediated through the interface indistinguishable from the inputs that the software expects from the user in a normal hardware configuration. In this article, we will describe some commercial interfaces of this sort and also show how easy it is to make one from an inexpensive microcomputer. For want of a better name, we will call these adaptive interfaces for special users, or, more simply, adaptive interfaces.

The Value of Adaptive Interfaces

There is now a considerable body of software that runs on microcomputers that we would like to make accessible to special students. This software includes explicitly educational software, languages, and powerful tools like word processors, filing systems, and financial packages. It would be wonderful if students with physical disabilities that prevented them from normal use of the microcomputer could still have access to this universe of software.

With an adaptive interface, everything that is special about a particular user is contained in the interface itself. It may require special hardware or software for each individual, but once that system is in place, any application software can be run without modification. In a sense, everything that is special about the computer for a particular handicapped student is confined to the adaptive interface. This means software and hardware is under your control and not part of a vendor-supplied package.

We feel that there is a great need for locally-generated adaptive interfaces. With these interfaces, a handicapped student can have access to the tremendously wide range of software currently available for microcomputers. This could aid in education as well as in communication and daily routines for individuals with a broad range of handicaps. We are anxious to hear from readers who undertake the construction of adaptive interfaces, and are willing to provide some limited technical support for these efforts.

— by Robert Tinker

Fig. 1: The adaptive interface in the center generates the electrical equivalent of keystrokes in response to head movement.

OCTOBER 2017

It is with humble pride that I submit my first letter to Hands On! as President of TERC. My journey at TERC began in 1994 as Controller. Over my 23 years here, I have been fortunate to work alongside incredibly gifted scientists, mathematicians, and researchers dedicated to furthering TERC's hallmark principles of creating equal access to effective curriculum and fostering a strong sense of agency in all STEM learners.

Bob Tinker, whom we sadly lost in June, was a pioneer and champion in the early days of TERC for educational technology for all learners. As I looked back at the Hands On! articles Bob edited, one from the summer of 1983 caught my eye, entitled "Special Interfaces for Special Students." Although technology continues to improve access for a multitude of learning styles and needs, this is not a battle won and done.

TERC's current efforts in the creation of signing science and math dictionaries for the deaf and hard of hearing, curriculum-integrated robotics for students with visual impairments, and neuro-cognitive research with learners with ADHD and high-functioning Autism, all highlight the commitment to access and equity that Bob ignited so many years ago, and which TERC is proud to continue.

— Laurie Brennan, President
October 2017

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FEATURE // BY SALLY CRISSMAN, SARA LACY, ROGER TOBIN, AND NICK HADDAD

Getting a Grip on ENERGY

When you look at a bird in flight, a train in motion, an apple on a window sill, or a windmill, can you tell a story about energy? Where is the energy coming from? How is it changing? How do you know? Now imagine fourth graders looking for evidence of energy in these same scenarios.

What do they have to say? Some students say the bird has energy because it's a living thing, but the apple doesn't because it isn't attached to the tree. Some say, the train's wheels have energy, but the train car doesn't because it's "just going along for the ride." They have many ideas about energy, but are missing a framework to tie them together.

Current science and engineering standards call for students to start learning foundational energy ideas in elementary school.[1] Thanks to its conceptual importance in all fields of science and engineering, and its relevance to important social issues, energy is widely acknowledged as a vital topic for K-12 science education.[3,7] However, studies show that existing instructional approaches are largely ineffective in bringing students to the kind of integrated understanding of energy that they need to meaningfully use energy ideas.[3,5,8]

Teaching and learning foundational ideas about energy in elementary school present a significant set of challenges:

1. Energy is abstract. Like matter, energy assumes different forms, flows within and between systems, and is conserved. But unlike matter, energy is not a material substance. How can students who are only nine or ten years old reason about something we cannot see, or touch, or even measure directly?
2. Researchers have identified four key energy themes (forms and transformation, transfer, dissipation and degradation, and conservation) that cannot be learned sequentially or in isolation.[3,5,8,9] This requires an upper elementary energy curriculum that weaves together these conceptual themes and advances them in tandem.
3. Elementary teachers feel unprepared to teach about energy—they need a solid understanding of the science, classroom activities, and resources.

Getting a Grip on ENERGY

FOCUS ON ENERGY TO THE RESCUE

Addressing the challenges of the abstract nature of energy, the need for an innovative curriculum, and the need for teacher preparation, TERC's *Focus on Energy* project has developed a 13-session curriculum for grades 4 or 5, supported by teacher professional learning, web-based resources, and assessments.

The *Focus on Energy* curriculum is comprised of a sequence of investigations of increasingly complex phenomena involving motion, elastic, and thermal energy. Each is framed by an investigation question, followed by firsthand explorations and activities, and the opportunity to make meaning. Students have multiple opportunities to apply and consolidate ideas about energy forms, transformations, transfer, and dissipation as they construct energy stories of ball collisions, elastic-band driven propellers, solar panels that can charge a capacitor, or temperature changes in the air of a "mini-room" warmed by a cup of hot water. Students using *Focus on Energy* go beyond simply identifying specific forms or transfers or transformations; they learn to track energy flow through each system. From the outset, students learn to use what we call the Energy Tracking Lens (ETL) and they use a set of representational tools to reason about energy flow and develop a model of energy.

Children investigate elastic energy.

The Energy Tracking Lens

PART 1. Describe what you observe.

PART 2. Tell the energy story.

- **What components are involved?**
- **Form(s) of energy?**
- **Increases and decreases in amounts of energy?**
- **Energy transfers?**
- **Change of energy from one form to another?**
- **Where does the energy come from and where does the energy go?**

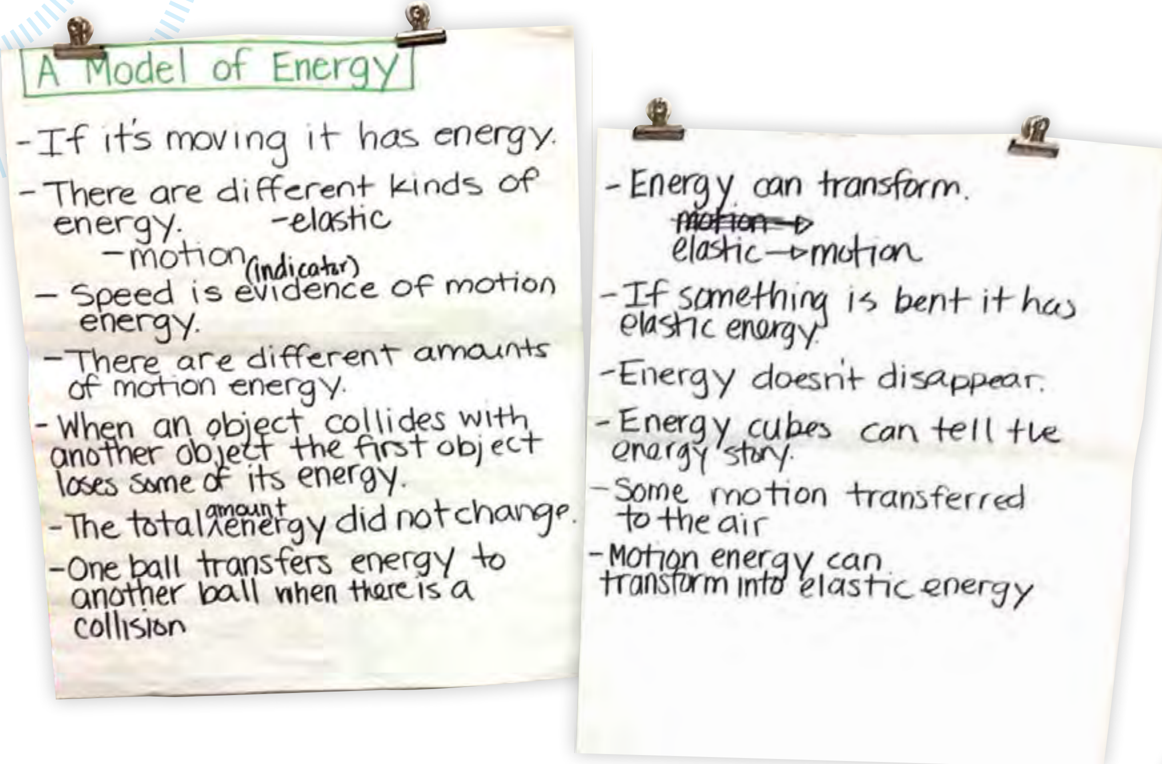
Use observations to support your energy story.

THE ENERGY TRACKING LENS (ETL)

The ETL provides a consistent framework and language that help students reason about energy flow in any phenomenon. The ETL begins with careful observation of an interesting phenomenon. Students describe what they observe, then use those observations as evidence of energy changes that they cannot see. Through a series of questions, students identify elements they'll need to tell the "energy story." Telling the energy story requires using the evidence they can see to infer or reason about the energy they can't observe directly. Implicit in the last question is the idea that energy is conserved—like matter, it cannot just appear or disappear, and whenever there is a decrease, there is an increase in some other forms or places. With the ETL, students begin to look at energy through the eyes of a scientist.

A MODEL OF ENERGY

Since energy is an inherently abstract concept that cannot be directly observed, the study of energy both demands and is an ideal context for modeling-based teaching and learning. The curriculum begins with an easy to observe motion phenomenon: a collision between a ball in motion and a stationary ball on a horizontal track. Students begin to generate a model in response to the question, "What can motion tell us about energy?" The class collectively adds to and revises the model throughout the unit uses it to construct sophisticated explanations of energy flow.



An emerging classroom model of energy.

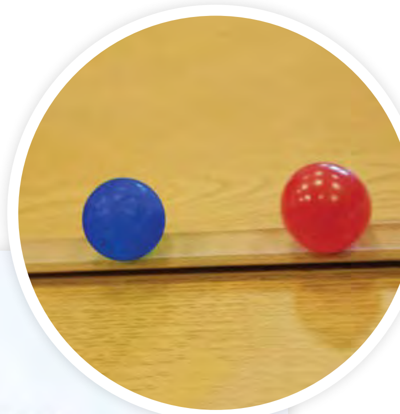
REPRESENTATIONAL SCHEMES

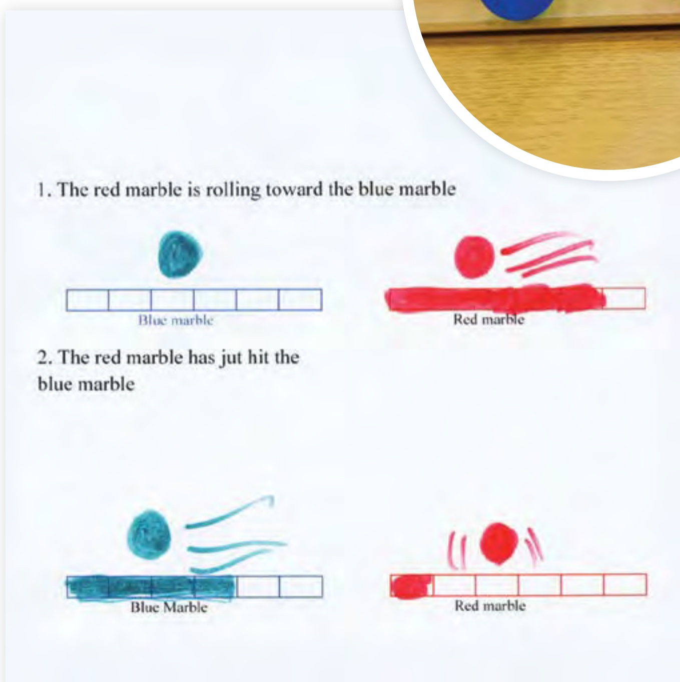
Representational schemes support model-based reasoning,[4,11] and the curriculum introduces representational tools that allow students to track energy flow in a flexible, context-independent way. Students use these representations to make the invisible visible, and to reason about the energy flow.

Energy Bars

Energy bars are introduced to show gains and losses during a collision and to convey the idea of energy as a quantity.[2,6] Students use the observable evidence of energy, in this case speed, to determine how many energy bars to color in. "The blue ball wasn't moving so I gave it zero energy bars but after the red ball collided with it, it moved pretty fast so I gave it four energy bars. I think it got its energy from the red ball. The red ball started out with five bars and after the collision it hardly moved at all, so I gave it one. It lost most of its motion energy."

Students use this single, versatile representation to show changes in motion energy, elastic energy, and thermal energy, reinforcing the idea that all forms of energy are the same stuff, and that the same tools and ideas can be used to analyze energy across a wide range of phenomena.





Students use energy bars to reason about energy gains and losses.

FEATURE // CONTINUED

Getting a Grip on *ENERGY*

Students use energy cubes to reason about energy flow.

Energy Cubes

A key *Focus on Energy* representational tool is Energy Cubes.[10] Units of energy are represented by small cubes similar to dice. Cube sides are labeled to indicate different energy forms, such as M for motion or Th for thermal. Students draw circles on a whiteboard to represent what they consider the relevant components of a system. They have six energy cubes to distribute among the components, based on their reasoning from observations. The representation provides a context and tool for co-construction of meaning.

Groups of students negotiate which components to represent and how to tell the energy story. They move and flip the cubes to represent energy transfer and transformation while holding one another responsible for consistency both with their observations and their overarching model of energy.

Sketches, Diagrams and Drawings

As they create a drawing, or sketch of their ideas, students take another look at their thoughts about an energy story. As they share their ideas, they ask, "Am I accounting for everything? Does this still make sense to me?"

A FRAMEWORK FOR THE FUTURE

Teachers and their students are finding the *Focus on Energy* activities engaging and motivating and we have seen students learn to use the tools in a remarkably short period of time. Armed with an emerging model of energy, a set of representational tools, and a common language, students are poised to apply energy ideas in their future school work as well as in their everyday life. Energy is abstract, but the *Focus on Energy* Project is bringing a new level of reasoning about energy to elementary classrooms.

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TO LEARN MORE: foeworkshop.terc.edu

FEATURE // BY GILLIAN PUTTICK & ELI TUCKER-RAYMOND, TERC, &
JACKIE BARNES, NORTHEASTERN UNIVERSITY

"We have to step up and do something"

Young People Designing Games About CLIMATE CHANGE

What happens when you let young people be in charge of designing a game about climate change? Do their environmental attitudes shape the game, or does the design process change their positions? As it turns out, the answer is: Both.

Edy and Ciara creating their games.

Building Systems from SCRATCH

As game design software has become accessible to young people, researchers are harnessing this technology to teach systems thinking, mathematics, and model-building. In any game environment, players can interact with a dynamic system and feel empowered by seeing the immediate consequences of their actions. As game designers, they have even greater agency.

We designed a summer workshop where young people could design games around the issue of climate change. On the first day of the four-day intensive workshop, middle school girls learned the programming language Scratch (scratch.mit.edu), in which commands are colored blocks that snap together rather like visual Lego®. Then as a group, they completed a concept mapping activity to form connections about climate systems. They watched a video on climate change, and visited a local wetland to observe and discuss how the reserve's characteristics relate to climate change.

We asked them to think about how people choose to use certain kinds of energy sources, connect those decisions to climate change, and then create a game to help other young people make these connections. They spent the next three days working alone on their designs and conducting user testing in pairs. At the end, they elaborated on the concept map to display all they had learned, and then gave a presentation to their families and community members.

Young People Designing Games About CLIMATE CHANGE

I learned about carbon sinks and methane and how the environment is really in drastic need of help . . . I thought we weren't as endangered as we are right now.

All of the programmers chose to focus on the causes of climate change and on ways to sequester the greenhouse gases methane and carbon dioxide. All of them said they hoped the games would have an impact on players' understanding of the issues and on their behavior. We are going to focus on the games developed by two students, Ciara and Lane, who had differing levels of Scratch experience, and whose environmental values differed.

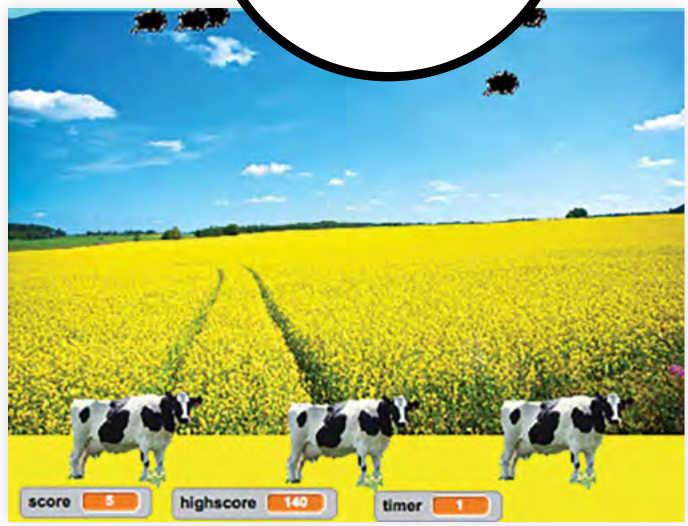
Ciara

With more than a years' experience with Scratch under her belt, Ciara was able to create three games, two of which focused on helping players learn about actions that can reduce greenhouse gas levels. The first game involved the capture of methane "farts" from cows.

Coming into the workshop, Ciara had conflicting views about climate change, agreeing with two contradictory statements: "Global warming isn't happening" and also "Humans can reduce global warming and will do so successfully." After the workshop, Ciara changed her initial statement that she had no intention of speaking with her friends about climate change, and she talked about what she had learned:

"I learned about carbon sinks and methane and how the environment is really in drastic need of help... I thought we weren't as endangered as we are right now. Because [the video] talked about these are the hottest years we've ever had, in recorded history and stuff like that. So I hope people learn that they need to do their part to help the environment, because we all need to help, because the environment is getting worse, and we have to step up and do something."

This change shaped the design of the next two games, with the goal of teaching others how to "do their part to help the environment." Her second game was a quiz about sources and sinks for carbon, which ended with an information screen that explained the connection between trash incineration and greenhouse gases. The third game asked players to sort items into trash or recycling.



Screenshots from Ciara's games on methane pollution and recycling.

CO_2

Lane

Lane created a game that asked the player to use plants to sequester carbon dioxide, with the goal of teaching players that plants have different uptake capacities, and that their capacity had limits. Her love of nature is evident in her hand-drawn depictions of a variety of plants and animals in the game.

Lane came into the workshop with no prior Scratch experience, and a strong attitude towards the need for environmental protection and for talking with others about climate change. She placed conservation above considerations for her own convenience, comfort, or money. She was keen to spread the word, saying people "could talk about global warming a lot and someone could overhear it, someone could get a spark in their head to do something."

Throughout the workshop, Lane expressed worries about the looming impacts of climate change and the inaction of society, saying people are "living their lives, not ignorant, but in willing ignorance." Her anxieties about inaction are depicted quite literally through a smiling couple sitting on a fence, and surrounded by other people enjoying the outdoors, despite a looming cloud of carbon dioxide above them. The "Buy Time" stand allows players to sacrifice points in order to add time to the game, but ironically, in the real world they have little time left to buy.

After the workshop, Lane remained certain that people are not willing to change their behavior, but she grew in her convictions to speak with others in order to motivate them toward action.

Several studies have reported that many young people feel worry and powerlessness about global problems, including climate change. We believe that teachers should encourage students to verbalize those emotions, focus on problem-solving strategies, and work together on concrete plans of action.

ACKNOWLEDGMENTS

We are grateful to Amanda Strawhacker for her back-up technical support during the workshop. This work was supported by TERC, and in part by grant #1542954 from the National Science Foundation. Any opinions, findings, conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the view of the National Science Foundation.

Screenshot from Lane's game on using plants to take up CO_2.

She was keen to spread the word, saying people "could talk about global warming a lot and someone could overhear it, someone could get a spark in their head to do something."

FURTHER READING

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TO LEARN MORE: buildingsystems.terc.edu

BY JUDY VESEL & TARA ROBILLARD

Introducing the Inclusive *What's the Weather?* eBook

Background

What are the temperature and moisture of the air in our schoolyard? What is the speed of the wind? Is air pressure rising, falling, or steady? With the arrival of "network science" in 1987[1], students in grades 3-6 became involved in conducting science experiments to answer questions such as these and then sharing their results through a telecommunications network. Spearheaded by TERC, in partnership with the National Geographic Society and with funding from NSF, this new use of technology for education resulted in the NGS Kids Network. Each of the Kids Network units, including *What's the Weather?,* focused on a topic that is typically taught in the elementary grades, is relevant to students' interests, and lends itself to data sharing. As technology advanced and the Internet and mobile devices became a reality, the units were revised several times but retained their initial structure and focus. Most recently, encouraged by the increasing use of iBooks in classrooms and broader use of Universal Design for Learning (UDL)[2] as a framework for optimizing teaching and learning for *all* students, TERC began to explore revision and redesign of the units as universally designed iBooks. The inclusive *What's the Weather?* eBook is a result of this effort.

eBook Components

The eBook includes a Teacher's Guide and a separate Student Packet that run on computers, iPads, and mobile devices with iOS operating systems and an Internet connection. The Teacher's Guide includes: an Overview of the unit; Implementation Tips about features such as navigation and accessibility options; and six Chapters, five of which correspond to the sessions of the original Kids Network unit. Unlike the original unit, which required doing the sessions in their entirety in sequence, chapters are structured so they can be done individually, grouped together with one or more chapters, and done in any sequence. This flexibility allows teachers to fit the unit into their core science curriculum however and whenever they choose. Also unlike the original unit, the chapters offer opportunities for students to collect data for their local area online using established links to Web sites with informative, subject-specific, scientific information—sites that are likely to remain active and current for many years. In addition, students can conduct many of the original hands-on experiments that also produce local data that can then be displayed and analyzed together or independently.

Chapter Questions

Using this updated structure, students doing the inclusive *What's the Weather?* eBook explore five chapter questions that are the same as those in the original unit:

1. **What Is Weather?**
2. **What Is the Moisture of the Air?**
3. **What Is the Temperature of the Air?**
4. **What Is the Pressure of the Air?**
5. **What Is the Speed of the Wind?**

A completely redesigned Chapter 6 gives students the opportunity to select locations they would like to use for collecting weather data online and to decide on the number of data-collection days, what data they will collect, and how they will record the data. Links to data-display tools give students opportunities to create displays of their data and to use their findings to describe what the weather is in the locations they have selected. Ultimately, the activities are intended to enable students to define weather as the sum of moisture, air temperature, air pressure, and wind.

Standards Alignment

As far as alignment with Next Generation Science Standards (NGSS)[3] is concerned, Chapters 1-6 support the Earth and Space Sciences (Earth's Systems, Weather and Climate). "Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather" (ESS 2.D). Chapter 2 also aligns with Physical Sciences (Matter and Its Interactions, Structure and Properties of Matter) and with Earth and Space Sciences (Earth's Systems, The Roles of Water in Earth's Surface Processes). "Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature" (PS1.A). "Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation" (ESS2.C).

Chapter Components

Pedagogical information for each of the six chapters is provided in the Teacher's Guide as follows: Description—summarizes what students will do. Goals—lists the intended results. Activity—has procedures and hyperlinks for online data collection. Assessment—provides guidelines for evaluating the extent to which the goals have been accomplished. Alignment with the NGSS—lists the standards supported.

Each chapter for students includes a Reading and an Activity Sheet. The Reading has text-based information about the chapter's science content. An alphabetical list of terms at the beginning of the Reading links to a chapter glossary. The glossary offers students the option to read a definition in English, view an illustration that conveys the meaning of the term selected, or view an ASL video of the term and its definition. Terms included in the glossary were researched and developed in conjunction with TERC's Signing Math & Science initiative (signsci.terc.edu), funded in part by NSF and the U.S. Department of Education. The definitions convey, in English and in sign, information that is scientifically accurate and age-appropriate and that can be fully understood by our target audiences. The Reading also includes a link to a chapter image gallery with audio description of all the graphic elements, and a link to an interactive quiz. The Activity Sheet includes the procedures for the activity—these match those described in the Teacher's Guide—and hyperlinks to the sites that are to be used for data collection or to find out about the chapter's core science content. An audio icon provides access to all text that appears in the Readings and Activity Sheets as computer-synthesized speech.

Activity Sheets and Readings are included in the Teacher's Guide. A Student Packet of the Readings and Activity Sheets is provided in eBook, PDF, and Word format, with space for students to record data and write.

Example of an entry in the glossary.

Introducing the Inclusive *What's the Weather?* eBook

Integration of UDL Principles

Taken together, the interactive features incorporated into the unit are consistent with the three principles of Universal Design for Learning. These are:

1. **Learners can acquire information in different ways.**
2. **Learners are provided opportunities for demonstrating what they know.**
3. **Learners are offered opportunities that make sense and are interesting.**

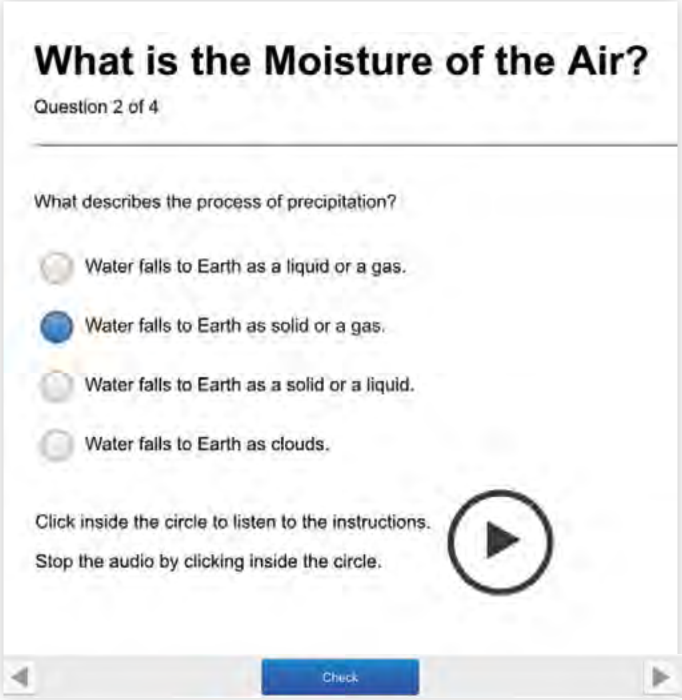
Addressing Principles 1 and 3, students have opportunities with the *What's the Weather?* eBook to: do hands-on inquiries and/or experiments; conduct online research; read English text using appropriate text size; listen to English text presented as audio; view illustrations; listen to audio descriptions; look up the meaning of terms as text, audio, or sign; collect, display, and/or analyze data; work individually and/or in groups. Addressing Principles 2 and 3, students have opportunities to: engage in oral explanations and/or conversations; write paragraphs and/or research reports; answer multiple-choice questions; set up and do experiments; collect, record, and/or analyze experimental and/or online data.

Preliminary Evaluation

Six teachers downloaded and reviewed the iBooks and PDF versions of the unit using the computer or device of their choice, and each completed an online survey. Results supplied answers to four primary research questions:

1. **Are teachers able to download and install the components?**
2. **How do teachers envision integrating the unit into the curriculum and into classroom practice?**
3. **What is the anticipated usability of the instructional design?**
4. **What is the anticipated usability of the accessibility features?**

Results of this preliminary evaluation indicate the unit is a resource that teachers could envision implementing in their classroom. The unit (or parts of it) would fit into their existing curriculum and address areas or concepts that they normally teach. With regard to usability of the instructional design, one teacher who works with students who are either deaf/hard of hearing or visually impaired says: "I would work with the general education classroom teachers to embed the eBook into the regular education science class so that my students could work with their peers. Another teacher would take a different approach and would prepare on her classroom computer using the PDF. Then she would have students work with the eBook version in the computer lab so that they could use some of the accessibility resources."



Example of an Interactive Quiz Page.

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FEATURE // BY ANDEE RUBIN

Zoo Learning Comes to Life

IMAGE COURTESY OF SAINT LOUIS ZOO

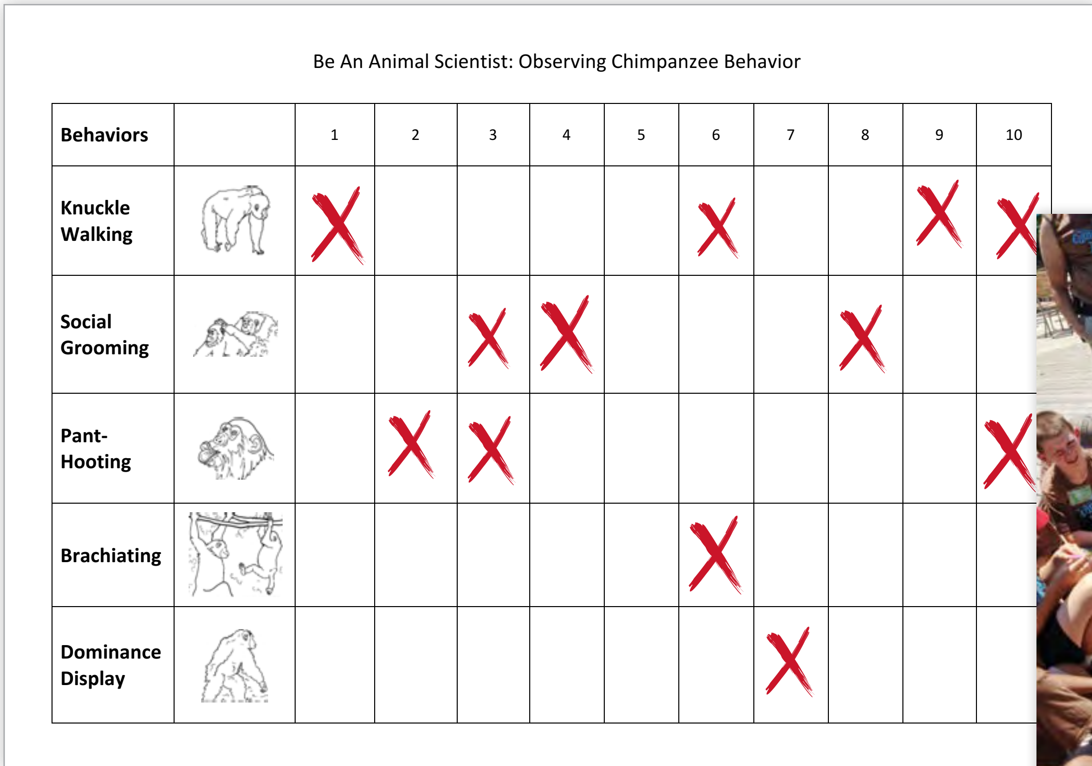
Zoos and aquariums attract millions of visitors each year, presenting a unique opportunity for informal science and math education in the context of "living collections." Zoo and aquarium educators, however, rarely have the opportunity to reflect critically on their jobs or to observe visitors closely to understand their experiences.

The Zoo and Aquarium Action Research Collaborative (ZAARC) addressed this gap by involving educators in action research, that is, research on issues arising from their own practice. ZAARC formed a collaboration between informal science education researchers and educators from four zoos and two aquariums: Maryland Zoo in Baltimore, Phoenix Zoo, Saint Louis Zoo, Woodland Park Zoo (Seattle), Aquarium of the Pacific (Long Beach), and New England Aquarium (Boston).

The goal of ZAARC was to investigate how educators might carry out action research, and how it would impact both themselves and their institutions. We chose action research because it empowers educators to study and analyze their own practice, guided by questions that arise from everyday events and dilemmas.[1,2] The ultimate goal of action research is to improve practice—in this case, to improve visitors' experiences. We wanted to help zoo and aquarium educators focus more intentionally on visitor engagement and develop a shared language to describe visitor experiences. We also hoped that participants would increasingly see themselves as members of a professional community with an ability to make a difference in the field.

ZAARC

Above: Camp KangZoo participants at the Caribbean Cove touch pool at the Saint Louis Zoo.



Be An Animal Scientist: Observing Chimpanzee Behavior

Behaviors		1	2	3	4	5	6	7	8	9	10
Knuckle Walking		X					X			X	X
Social Grooming				X	X				X		
Pant-Hooting			X	X							X
Brachiating							X				
Dominance Display								X			

Be an Animal Scientist *data sheet filled in after an observation session at the chimpanzee exhibit.*

Saint Louis Zoo educator Bridget Ebert graphing data from the BAAS *activity.*

IMAGE COURTESY OF SAINT LOUIS ZOO

ZAARC developed a model of Mentored Team Action Research. Participants worked in teams of two to four from each of the six zoos and aquariums, because we believed groups would be more likely than individuals to find the time and resources to carry out an action research project. A team also provided a natural context for the kind of reflective discussions of evidence that are a critical part of action research. We realized that taking on an action research project would be a novel and challenging experience for participants, so each team also included two mentors from TERC, Oregon State University, and/or California State University, Long Beach.

During the three-year ZAARC project, each team engaged in two action research projects. First, everyone implemented the *Be an Animal Scientist (BAAS)* activity, in which zoo visitors track, record, and graph animal behavior. As they observed visitors, ZAARC participants focused on identifying and measuring visitor engagement. Each team chose its own species for this activity, including flamingos, chimpanzees, sea lions, stingrays in a touch pool or lorikeets in an open aviary.

A Sample Action Research Project

Next, each site carried out distinct action research projects. For example, the Saint Louis Zoo team studied the impact of introducing the *BAAS* activity in three exhibit contexts, which differed in terms of their level of interactivity between animals and visitors. The low-level interactive exhibit was the addax (an endangered antelope); the mid-level one was the chimpanzee, and the high-level exhibit was the stingray touch tank. They hypothesized that visitor engagement would increase when the *BAAS* activity was introduced, and even more so at the low-level exhibit.

The team measured engagement by how long visitors stayed at an exhibit and by the frequency of behaviors that indicated thoughtful engagement, such as drawing conclusions and displaying positive emotions. Their data confirmed their hypotheses: time spent at either the addax or the chimpanzee exhibit increased significantly when visitors participated in *BAAS.* At the addax exhibit, average time increased from 39 seconds to over 7 minutes and at the chimpanzee exhibit, average time increased from just over a minute to over 9 minutes. The team used these data to advocate for introducing more such activities at the zoo, especially at exhibits where visitors otherwise tended to spend only a short time.

Zoo Learning Comes to Life

IMAGE COURTESY OF SAINT LOUIS ZOO

Other teams examined issues such as the impact of educational programs on visitors' engagement, evidence of empathy among young children in nature-based playspaces, and the effect of structured reflection time on staff's perception of themselves as interpreters. This wide array of projects reflects the different needs of each institution and demonstrates how each team incorporated a lens of learner engagement into the examination of their practice.

Participant Perspectives

At the conclusion of the three-year project, we conducted exit interviews with the ZAARC participants to explore their perspectives on the project. Several educators remarked how the research process was an important part of professionalizing the field of informal education, such as the one who commented, "I walked away with...this understanding that there was a lot more research and kind of a more formalized framework that I could build off of as an informal educator than I ever imagined possible." This insight came both from participants' appreciating the importance of evidence for improving practice, and from recognizing that other researchers were studying and reporting on the same issues that they were experiencing in their own practice.

"I walked away with ... this understanding that there was a lot more research and kind of a more formalized framework that I could build off of as an informal educator than I ever imagined possible."

Participants described a new appreciation of observational approaches for gathering data about visitor experiences. The idea of using observation as a tool for assessment was powerful to many participants, despite the time and effort such approaches require. One commented, "We were able to step back and watch an activity take place and then look or

Above: Camp KangZoo participants discussing animal behaviors they observed at the Saint Louis Zoo.

“I feel like I learned a really easy, structured way that I can strategically improve my practice... and the programs that I do — whether they are for other educators, or for students... that I can use forever.”

kind of determine what we wanted to see as an outcome [compared to] what we were seeing; made some decisions on how we wanted to change that and then we would immediately make the changes within the activity and then step back and watch again.”

For many participants, doing action research allowed them the opportunity to reflect on their own practice—something they rarely had time, or even the intention, to do. Some even defined action research as a reflective tool: “I think this project gave me access and avenues and time to both read articles and kind of reflect on our programs in a new light, but also reflect on our programs with other people with a shared language, which has been very helpful.”

ZAARC educators also reported an increased sense of value to their institution. Some educators reported that their efforts changed their “status” within their institution, and some felt that colleagues in other departments were now more aware of their talents and contributions. “I don’t know if it changed how I saw myself, but I can tell you it changed how a lot of other people saw me. I knew I could do this stuff, like that’s not surprising to me.... I now have people asking me for help on stuff that [they] would never have had probably asked me for help before.”

Many participants commented that action research had helped them to define or achieve their institution’s mission, as it became necessary to revisit their goals when considering which outcomes might count as evidence for various audiences. For instance, one said, “I feel like I learned a really easy, structured way that I can strategically improve my practice... and the programs that I do — whether they are for other educators, or for students... that I can use forever.” For this educator and the other project participants, the ZAARC project provided a valuable professional development experience through action research, contributing to improvements in practice, creating opportunities for practitioners to reflect on their work, and enhancing the professionalism of the field of informal education.

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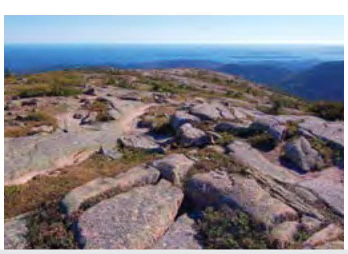
iSWOOP
interpreters and scientists working on our parks



SCIENCE IN THE PUBLIC EYE: LEVERAGING PARTNERSHIPS

San Francisco Marriott Marquis
January 6, 2018 • San Fransisco, CA

Museum exhibit designers, endangered species researchers, citizen science leaders, and iSWOOP project leaders will meet in San Francisco January 6 making their case for scientists to increase the visibility of their cutting edge research by exploring partnerships with informal educators. In parks and other informal spaces, the sky is the limit, the science goes deep into the earth and the ocean. Adults and children are invited to touch, to talk, and to puzzle over some of the same questions that drive scientists' work.

Those with an interest in the rich rewards that come when scientists and those in informal venues like parks and museums collaborate are invited to attend. Learn more about the trade-offs and compromises, as well as the rewards. Register for the annual conference or join the Society for Integrative and Comparative Biology.

sicb.org/meetings/2018

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