ATLAS
Always Think Like a Scientist

A Smithsonian Science Education Center Program

Santa Fe ATLAS
Always Think Like A Scientist

Comprehensive Guide to Implementing the ATLAS Program in Your Community

Smithsonian
Science Education Center

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Introduction

Dr. Carol O'Donnell

The Smithsonian Science Education Center is part of the Smithsonian Institution, a non-profit organization, whose mission is to increase and diffuse knowledge. The Smithsonian is the world's largest museum, education, and research complex. It is made up of 19 museums, 9 research centers, 3 cultural centers, a zoo, 21 libraries, and 4 education centers. The Smithsonian understands deeply the importance of integrating history, art, culture, and science. The Smithsonian Science Education Center is the only organization within the Smithsonian whose sole mission is to transform K-12 Education through ScienceTM in collaboration with communities across the globe.

In July 2017, the Smithsonian signed a Memorandum of Understanding (MOU) with the Global Partnership for Science Education through Engagement (GSEE), under the direction of renowned physicist Dr. David Pines—founder of the "Think Like a Scientist" (TLS) initiative. Through the MOU, the Smithsonian agreed to take responsibility for two initiatives:

1. **Network for Emergent Socio-Scientific Thinking (NESST)**- a global movement that recognizes, connects, and expands the efforts of individuals and organizations seeking to stimulate all students to understand complex socio-scientific issues through the lens of "emergence"
2. **Always Think Like A Scientist (ATLAS)** – a near-peer mentoring program for middle school and high school students, which tests the idea of "emergent socio-scientific thinking" by engaging youth in discovery, understanding, and acting upon complex socio-scientific issues through place-based learning. ATLAS is a supervised after-school program that young people regularly attend when school is not in session including out-of-school time directly after school, or during evenings, weekends, summer vacations, and holidays.

Grounded in the most current research in science and socio-scientific thinking, the content-rich ATLAS program serves as a platform for helping middle school students engage with complex socio-scientific issues and advance their 21st century skills. These skills include their ability to collaborate with others, learn from their mentors and partnering scientists, learn through technology and citizen science games, think and reason abstractly, and engage in an emergent universe that is constantly in flux.

Given the unprecedented challenges our world faces (such as ecosystem loss, deforestation, climate change, and water scarcity), teachers, today, more than ever before, need to gauge student thinking in order to design instruction and help students solve complex socio-scientific problems for which there is no one solution. Yet 2015 NAEP data show that only 25% of 4th graders in the US have teachers who emphasize teaching scientific inquiry skills “to a large extent”. Moreover, research indicates there is not adequate time during the day for elementary or middle school teachers to teach science at regular intervals and with lessons of sufficient duration (NRC, 2013). In addition, students often do not have opportunities to collaborate with knowledgeable others to experiment with scientific ideas and engage in community projects that address complex problems. We need solutions that deepen students’ scientific expertise and allow their mentors to engage students in “emergent socio-scientific thinking” through the lens of local community-based research.

To address this challenge, ATLAS engages teachers, students, scientists, citizen scientists, museum specialists, game designers, and others collaboratively in scientific and socio-scientific thinking, reflecting on practice, and receiving support from knowledgeable others. A beta test in Aspen paid by local philanthropy proved this is possible.

This guide is designed to help you bring ATLAS to your community.

We believe emerging technologies give teachers and scientists the ability to create resources and activities designed to inspire students to think like scientists, provide teachers with ways of thinking about the science they teach from multiple perspectives, connect engaged teachers and students to mentors from the local scientist community, and inspire all involved to a call for action. This, in essence, is the foundation of the ATLAS program. ATLAS will explore what we can do together that we cannot do separately and search for synergies among many approaches that are being pursued simultaneously.

We hope this guide proves helpful as you begin your journey to catalyze students to think like scientists—skills that are critical to developing a global, scientifically literate citizenry.

Best,

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ATLAS: The Role of Emergence

ATLAS is a program in which high school students act as Lead Explorers who engage middle school students in ideas, concepts, and methods that help them learn to think like scientists using local socio-scientific issues as the framework for "place-based learning". The guiding philosophy of ATLAS is, "What we don't understand, we explain to each other." It involves learning in teams and makes great use of online Smithsonian resources beginning with an introduction to emergence, emergent behavior, and what it means to live in an emergent universe.

ATLAS incorporates into every major deliverable two crosscutting themes: the role of emergence, emergent socio-scientific thinking, and emergent behavior; and an emergent-based strategy for solving complex socio-scientific problems evident in the community (such as clean water, food scarcity, climate change, biodiversity loss, plastic consumption and production, etc.).

Emergent socio-scientific thinking is defined as a multi-faceted approach using emerging technologies, citizen science, hands-on inquiry, games and simulations, and highly immersive community experiences (such as trips to local museums or businesses to see science in action). In emergent socio-scientific learning, **because of the many possible interactions and synergies between these different modes, the whole becomes much more than, and different from, its parts.**

Therefore, emergent socio-scientific thinking involves learning how to think like a scientist in some or all of the following ways:

- in teams, face-to-face, online, out of school, and in school with teachers who have been given the necessary tools
- from a variety of mentors (high school students, undergraduates, scientists)
- from innovative educators, citizen scientists, science museum leaders, game designers, each describing their research
- from games, simulations, multi-media, videos of scientific

phenomena, videotaped and live interviews with scientists, visits to science museums

- by focusing on overarching concepts such as emergent behavior and phenomena, equilibrium and far-from equilibrium behavior, linear and nonlinear behavior
- through emerging technologies (e.g., IOLAB sensors, augmented reality, 3D printing) to devise and carry out experiments
- through new paradigms and citizen science games (e.g., Research-Enabling Game-Based Education (REGBE) from ScienceAtHome)

ATLAS:

- promotes partnership between engaged community scientists and engaged education innovators in community settings using the community as the laboratory
- focuses on carrying out experiments
- incorporates important emerging technologies into every major deliverable
- is multi-modal
- focuses youth on discovering, understanding, and acting on local and global socio-scientific issues

Sessions may include:

- interactions with near-peer and science mentors
- community-based surveys
- place-based learning
- project-based learning
- identity mapping
- virtual reality exploration
- using sensors to measure and collect data
- games, simulations, and citizen science experiments
- hands-on experimentation
- field trips and other highly-immersive experiences in the community

The goal of ATLAS is to experiment with near-peer learning and emergent socio- scientific thinking and, in so doing, create a model for the Network for Emergent Socio-Scientific Thinking (NESST) of the Smithsonian Science Education Center in order to expand the program statewide, nationally, and worldwide.

Parents have an important role in all of this as well. Students in this program are participating in a fluid learning process in which curiosity is encouraged, mistakes are made, and emergent thinking is emphasized. Therefore, support is important in helping students truly think like scientists and take risks to extend their curiosity. In the end, the program will help students be skeptical, be complex problem solvers, and look for connections in their findings so that they can grow as citizens and become effective critical thinkers.

This guide is based on the pilot of ATLAS in Aspen, CO called "ATLAS Aspen" and has been modified to include ideas from ATLAS in Santa Fe, NM. Other communities could copy the ATLAS Aspen and ATLAS Santa Fe approaches, scale it back, or ramp it up depending on their interest and community enthusiasm. The concepts can be explored with a small group of committed individuals and could be scaled up to involve the entire community. Lifelong emergent learning about local and global socio-scientific issues is the goal and this goal can be achieved through many avenues.

NESST and ATLAS are part of a broader program called "Think Like a Scientist" (TLS). To learn more go to http://tls.scienceathome.org

Background Information

ATLAS should familiarize students with how science and scientists work while helping students use their scientific knowledge to engage in civic decisions in their communities and enhancing students' scientific (and socio-scientific) literacy. Our job as science educators is not only to prepare our students for college and career and support students who may go on to enter the STEM workforce, but it is also to ensure that all students become scientifically literate global citizens.

Scientific Literacy

The National Academy of Science (NAS) report, "Science Literacy: Concepts, Contexts, and Consequences" (https://www.nap.edu/catalog/23595/science-literacy-concepts-contexts-and-consequences) defines "science literacy" in this way:

Science is a way of knowing about the world. At once a process, a product, and an institution, science enables people to both engage in the construction of new knowledge as well as use information to achieve desired ends. Access to science—whether using knowledge or creating it—necessitates some level of familiarity with the enterprise and practice of science: we refer to this as science literacy.

Science literacy is desirable not only for individuals, but also for the health and well-being of communities and society. More than just basic knowledge of science facts, contemporary definitions of science literacy have expanded to include understandings of scientific processes and practices, familiarity with how science and scientists work, a capacity to weigh and evaluate the products of science, and an ability to engage in civic decisions about the value of science. Although science literacy has traditionally been seen as the responsibility of individuals, individuals are nested within communities that are nested within societies—and, as a result, individual science literacy is limited or enhanced by the circumstances of that nesting.

Systems Thinking

In many countries the vision for improving science literacy through improved science education has been difficult to realize, but there are numerous efforts underway. States across the U.S., for example, have recently or are in the process of adopting new college and career ready K-12 science standards based on the U.S. National Academies' Framework for K-12 Science Education. The Framework calls for significant changes in how science is taught. It provides a vision of science education where there is renewed focus on core ideas, scientific practices, crosscutting concepts and student driven learning opportunities. The goal of the Framework is to ensure that all students actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of core disciplinary ideas.

The K-12 Framework that served as the foundation for the Next Generation Science Standards (NGSS) has as one of its Crosscutting Concepts (CCC) a focus on "Systems and System Models". The progression for this CCC follows:

4. Systems and System Models			
A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.			
Primary School (K-2)	**Elementary School (3-5)**	**Middle School (6-8)**	**High School (9-12)**
Systems in the natural and designed world have parts that work together. Objects and organisms can be described in terms of their parts.	A system can be described in terms of its components and their interactions. A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.	Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models are limited in that they only represent certain aspects of the system under study.	When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Systems can be designed to do specific tasks.

The NAS *K-12 Framework* defines a *system* as "an organized group of related objects or components that form a whole." It states that often, "the parts of a system are interdependent, and each one depends on or supports the functioning of the system's other parts. Yet the properties and behavior of the whole system can be very different from those of any of its parts, and large systems may have **emergent** properties, such as the shape of a tree, that cannot be predicted in detail from knowledge about the component and their interactions" (p. 92 of the *Framework*).

It is our contention that students need to understand that not all scientific behavior can be predicted, and that uncertainty in science (including uncertainty related to socio-scientific issues such as climate change or infectious disease) are just as important as the ability to predict. We also contend that helping students understand that while some systems are simple (e.g., a pen), and others are complicated (e.g., moving water through a pipe), many systems (including socio-scientific issues) are complex and therefore, more difficult to predict (e.g., climate change). As the Framework states, "In more complex systems, it is not always possible or useful to consider interactions [at a] detailed mechanical level, yet it is equally important to ask what interactions are occurring…and to recognize that they will involve transfers of energy, matter and (in some cases) information among parts of the system" (p. 93.)

Emergence

When electrons or atoms or individuals or societies interact with one another or their environment, the collective behavior of the whole is different from that of its parts. We now call this resulting behavior "emergent." ***Emergence*** refers to collective phenomena or behaviors in complex adaptive systems that are not present in their individual parts. Emergence is used in the fields of physics, biology, fine arts, and philanthropy, among others. From the discovery of novel ordered states in quantum matter to eggs cooking, birds flocking, collective behavior in ant colonies, the development of consciousness in infants, the latest measurements on the early universe, or global climate change—emergence is all around us. Simply put, emergence is the view that the whole is greater than and different from its component parts.

The focus of ATLAS is on teaching "**emergent socio-scientific thinking**" – that is, exploring **complex socio-scientific problems** with the understanding that interactions between people and matter and the environment lead to unexpected consequences and unpredictable behavior. ATLAS espouses that "emergent socio-scientific thinking" is essential for all students to be able to explore the complexities of the natural and man-made world and then to use their new-found knowledge to do social good in their community.

ATLAS incorporates the concept of near-peer mentoring where peer-led instruction models are brought to the students to promote the disciplinary habits of practice. When students see themselves enacting the practices of seasoned students, they are more likely to develop the identity of a scientist. The classroom becomes a community of practice, promoting inclusion and a sense belonging. In turn, students who participate as Explorers are more likely to mentor future Explorers creating a waterfall effect for future Lead-Explorers.

ATLAS Aspen and ATLAS Water in Santa Fe provide examples of the ATLAS programs that have been successfully implemented:

- ATLAS Water is an after-school science program consisting of 12 elementary school students at Piñon Elementary School in Santa Fe, New Mexico. It teaches kids principles to “Always Think Like a Scientist.” Developed by Santa Fe Public School teacher Delara Sharma and local scientist Joel Berendzen for the Smithsonian Science Education Center in Washington, DC, ATLAS Water explored local and world history of water infrastructures. Using socio-scientific issues-based instruction, the team examined the impacts of climate change, modeled Santa Fe’s access to water in 2040, and compared the future of Santa Fe to the catastrophe of Angkor, Cambodia.
- ATLAS Aspen included two Aspen High School students, participating as mentor-type instructors to middle school students in a program titled “Always Think Like a Scientist,” or ATLAS, on early-release Wednesdays. Jackie Francis, a former director of the Aspen Science Center now with TLS/Aspen, led the club’s effort of thinking like a scientist and emergent thinking. The 10 fall sessions lasted two hours each. “The immediate goal with our first semester is to set an idea of looking at science in a different way,” said Lead Explorer Luca Morrow-Yeager.

The next section provides general suggestions for setting up ATLAS in your community.

Suggested Staffing

In order for this program to be successful, significant support is necessary from committed people who can structure the program and guide students in their thinking and practices. We know, however, that because of its focus on place-based learning, ideas for your ATLAS program will be emergent. Staffing suggestions include:

Staff

1. Paid Education Coordinator

The Education Coordinator should be an educator with science experience or a scientist with strong education experience. Training for the role in the classroom should be required. This person should communicate with school administrators, students, and parents, and be detail oriented as well as creative. This person should be able to execute the program with scientific integrity and be able to accurately assess what is working and what needs improvement. He or she should be comfortable with keeping good financial records, dealing with a variety of people, and understanding the concept that learning is emergent.

The purpose of this position is to act as a facilitator for the educational process and to ensure that program goals are considered in every part of the planning and delivery process. This includes:

- helping to recruit and process applications for middle school participants (Explorers) in the program
- identifying two high school students to serve as Lead Explorers (in exchange for independent study credit)
- helping to develop session outlines based on ideas and notes from scientists and advisors
- working with the Lead Explorers to revise and edit session outlines to fit their comfort level and understanding
- attending each of the sessions led by the Lead Explorers and posing questions that help promote discussions during sessions
- guiding the debriefing process with the Lead Explorers at the end of each session

2. Classroom Volunteers

Volunteers support the Education Coordinator in implementing the program. Duties would include lending an extra hand during sessions and drafting communications with participants. This person could be a community volunteer, parent, or high school volunteer.

3. Independent Study Liaison

Preferably, a science teacher at the local high school fills this position. The liaison helps to recruit interested high school students and parents and aligns the requirements for independent study credit with the ATLAS program's learning objectives and outcomes. However, the Education Coordinator can do this job if the Education Coordinator has appropriate experience.

Participants (non-staff)

1. Mentors (Scientists)

A mentor is typically a high-level scientist, but can be anyone (e.g., a parent or community volunteer) who has enough experience or expertise on a topic to serve as a valid and reliable source of information for the program. A mentor also needs to be willing to work with teenage Lead Explorers before a specific session to help influence the development of a session outline (via Skype calls, answering email questions, and/or doing a face-to face visit). The mentor does not necessarily need to be available during the session but should be willing to communicate with the Lead Explorers as their expertise is needed and as questions arise before or after the session. A database of qualified mentors will be available through the Smithsonian's Network for Emergent Socio-Scientific Thinking (NESST).

2. Lead Explorers

Lead Explorers are typically high school students in their junior or senior year. They should demonstrate a strong desire to facilitate an ATLAS program, have a strong background and passion for science, and be willing to do the necessary work that leads to successful sessions mentoring younger students. This includes giving input about session ideas and outlines, meeting with or talking to program mentors, working with the Education Coordinator to make sure session outlines meet desired goals, doing preparation work to make sure everyone is ready for each session, and participating in session debriefs. This position requires reflections after each session and a culminating project if the Lead Explorer would like independent course credit. This position requires about 5-6 hours per week of work. Making this commitment a high priority is necessary; therefore, Lead Explorers should not have too many competing obligations during the program.

Lead Explorers are trained in various ways. They not only learn science from their mentor scientist, but they learn how to work with near-peer middle school students through explicit instruction about classroom structure (e.g., desk arrangement, best place to present, whiteboard use, and presentation tone), inclusive language, open-ended questioning, and ways to help settle a group who gets off task. At the end of each session, the debriefing that occurs between the Lead Explorers and the Education Coordinator helps strengthen these skills so that Lead Explorers are more comfortable and better presenters in each subsequent session.

3. Junior Lead Explorers

Junior Lead Explorers are typically freshmen students (or possibly sophomores) who are willing to learn how to be Lead Explorers. They must be willing to attend many of the sessions and help in the planning and/or delivery of curriculum when asked to do so in an effort to better understand how Lead Explorers interact with Explorers during the sessions. Ultimately, these students will want to become Lead Explorers in subsequent programs and may work with the Education Coordinator to get high school credit at that time.

4. Explorers (Participants)

Explorers are typically 8th graders (although younger, passionate students could fit into this category as well) who are recommended by their teachers to participate in this program. These students will have demonstrated a high level of knowledge and curiosity in their science classes. They will also want and have the time to participate in this after school program fully, which means they should not have any competing obligations during the ATLAS program meeting time.

Timeline and Logistics

90 Days Prior to Start of Program:

1. Identify the process for executing against the program.
2. Identify funds for implementing the program.
3. Firm up program budget.
4. Create a database of relevant mentors. This can be local and/or from the NESST mentor list.

45 Days Prior to Start of Program:

1. Hold a conference/summit for the Education Coordinator to meet with the Lead Explorers, independent study liaison, classroom volunteers, and mentors.
2. Find appropriate space to use (e.g., public or independent school, community center, museum, science center, etc.)
3. Connect to high schools by trying to meet with the high school principal and science teachers. This can include conversations about how to set up independent study credits for Lead Explorers and possibly extra credit for Junior Lead Explorers.
4. Customize an application for all participants. (See Appendix B for an example.) The application could include a pre-course assessment.
5. Advertise the ATLAS program through social media and disseminate the application to potential middle school students who may be interested in ATLAS.
6. Connect to middle schools (ideally principals) and get recommendations for Explorers. Teachers and current participants can also be helpful in recruiting other participants who might want to apply.
7. Choose Lead Explorers/Junior Lead Explorers and Explorers. These can be recommended by teachers, principals, or community leaders. The selection process is determined by community desires.

8. Make sure requirements for independent study are set up (this requires buy-in from high school teachers for oversight).

1-2 Weeks Prior to Start of Program

1. Secure insurance.
2. Select applications. Request that they complete a Student Information Card, Health History Form, and Parent/Guardian Acknowledgement Form (see Appendix C, D, and E respectively).
3. Host an informational student/parent event to ensure commitment to program as stated in selection process.
4. Draft overall session structure and outlines for the first three sessions. (See Appendix A for example session outlines from ATLAS Aspen and ATLAS Santa Fe.)
5. Schedule mentors and volunteers who will be helping with any of the sessions.
6. Gather all participants' email addresses in a group contact list and communicate the expectations for the first session along with any helpful information, such as locations, times, items to bring, etc.
7. Order or purchase any supplies needed for (at least) the first two sessions.

NOTE: Finalize any contracts before the start of the program

Session Logistics

1. ATLAS sessions are intended to last approximately 2 hours and can run over 10 weeks during the school year (i.e. meeting once per week after school or on a Saturday); or meeting over two weeks in the summer (i.e. meeting once per day Monday through Friday for two consecutive weeks
2. Lead Explorers (including Junior Lead Explorers who are helping that day) should arrive at least 15 minutes before participants to set up the room and review session details with two adult supervisors if possible (this should be the Education Coordinator and a parent, community volunteer, or mentor).

3. At least one adult needs to be present in room at all times during each session.
4. Providing snacks is suggested.
5. Having a "toolkit" of common items available could make sessions run more smoothly (e.g. whiteboard markers, nametags, tape, scissors, etc.).

Fundamentals of ATLAS Session Plans

ATLAS session outlines may look similar to many session outlines used in science education classes. However, for this program, they are constructed differently and with input from many parties before they are actually delivered to their intended audience. What also makes them different is that while there is a common theme that connects one topic to another (e.g. ATLAS Santa Fe focused on water scarcity in the Santa Fe region), the lessons touch on many different scientific interests and are intentionally open ended. This framework promotes curiosity, place-based learning, emergence, and deep discussions for students who are excited about science.

While this is not a required structure, sessions typically flow from review of previous week's topic, a delivery of information for the current week's topic, and a substantial amount of time for an activity. The last 10-20 minutes of each session should be reserved for closing comments and reflection, which includes encouragement of participants to fill out the session evaluation form so that feedback can be shared with the Lead Explorers immediately following the session during the debrief. This ensures that the next session outline is responsive to the needs of the students and the current events influencing students' discussions (e.g. a recent weather event that impacted their town).

Each session outline seen in Appendix A from the ATLAS Aspen pilot project and the ATLAS Santa Fe project was developed with world-renowned scientists, educators, and Lead Explorers all working together to create a hands-on experience for middle school students. Because emergent behavior is the theme that connects all of these session topics, the sessions outlined in Appendix A are merely examples—these are just ideas that one group decided upon and developed on the basis of socio-scientific issues affecting their community. However, other ATLAS groups may find that their interests, access to resources, and learning goals are different. With this in mind, note that your topics will be different and will emerge based on the students' interests and your local context. This process can be replicated by other groups who come together to create and deliver ATLAS sessions.

Note: ***It is important that Lead Explorers take a role in planning session content.***

Pre-Session Work (for example, Saturdays 2:00 – 4:00 pm)

1. Lead Explorers and the Education Coordinator brainstorm the big idea that is meant to be the overarching theme of all sessions (e.g. clean water, mosquito-borne diseases, climate change) and the underlying theme of each session (e.g. emergence, data quality, complex problem solving, or specific areas of scientific study).
2. Build session ideas around the theme (creating lesson titles based on an open- ended question may help).
3. Decide what resources are available to support session topics (i.e., experts in the field of interest, materials for experimentation, Lead Explorer interest and understanding, teacher support) and secure these materials, tracking costs as needed.
4. Use example content outlines (Appendix A) to start gathering ideas, resources, and questions that serve as foundation for each session.
5. Work with other group members to revise and edit session outlines. This can be done face-to-face or digitally, but make sure that Lead Explorers have taken the time to understand the material in the outline and can provide feedback. Ideas that fit their understanding of the topic is critical
6. Set up phone calls or video chats with experts in the field who can help Lead Explorers understand their session topic even better before they deliver information to other students. Lead Explorers need to be prepared for these special sessions with a strong understanding of the session, outline of the session, and questions for the scientists. This is the best time for the scientist to mentor the Lead Explorers.

Session Delivery (for example, every Wednesday during early release days from 2:30 – 4:30 pm)

7. Lead Explorers, with supervisory support from the Education Coordinator set up room for the session and make sure that materials are ready.
8. Lead Explorers deliver lesson to students while adult advisor(s) (e.g., Education Coordinator, parent or community volunteer, scientist mentor) observe and take notes. These advisors may also offer guidance during the sessions when necessary. However, the goal is to let Lead Explorers facilitate learning as much as possible on their own. The adult supervisor(s) only intervenes if the conversation gets off track, misinformation is being delivered, or classroom management needs attention. The adult advisor(s) should behave like a coach, watching their players sometimes make mistakes and guiding the experience.
9. Lead Explorers encourage student participants to fill out a short post-session feedback form at the end of the lesson so that relevant information is available for session debrief. (See Appendix G.)
10. Everyone works together to clean up.

Post-Session Debrief (directly after the session)

11. Lead Explorers sit down with advisor(s) to discuss the lesson. This is a critical part of the program that needs to be well designed and executed to promote positive support while also providing constructive feedback during the reflection process. Some questions that can support this process are as follows:
    a. How did you feel about the session?
    b. What went well with your plan and/or the session?
    c. What areas do you think needed improvement?
    d. What do you think the students learned from today's session? Was this what you intended? Why or why not?
    e. When you think about how the activity went today, what worked well? What might you do differently next time?

f. Who in the group seemed most engaged? Who was least engaged? How could you try to draw students in who might not seem to be participating?
g. What parts of the session need to be added or changed?
h. What do you want to discuss in terms of the scientific ideas we covered today?
i. Based on students' comments today, what do you think we should revise or add to the next session?

In between responses, advisor can add statements about the observations that support the answers or help students understand the great work they did. **<u>Students tend to be harder on themselves than necessary, so inserting positive feedback is important.</u>

12. Take a few minutes to review the basic outline for the next session and see if there are any questions or comments about it.
13. Decide on the timeline for next week to get tasks done for next session.
14. Return the room to its original condition before you leave.

Setting up Lead Explorers for Success

- Make expectations clear ahead of time (i.e., reflections from each session need to be done right after each session, email announcements need to be made by a certain date).
- Help them decide how to best utilize their Junior Explorers in each session.

ATLAS Pedagogy and Principles

The Smithsonian Science Education Center- whose mission is to transform K-12 Education through Science in collaboration with communities across the globe- attempts to empower the next generation of decision makers capable of making the right choices about the complex socio-scientific issues facing human society. ATLAS programs help youth discover, understand, and act on the most pressing socio-scientific challenges of our time.

This learning model builds a progression that helps leaders first understand students' identity, cultural context, and learning dispositions; then engages students in questioning and investigating the issue using their community as their laboratory; next supports students critical reasoning and systemic understanding of the issue from multiple perspectives; and finally promotes students as they use their new scientific knowledge to take action in their own communities. Through ATLAS, student learning teams use their understandings to develop sustainability mindsets by finding common ground, building consensus, and planning and carrying out local actions for one of their community's socio-scientific issues.

ATLAS promotes the idea that transdisciplinary socio-scientific understanding has the power to drive students' agency to bring change to their local environments while helping impact global goals. Field testing of the program revealed a meaningful improvement in students' content knowledge and agency, demonstrating that students believe they can impact their own lives and their communities' through scientific discovery, understanding, and action. Students discover their own identity and the identity and perspectives of their peers and their community members as it relates to the socio-scientific issue; understand firsthand the science, technology, engineering, and math (STEM) concepts and practices that underlie the issue; and then act on the issue directly in their community through civic engagement.

ATLAS Concepts: Student Checklist

This checklist, designed specifically for students, summarizes the skills that go into thinking like a scientist. Each ATLAS Session should help students address one or more of these skills.

The Scientific Approach as a Habit:

1. Be curious and inquire!
2. Never accept that something is unexplainable. We just don't have the answers, yet.
3. Collaborate and communicate through participation in group projects.
4. Be skeptical—ask if the new fact is science based.
5. Carry out experiments, make measurements, examine data from the web and ask how the results might be connected.

Scientific Concepts and Methodology:

6. Analyze and interpret data.
7. Learn to look for patterns in your data, whether obtained on the web or the results of your own hands-on experiments.
8. Begin to understand systematic and statistical errors in your data.
9. Begin to devise scenarios and logical alternatives to explain your observations. Consider how things are connected or how your observations change with the environment in which they are carried out.
10. Understand that making mistakes is part of doing experiments and recording observations. These can also bring science forward.

Scientific Thinking:

11. Be a systems thinker- Consider how the parts of the system interact. Can you do an experiment, apply a mathematical principle, engineer a solution, or integrate technology to show that it is true?
12. Be a complex problem solver—recognize that almost all problems are complex in that there is no single cause and, therefore, no single solution. To make progress, you need to experiment and try several solutions, and then determine from observations which combination works best.
13. Connect—ask whether there are connections between different kinds of emergent collective behavior (e.g., birds flocking, fish schooling) or between the results of an experiment/observation and one of the Big Ideas in Science.
14. We live in a complex, emergent universe in which the interactions between people and matter and the environment in which they exist, lead to unexpected consequences and unpredictable behavior. In emergent scientific learning, because of the many possible interactions and synergies between these different modes, more is different and the whole is different from its parts.

Evaluation and Assessment

Because ATLAS is designed as an after school program, the idea of assessment is different than in school settings. In this case, allowing students to demonstrate what they have learned occurs more organically than in a traditional classroom; therefore, it really serves as a different form of evaluation. The ongoing information collected from students requires a more continuous and critical look at what they are learning, what is working, and what needs improvement so that plans can be changed and/or improved upon from one session to another.

Remember we live in a complex, emergent universe in which the interactions between people and matter (and the environment in which they exist) lead to unexpected consequences and unpredictable behavior. In emergent scientific learning, because of the many possible interactions and synergies between these different modes, more is different and the whole is different from its parts. Every session will be different depending on the day, the setting, the time of year, the people, and the results of the experiences.

***Session Evaluation*:**

Several ways to attain information about goal attainment can come from the following people and in the following ways:

1. Explorers (Participants)
    a. Takes Pre-course Survey that shows what participants might already know about a specific topic. (See Appendix F.)
    b. Fills out the Session Feedback (see Appendix G.)—a five-question survey at the end of each session that addresses what was liked, what wasn't liked, what was learned, suggestions for improvement, and questions that might want to be explored in future sessions.
    c. Completes End-of-Course Program Evaluation for Participants. (See Appendix H.)

2. Lead Explorers and participating Junior Lead Explorers

    a. Participates in session debrief at the end of every session.
    b. Reviews participants' responses from the ATLAS Session Feedback. (See Appendix G.)
    c. Writes reflections in a notebook after each session. This is particularly critical if students are receiving course credit for their work.
    d. Creates a summative product (e.g., guide, slideshow, video, etc.) that can serve as a guide to other Lead Explorers about how to facilitate future sessions. This can serve as a final project for students who are receiving course credit.
    e. Completes End-of-Course Program Evaluation for Lead Explorers (see Appendix I).

3. Education Coordinator (responsible for collecting observational and response data throughout each session)

    a. Continuously takes notes about observations in each session. This includes information about how the Lead Explorers interact with the Explorers (participants), the spontaneous questions and understandings ("ah ha" or "eureka" moments), and other observations that are worth discussion at each session's debriefing.
    b. Asks Explorers (participants) to complete ATLAS Session Feedback. (See Appendix G.)
    c. Looks over Explorers' (participants') responses at the end of each session and uses them in the debriefing conversation with the Lead Explorers and Junior Lead Explorers who participated in that session. This real-time information from Explorers can be added into what the Education Coordinator directly observed, or it can frame some additional comments that can be communicated to the Lead Explorers so that they can receive feedback that helps them in subsequent sessions.

4. Parents

    a. Participates in end of ATLAS course celebration to learn about students' ATLAS projects and hear their presentations.
    b. Completes End-of-Course Program Evaluation for Parents. (See Appendix J.)

Final Program Evaluation:

1. Explorers (participants) engage in a cooperative task during the last session that allows students to demonstrate an understanding of emergence and the scientific principles introduced and focused upon in each session.
2. Help the Lead Explorers create a pre-course and post-course survey, noting that the Lead Explorers will learn more about the construct of Emergence by creating this survey than they would if you taught the concept to them didactically or if they read about the construct on their own. Consider giving this evaluation before and after you complete the course in order to demonstrate students' growth in the concept over time. An example of a Pre-Course Survey can be found in Appendix F.
3. All Explorers (participants) and their parents are encouraged to do a final evaluation of the program (See Appendix H and J) that can both show learning throughout the program and provide additional feedback that helps the Education Coordinator develop the next programming cycle.

Frequently Asked Questions

Is it a realistic aim to teach *every* middle school student to think like a scientist?

- Yes, because all students began life as "scientists in the crib," according to Alison Gopnik. They learn for their first 18 months by carrying out experiments on themselves and their immediate environment. This suggests that we are all "wired" to think like a scientist, and for many students, our task is to help them unlearn the social behaviors that led them in other directions.

Do the skills described in Concepts apply to all scientists?

- Yes, these are the skills indispensable to scientists who are active in research and they are of more general applicability used in their everyday life.

Is thinking like a scientist better than thinking like an artist, a poet, a doctor, an engineer, or a lawyer?

- No, but it is different. Using the skills to think like a scientist can be useful in any career. Learning these skills may significantly help future leaders of our society.

Will parents find this program valuable to their children? Will the program meet their expectations?

- The parents of the participants involved in the previous ATLAS programs stated the program exceeded their expectations and was valuable for understanding the concepts and ideas as well as providing socialization with the other participants.

How much time does it take a Lead Explorer to prepare for a session?

- Lead Explorers vary in the time they spend preparing for the sessions. Usually 4 to 6 hours per session is adequate time to converse about the material and understand the processes of the session.

What happens if Lead Explorers are confused about information in an outline and need clarification?

- Lead Explores can check in with the Education Coordinator or a mentor scientist with any questions. Before all sessions, adults can help the Lead Explorers feel comfortable with the session outline.

Is it hard for Lead Explorers to present information to students who aren't much younger than Lead Explorers?

- Results have shown near-peer mentoring to be easy and extremely effective. The camaraderie becomes stronger every week. Research shows the positive effects of near-peer mentorship for both parties.

What is required of participants?

- Participants are expected to commit to the full 10 sessions. Exceptions can be given.

Why focus on emergent complex, socio-scientific issues?

- Engaging students in scientific discovery using their community as their laboratory will drive students to use their new scientific knowledge to do social good in their region.

Why near-peer mentoring?

- Studies find that peer-led instruction is effective in increasing student persistence, retention and student learning. Both leaders and students benefit from the enhanced learning experience. (Brownell & Swaner, 2010)

As an educator, how much actual teaching should I expect?

- The educator's role is to support the Lead Explorers. It is not to teach the lessons. There may be times you will need to assist with teaching a lesson, help with clarification, or teach the Lead Explorers strategies for working with students but the educator should not be expected to teach each lesson.

What is the relationship of the educator and the scientist?

- The scientist and the educator should expect to work closely with each other and learn from each other. They should function as equals. The scientist should expect to learn teaching pedagogy from the teacher and the teacher should expect to pick up scientific skills and practices from the scientist.

Brownell, J E , Swaner L E *Five high-impact practices: Research on learning outcomes, completion , and quality*. Washington, DC: Association of American Colleges & Universities; 2010.

Addendum Documents from previous ATLAS Programs

Appendix A:

Example Content Outlines & Curriculum

Example Content Outlines

The following pages are examples of content outlines that can be used when planning sessions. The first one is the overall outline from ATLAS Santa Fe. The two that follow are individual lesson outlines from ATLAS Aspen. Either format is acceptable.

Always Think Like a Scientist (ATLAS):
Access to Water for Our City in the Face of Climate Change

Action Plan

Pre-session preparation (now-Feb 4) of materials, check-ins to SSEC, and training of Lead Explorers. Coordination with local water infrastructure and conservation efforts.

Scheduling of field trip.

Sessions (Feb 4- April 22):

1. Introduction: **Think Like a Scientist** about access to water over the next 20 years
    a. Goal: Help our city survive climate change
    b. Approach: Web-based research, communicate, pledge meaningful change
    c. Identity Map: Who are we? Where do we *think* our city's water comes from?
    d. Emergence: A central concept we'll use to make connections

   e. Think like a Scientist: 13 principles of ATLAS
   f. Search Like a Scientist: using search engines (incl. scholarly and geographic)

2. The **past, present, and future** of our city's water

   a. Water is Life (*Agua es Vida*)
   b. Where exactly does our city's water come from, now and over history?
   c. How will our water sources likely be impacted by climate change (20 years)?
   d. How complex is the network that delivers us water?

3. What can the **history of Angkor** can teach us about our city's future?

   a. What was Angkor? (the largest pre-industrial city on earth)
   b. What made Angkor fall? (**cascading failures** from extreme **weather events**)
   c. What was happening before Angkor fell? (**climate change**)
   d. What patterns does Angkor show? (**emergence of criticality**)

4. Seeing our **water infrastructure** for ourselves (field trip to a local water treatment plant)

5. Long-term **model predictions** of effects of climate change on our water supply

   a. Where are our city's watersheds (% for each source)
   b. What are the changes to our watersheds predicted in 20 years? (% changes)
   c. What is the relation between climate change and extreme weather events? (extreme events, both wet and dry, become more likely)
   d. Could cascading failures of the water supply happen to our city?

6. What is the **role of conservation and new technology**?

   a. How much water per capita does our city use compared with similar cities?
   b. How people's personal choices affect overall city water use?
   c. How does conservation help during extreme events? (changing *before* crisis)

   d. Will salt water conversion be cost-effective soon?
   e. Simple conservation **steps we can individually do**

7. **Making positive steps** about water use in our community

   a. How we can create **emergence of conservation** to combat climate change? (pledging water conservation across our school community)
   b. Create water pledge and video for distribution to school community

8. Processing results of our pledges

9. Creating and practicing a group presentation of our results

10. Post-survey and oral/video presentations

Post-session summary (April 29- May 31) and final preparation of deliverables to SSEC

ATLAS Aspen
Content Outlines

Session 1- Introduction

Big Ideas/Key Concepts:

- Introduction of the program
- The 13 skills of Thinking Like a Scientist
- Introduction of the importance of questioning

Objectives:

- Introduce the program and give an overview of how the Explorers will "learn to think like a scientist"
- Introduce the idea of emergence
- Connect VR glasses with the idea of emergence and to 13 TLS skills

Plan:

Engage:

- Introductions—everyone says their name and anything that might be interesting to conversation (consider coming up with 3-5 questions you want everyone to answer like school, grade, reason they decided to participate, or play short ice breaker game like "Two Truths and a Lie" (see in resource list below)
- Start discussion about program and propose these kinds of questions:
  - What is science?
  - What is the purpose of science?
  - How is it done?
  - How do we know it's true?
- Introduce 13 skills on a poster or with handouts
  - Talk about connections to the 13 skills that will be made throughout the course
  - Talk about final project/activity that everyone will work together to complete
  - Emphasize concept of emergence
    - What emergence is and why we are talking about emergence
    - How emergence applies to everything in the world and why we all live in an emergent universe

Explore: ◦ Ways that 13 skills can be applied to learning about your health ◦ What is the role of emergence in your health? ◦ Why is that important? ◦ Collect personal data (20 minutes) ▪ Heart rate or pulse (repeat different scenarios to collect data like walking or running) ▪ Analyze data ◦ Try out VR glasses (15 minutes) ▪ Talk about how VR is a tool to introduce you to the remarkable emergent behavior that is going on inside your body ◦ Talk about other kinds of opportunities participants will have to explore emergent thinking via IOLab sensors, quantum games, and other engaging science games
Explain/Discuss: • Talk about emergence in relation to health data collected ◦ What are you learning from this? ◦ What collective behaviors or ideas can come from this? ◦ What were you expecting and what questions do you still have? • Ideas that come from using VR technology (connection with emergence) ◦ How can we observe things on the micro level and translate this information to the human body as a system? ◦ Why is this important? ◦ How can we use data to get a sense of a bigger picture that can be helpful in diagnostics?
Elaborate: • Connection between emergence and how it underlies VR technology and other innovations • Connections between all activities and the 13 skills

Evaluate/Reflect:
• Get Explorers' input about the day (round-robin sharing, exit ticket, etc.) and offer take away questions:
  ◦ Why is all of this important?
  ◦ What more do you want to do?
  ◦ Why should you observe or measure your own heart rate at different times?
• Lead Explorers debrief with coaches at the end and reflect on the session

Resources: • Two Truths and a Lie • Gateways to Emergent Behavior in Science and Societies. A PowerPoint presentation given at a popular lecture in Kyoto in 2013
Mentors:

ATLAS Aspen
Content Outlines

Session 2- IOLabs

Big Ideas/Key Concepts:

- Connecting the 13 skills of "Thinking Like a Scientist" to rest of lesson
- Emergence
- Statistics and data gathering and analysis (IOLab)

Objectives:

- Explore scientific ideas as problem solvers and emergent thinkers
- Use data from Aspen experiments using the IOLab sensor
- Understand how data give us information
- Learn about necessity for collaboration and cooperation to reach goals

Plan:

Engage:

- Review ideas from last week (specifically thinking about the ways in which simple data are collected and used to solve complex health and medical issues)
    - How something as simple as measuring pulse rates can impact bigger questions in health and medicine (i.e., heart and respiratory illnesses and diseases)
    - Consider showing Jane Adams' TED talk (listed in resources)
- Move into conversation involving IOLab accelerometer

Explore:

- IOLab sensors
    - Used to study acceleration and learn that there is a gravitational force and it has a direction
    - Use accelerometer to find data

Explain/Discuss:

- IOLab
    - Define x, y, and z and define acceleration
    - Do the results of the accelerometer make sense?
    - How can you make it 0?
    - How accelerometers work
    - Spring responds to acceleration, not pulling
    - Spring stretches more with more acceleration
    - Gravity is invisible to the accelerometer

Elaborate:

- Emphasize connections to some of the 13 skills
    - How are we being curious?
    - Where are patterns?
    - How do we create an experiment?
    - How do we interpret results?
- Connections to other phenomenon
    - This is like how we feel acceleration
    - Do you feel your weight, the ground is pushing up on you
    - Elevator, car, plane, water
    - When it is sitting down, it feels as if the ground is pushing up on it
    - If gravity is important, use other sensor than accelerometer

Evaluate/Reflect:

- Consider how IOLab can lead to the exploration and understanding of bigger scientific topics through emergence

Resources:

- How Ants Find Your Picnic Basket (Jane Adams)
- IOLab resources and ideas for experiments (Mats Selen)
- IOLab "Playlist" (Mats Selen)

Example Curriculum

The following pages are examples of curriculum that can be used when planning sessions.

Lesson 1: Introduction to ATLAS

In this session, we tell the Explorers to what we hope to accomplish in ATLAS Water, introduce the central concept of emergence, set out the 5 ATLAS principles which will be used throughout, and help the Explorers start to interact with each other.

There are 19 slides in this session and a handout. None of them require customization other than changing the name "Santa Fe", but the handout would benefit from localization. Since in this session everyone is getting started, including the Lead Explorers, this session has extensive Speaker's Notes to make clear points that need to be discussed. The speaker's notes will require modest localization.

Big Ideas/ Key Concepts

ATLAS presents an exciting opportunity for you to explore complex socio-scientific issues (such as water scarcity, climate change, deforestation, etc.) and understand your emergent universe and how emergence is in all aspects of life. **Emergence** is the key concept for the whole ATLAS program. It's introduced here both by slides and a YouTube video, from which the following quote is lifted. "Emergence is stupid things doing smart things, together."

Objectives

- Have Explorers be able to restate what emergence is in their own worlds, and give a social example (e.g., ants building anthills) and an infrastructure example (e.g., power grids growing very complex with time).

- Explorers should be able to list the 5 ATLAS principles: Search, Analyze, be Curious, Connect with each other, and keep a Notebook.
- Explorers should know how to use the search tips from the handout, especially quotes and Google Scholar.

Plan

This session sets the outlook for ATLAS water and gives Explorers conceptual tools as well as some handy search-engine skills that they will need to navigate the module. The search skills are very useful for anybody doing research, and few adults know them thoroughly. In the handout, Spiderman was used as an example. Explorers should be encouraged to search for their own favorite topics.

Lead Explorers will need to practice the searches in the handout in order to give a live demo so that students can follow along.

Engage

It is best if the notebooks are handed out at the beginning of the session and stickers are available to hand out. Go sticker-happy on this first session, and if you have an idea for what an end-of-project reward might be, hint that whomever ends up with the biggest sticker collection will get a reward.

At 19 pages, the slide deck goes by pretty quickly, but you may find Explorers stuck on unanticipated problems such as typing skills. The slow parts are the Identity Map session, so it's best to save that for next to the end.

Explore

There is a mix of timeless scientific approach (e.g., plot your data as soon as possible) with up-to-the-minute tips on how to use the power of modern search engines.

Explain/Discuss

Elaborate

Evaluate/Reflect

When one launches a web search, a remarkable collection of computers around the globe work in coordination to deliver answers to your browser in a fraction of a second. Data scientists estimate that 90% of the data the world has ever collected was collected in the last 2 years, and search engines are the easiest route into that world. It's been calculated that each Google search uses the equivalent amount of power as heating up a cup of coffee.

Identity Map ideas:

Create an entry by starting your own paragraph with this model:

Name City Ethnicity Generation Skills

Where:

- ***Name*** is your first name
- ***City*** is the name of the city you live in, without spaces
- ***Ethnicity*** is whatever word you feel describes you, e.g., Anglo, Hispanic, Mexican, Native
- ***Generation*** is how many generations you feel your family has been in the US (skip if Native)
- ***Skills*** are two of your strengths from the following list: Writing, Speaking, Spanish, Math, Drawing, Video, 3-D

Example:

Joel SantaFe Nerd 5thGen Writing Math

Session 2: Santa Fe's Water, Past, Present, and Future

Session 2 is the biggest session in ATLAS Water, and the core of the material to be discovered in the ATLAS Water module.

Big Ideas/ Key Concepts [Hot Topics]

- **Agua es Vida - Water is Life** is a very common sentiment in many places, but especially in New Mexico.
- Water often travels far and wide to get to its final destination, so we will **study the complexity of the system that delivers water to Santa Fe.**
- Since Santa Fe is a high elevation desert, there is not enough water, so **where does Santa Fe water come from?**

Objectives

- Divide Explorers into groups of 2 or 3 and Search various topics related to today's Hot Ideas.
- Be Curious about where Santa Fe's water comes from.
- Analyze small group findings to come up with some common group determinations about why 'Water is Life' is symbolic and pertinent.
- Reflect in a Notebook on why the term 'Water is Life' is significant to New Mexico. Today's small group slide presentations will also serve as a digital notebook.

Plan

In this session, students will get a true picture of the format of the remaining weeks. We begin with a quick overview of the session and move onto the previous week's review. Students should have a hard copy of the Identity Map from session 1 to place in their notebooks. Emphasis is laid on reviewing 'Emergence' from Session 1, so students have a good grasp on this key element of ATLAS.

It's important for the Lead Explorers to have researched and identified websites we would like small groups to get to in this session.

Engage

We recommend looking for regional resources for this session to be relevant to students. A good start is your city's Water Division, City Conservation Departments, Watersheds or Water catchment departments.

Explore

Lead Explorers must familiarize themselves with resources like the sample group assignments below, so they can help Explorers reach pertinent information in the time available.

The Lead Teacher will need to explore and earmark websites and resources relevant to their region for Session 2. There will be some overlap in resources and websites which is intentional to facilitate discussion on Explorers findings and an analysis of similar resources.

Group 1:

Search: Where does Santa Fe's water come from?

Lead this group to Buckman Video

https://vimeo.com/221964010

Group 2:

Search: Water is Life (*Agua es Vida*)

Lead this group to TAOS Acequias video

https://www.youtube.com/watch?v=Trs_jJIAHs8

Group 3:

Buckman Videos

https://youtu.be/UEThFqR6QZw

https://bddproject.org/take-a-virtual-tour/

Group 4:

How complex is the network that delivers water to Santa Fe?

[Santa Fe Basin Study: Adaptations to Projected Changes in Water ...]

https://www.usbr.gov/watersmart/bsp/docs/finalreport/SantaFe/Santa-Fe-Basin-Final.pdf

Chapter 2

2.3. Present Water Supply page 21-28 (maybe have a printed copy available)

Group 5:

Lead students to this page:
https://www.santafenm.gov/water_division

MISSION

The mission of the City of Santa Fe Water Division is to provide a reliable, safe and sustainable water supply to meet the needs of o customers and our community. The Water Division provides the following services and information on:

- How Do I Get Water Service
  - Customer Service and Utility Billing - Application to start rental services, apply for an adjustment, pay your utiity bill, collections information, and frequently asked questions.
  - Water Engineering - New meter install, meter sizing, development review (Capital Improvement Projects), fire flow anal approved contractors
- What are the Water Rates?
- Municipal Watershed Management
- Reports and Studies Related to Water Management - production, quality, and water use reports
- Santa Fe River - stream flow, storm flow, reservoir storage, river studies
- Transmission and Distribution - water line flushing, water meter calibration, water line operation, maintenance and repair
- Water Conservation - rebates and incentives, education programs, water use restrictions, Water Conservation Committee
- Water Policies and Ordinances
- Water Quality and Compliance - cyclical water sampling and analysis in accordance with local, state and federal clean water standards
- Water Rights Acquisition and Compliance - water bank, purchases, and Buckman Well Field Water Level Monitoring Program compliance
- Water System Improvements - pipeline improvements, water tank rehabilitation, reservoir maintenance and upgrades
- Where Does Our Drinking Water Come From? - primer on the City's water supply sources

Explain/Discuss

For this module, we spent the majority of the session time on research and assimilation of information into Google Slides. Discussion was facilitated by the Lead Explorers once the slides were completed and shared. This was a quick turnaround, so keeping students on task was really important.

Elaborate

In the pilot, the group of Explorers was proficient in using Google Slides, so it was easy for them to get distracted by formatting options. Clear directions and expectations should be laid out so information researched is transferred to the slides. It is helpful if the Lead Explorers work with 1-2 groups each, to help keep students on task. Another time management suggestion is to assign roles within the small group- researcher, note taker, slide presentation creator. Alternatively, students can create posters to present their findings.

Evaluate/Reflect

In session 2, Lead Explorers must set the tone for session evaluations and reflections. It is recommended that each session have a quick 'Evaluation'. This could be a simple 2-minute Google Forms Evaluation to check in with Explorers. In addition, the last 5-10 minutes must be dedicated to a Session Reflection. This should preferably be in the Student Notebooks, so Explorers get into the habit of having a running record of what the Big Ideas/Takeaways are from each session. This component often gets skipped over, especially when time is short, so ensure that Lead Explorers set a timer or reminder to ensure its execution.

Reflections are a way for students to show their understanding of the Hot Ideas covered in the Session. There should be a level of flexibility in how students choose to reflect - words, diagrams, flow charts, illustrations, graphs, etc. It is helpful to debrief and share in the last 2-3 minutes, so Explorers can add in any key ideas they may have missed.

Session 7: Our Water's Future

At 23 slides, session 7 has the most content in ATLAS Water, and is at core of the material to be discovered in the module. It will require heavy customization of 4 slides.

Big Ideas/ Key Concepts

- You can **see predictions of local long-term climate models** for yourself.
- **Indirect effects** of climate change on your life may be more significant than the direct effects of changed temperature and precipitation.
- There is **hope in emergence** of a response to climate change. That hope includes **pledging for ourselves** combined with **teaching others how to live with less water.**

Objectives

- Have Explorers **Search** for themselves and **Analyze** predictions of local climate in 2040.
- Be **Curious** about indirect effects of climate change such as extreme weather events, migration, and reallocation of water resources.
- **Search** for and **Analyze** average per-capita water use of neighboring or comparable cities.
- **Connect** with a climatologist and hear their point of view on questions.
- **Reflect** in a **Notebook** on some hopeful things about climate change and local water use. **Consider** what can be easily be made better, and what can be taught to others.

Plan

If possible, try to schedule this module for a week when Explorers are not too exhausted by external events. Watch your timing on this module. Explorers will need time to interact with a site such as NOAA's Climate Explorer, so allow for more time on that bit.

In this session we show students how to find for themselves the predictions of climate change. This activity depends on the students having web browsers, network connections, and a site designed for the public to view climate predictions. For US groups, this site will be the Climate Explorer, which is part of the Climate Explorer at NOAA's climate.gov. For non-US groups, you will have to find other appropriate resources, such as the KNMI Climate Explorer which focuses on Europe. Resources are evolving quickly, with new ones appearing all the time. If your class doesn't have internet access or per-person browsers, try to do a demo on a device with access rather than just present the canned slides.

It's important for the Lead Explorers to have some experience with browsing the climate data site you plan to use. It's also key to have read off the predictions of yearly rainfall and temperature changes in advance rather than fumbling for it in-session. Be aware that some scientific sites do poorly with mobile devices.

The Climate Explorer tool is changing quickly, and when we ran the pilot, there were no annual rainfall predictions nor temperature-delta maps. Therefore, **slides with Climate Explorer predictions (10 and 11) must be revised before you run this module**; they will not be correct even for Santa Fe because they show one out of 4 quarterly results.

Engage

We recommend looking at the articles in the following links as background material to be ready to engage students. From *Ars Technica*, the article "Climate Change or Just the Weather?" is a good introduction to how we know what we know about the interaction of climate change with different types of extreme weather events. Also a recent *New York Times* Sunday Op-Ed on climate change entitled "Time To Panic" quickly summarizes the likely impacts of climate change and how fear may motivate our response.

Explore

NOAA Climate Explorer is making a change that will allow the yearly precipitation and temperature values to be viewed directly, but the updated maps are not yet available. So, even if you're doing this module in the SW USA, you should update the maps currently in the slides.

Be careful in comparing average total per-capita water use (in the US, a quantity in gallons per day, GPD) among locales. Some searches will give you the *residential* calculations, which are necessarily much lower (a factor of two, sometimes more) than the *total* water use values which include commercial, industrial, and recreational uses. Comparisons of water use within administrative boundaries such as states or provinces are more likely to be than across boundaries by virtue of following a common administrative order by a person. However, the most interesting comparisons are usually with other cities across jurisdictional boundaries.

Here in the desert, total water consumption is the #1 issue, and it has been so for the 400-year history of our city. In other regions, the hot-button issue will be different and the slides on per-capita consumption should be replaced with that. For instance, in coastal areas, seawater infiltration of freshwater sources is an issue. In areas which have historically had a plentiful water supply the main issue may be flooding and sedimentation from extreme weather events. None of these issues is covered by Climate Explorer, but I am advocating to them that they should be.

Explain/Discuss

For this module, we did the Connect with a NOAA climatologist, Dr. Howard Diamond. It's rather difficult and time-consuming to get the attention of a climatologist and they are a bit skittish about public statements. If you do ask one questions for public distribution you will have to be clear about that in advance and likely get the help of their Public Information Officer. So, I'd suggest keeping the Connect as-is unless you have a climatologist in your back pocket already; Dr. Diamond's Connect contains several well-thought-out points that tie back to the Hot Topics.

Elaborate

In the pilot, we were somewhat limited by the state of online resources such as Climate Explorer, but these seem to be changing fast. One area where things could be improved are considering the consequences of choices on climate action. Such choices show up in the 2040 timeframe, but are much larger as one goes on. Asking the question "what about your grandchildren's climate?" is a natural progression to the climate models in 2060 and beyond where the effects of different emission models really shows up. Another area where resources are sorely needed is in discussion of indirect effects. Dr. Diamond steered us towards the extreme weather prediction in the 4th Climate Assessment, but more models of this type are needed. We suggest you search again before presenting this module.

Evaluate/Reflect

It should be noted that not all the climate predictions were grim. Total rainfall *increases* across most of the interior of the US due to climate change, and the higher-emission scenario showed dramatically more rain after 2040. In the models used, there really isn't much difference between the low- and high-emission scenarios before 2040 due to the assumptions that 2040 is about when we'll do something in the low-emission scenario.

We are still looking for ways to make the point more clearly about the ***indirect effects of climate change*** may be greater than the effects from precipitation and temperature shown in the charts. While Santa Fe's total precipitation isn't forecasted to change dramatically by 2040, higher temperatures will increase evaporation leading to less of the precipitation being available as runoff. In coastal areas (where most of the world's population lives) the sea-level rise resulting in saltwater infiltration of previously freshwater sources may be the dominant effect. Migration may also play a sizeable effect in places that feel few direct effects of climate change. Extreme-weather events such as flooding are present everywhere and may play a big role in determining how the effects of climate change will be felt locally.

Appendix B:

Example ATLAS Student Application

<u>Basic Information:</u>

First and Last Name: ____

Are you male or female? (Optional) ____________________________________

School that you attend: ____

Phone Number: ____

Address: ____

Parent(s) Name(s): ____

Parent(s) Email Addresses: ____

Devices you have available for your personal use? (i.e. laptop or cell phone)

____

Are you able to attend all sessions (scheduled to occur on the following dates: ____________________) Circle: YES or NO

Getting to Know You:

What are your favorite activities?

What are your favorite interests?

Are you naturally curious?

How can you tell the difference between scientific facts, opinions, and falsehoods?

Which of the following do you most enjoy?

☐ Math

☐ Art

☐ Reading

☐ Making and building things

☐ Working with others

☐ Solving problems

☐ Science

☐ Making music

Please explain why you think you are an ideal candidate for ATLAS?

Who, if anyone, is recommending you for the ATLAS program (e.g., teacher or principal)?

Commitment:

ATLAS presents an exciting opportunity for you to explore complex socio-scientific issues (such as water scarcity, climate change, deforestation, etc.) and understand your emergent universe and how emergence is in all aspects of life. If selected for the program, you commit to attend all sessions of the Always Thinking Like a Scientist (ATLAS) out-of-school program.

Signature: ____

Appendix C:

Example Student Information Card – For Quick Reference

STUDENT INFORMATION

Please print legibly

Last Name:______________________________First Name: __________________________

Nickname: ______________________________Birthdate: ___________________________

School:__________________________________ Gender: M F Grade Level: _______

Parents' Names: ____

Physical Address: ____

Mailing Address (if different from physical address): ___________________________

____

Email Address: ____

Parent Phone Number(s): ____

Student Phone Number(s): ____

Emergency Contact(s):__________________ Relationship to student: ______________

Contact email and phone number(s): ____

Appendix D:

Example Student's Health History Information

Important: Follow all guidelines for Personally Identifiable Information (PII) and HIPAA laws prior collecting this information.

STUDENT'S HEALTH HISTORY INFORMATION

ATLAS operates on the School District campus; however, your child's health information and medication are not accessible to the organization. To ensure ATLAS provides a physically and emotionally safe environment for your child, please fill in all information and attach documents if needed. To request ATLAS staff administer medication to your child while attending the program, parent/ guardian and healthcare provider must complete and sign the Authorization to Administer Medication Form available from the Program Leader. Participation in ATLAS may be delayed if appropriate accommodations cannot be made prior to student's participation. Withholding this information may result in your child's disenrollment from ATLAS.

1. Does your child have any of the following medical conditions?

   ◻ Asthma ◻ ADD/ADHD ◻ Diabetes ◻ Severe Allergy/Epinephrine Auto Injector ◻ Seizure Disorder ◻ Other ___________________ ◻ None

   If you marked any condition above, please describe the type and any special instructions ATLAS staff needs to know in relation to the condition: _________

   ____

2. Will your child require medication during ATLAS programming?
   Yes ______ No _______ If yes, please describe the medication and any additional information necessary______________________

   ____

3. Please list any food, drug, or environmental allergies, dietary restrictions or physical activity limitations: __________________________

   ____

4. Please provide any additional information that would help your child's success in the ATLAS program ____

   ____

Appendix E:

Example Parent/Guardian Acknowledgement

Parent/Guardian Acknowledgement

Please read the following carefully and acknowledge your agreement by signing below.

Authorization for Emergency Medical Treatment

- In case of an accident or emergency, I authorize ATLAS staff to facilitate the transport of my child to the nearest emergency hospital for emergency treatment and measures as deemed necessary for the safety and protection of my child, at my expense.
- I understand that ATLAS does not maintain health insurance for injuries to the participant that may arise from involvement in ATLAS programs.

Photo/Video/Media Release

Throughout the year, ATLAS will hold events that the news media partners may like to feature. A representative may gather photographs and/or video footage highlighting the events and featuring ATLAS students. We value your child's participation and ask for your permission to include him/her. **Please indicate by checking the box(es) below whether your child has your permission to participate:**

☐ I give my permission to have my child **interviewed and photographed/ videotaped by the news media.**

☐ I give my permission to have my child **photographed** by the District and/or ATLAS. Photos may be used on the School District and/or ATLAS website.

☐ I give my permission to have the School District and/or ATLAS feature my child's **work** using first name only (e.g. art, essays, etc.).

☐ I give my permission to have my child be videotaped **by the School District and/or ATLAS. Videos may be viewed by S**chool District staff or the public.

☐ Please do not include my child in these activities. I do not want my child photographed or videotaped.

Program Activities

Throughout this program, student explorers will have the opportunity to participate in many engaging science activities that could involve use of specialized equipment under the supervision of a responsible adult. **Please indicate by checking the box(es) below your level of comfort with your child's participation in these activities:**

☐ My child **can participate in all activities he/she feels comfortable doing.**

☐ Please **ask for my permission before each session** if any specialized equipment will be used or unusual activities will occur (i.e. finding out blood type with finger prick during first session).

☐ My child is **not permitted to use any specialized equipment or participate in unusual activities during this program.**

I understand that it is my responsibility to keep all information including health and contact current; failure to do so may result in disenrollment.

In signing below, I acknowledge I have read the above information thoroughly and indicated my preferences when asked to do so.

Parent/Guardian Printed Name: ____

Parent/Guardian Signature: ____

Date________________

Appendix F:

Example Pre/Post Survey

Participants fill out at the beginning and the end of the ATLAS project.

Please keep in mind this one was designed specifically for ATLAS Santa Fe.

How many gallons of water do you think you (not your family) use every day?

- ☐ 0- 20 Gallons / 0- 75 Liters
- ☐ 20- 40 Gallons / 75- 150 Liters
- ☐ 40- 60 Gallons / 150- 230 Liters
- ☐ 60- 80 Gallons / 230- 300 Liters
- ☐ 80- 100 Gallons / 300- 380 Liters
- ☐ 100- 120 Gallons / 380- 455 Liters
- ☐ I don't know.

How much water does your family use in a month?

- ☐ 10,000 Gallons
- ☐ 12,000 Gallons
- ☐ 14,000 Gallons
- ☐ 16,000 Gallons
- ☐ I don't know

What uses the most water in your house?

- ☐ Dishwasher
- ☐ Toilet
- ☐ Shower/ Bath
- ☐ Using the tap/sink
- ☐ I don't know

What kind of landscaping do you have?

- ☐ Zero Scaping (Rocks)
- ☐ Some Scaping (a few small plants and or trees)
- ☐ More Scaping (trees, plants, grass)
- ☐ Lots of Scaping (grass, plant(s), tree(s), and fountain(s))

Do you have a rain barrel at home?

- ☐ Yes
- ☐ No
- ☐ I don't know.

Is more water used when taking a bath or taking a shower?

- ☐ Bath
- ☐ Shower
- ☐ They use the same amount of water
- ☐ I don't know

Do you have clean water?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ I don't know

How do you use water every day?

Where does your water come from?

Where does Santa Fe’s water come from?

Where does New Mexico’s water come from?

Where does water come from?

What percent of the world is covered in water?

- ☐ 25%
- ☐ 50%
- ☐ 70%
- ☐ 90%
- ☐ I don’t know

What is the difference between saltwater and freshwater?

Is salt water usable?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Other _______________

What is climate change?

What is the difference between climate and weather?

How will our water source likely be impacted by climate change over the next 20 years?

What does water mean to you?

What are some events that you know of where water was the main focus?

Will our city have more or less water in 20 years?

☐ More

☐ Less

☐ Same amount of water

Do you know about what is happening in Flint Michigan?

☐ Yes

☐ No

If you said yes to the question above, please explain what is happening in Flint Michigan.

Do you know of any new technology surrounding water?

☐ Yes

☐ No

☐ I don’t know

If you said yes to the question above, please list some new technology.

Why do you think water is so important?

Why do you think water conservation is important?

What are some things you can do to conserve water?

Define Emergence.

Define cascading failure.

What are similarities between and Angkor and Santa Fe?

What is Buckman?

What did you like about ATLAS Water Santa Fe?

What are some things we could do to improve this program?

Appendix G:
ATLAS Session Feedback

(Participants fill out after every session)

Name (this is optional)

What did you like about today's session?

What did you learn from the topics explored today?

What did you not like about today's session?

What suggestions do you have for the Lead Explorers to make session even better?

What questions do you want to try to explore in the next sessions?

Appendix H:

ATLAS Program Evaluation (Participants)

Thank you for taking several minutes to give feedback about the ATLAS program

Over the course of this program, I learned to “think like a scientist.”

Not at all true 1 2 3 4 5 Very true

Over the course of this program, my interest in science increased.

Not at all true 1 2 3 4 5 Very true

The topics in this program were interesting to me.

Not at all true 1 2 3 4 5 Very true

Please comment on topics you really liked and/or others you want to include in the program for the future: ____

____

The sessions were organized well.

Not at all true 1 2 3 4 5 Very true

I plan to re-apply to the next session of the ATLAS program.

Not at all true 1 2 3 4 5 Very true

I would encourage my friends and/or classmates to participate.

Not at all true 1 2 3 4 5 Very true

What was your overall impression of this science program?

Very poor 1 2 3 4 5 Excellent

Please give a short explanation for the rating you gave:

What is at least one thing you learned from this program?

Please comment on the experience of learning with Lead Explorers who are close to your age?

Do you think you might want to be a Junior Leader or Lead Explorer one day?

Please add any additional comments or suggestions here:

Appendix I:

ATLAS Program Evaluation (Lead and Junior Explorers)

Thank you for taking several minutes to give feedback about the ATLAS program

Over the course of this program, I learned to “think like a scientist.”

Not at all true 1 2 3 4 5 Very true

Over the course of this program, my interest in science increased.

Not at all true 1 2 3 4 5 Very true

The topics in this program were interesting to me.

Not at all true 1 2 3 4 5 Very true

Please comment on topics you really liked and/or others you want to include in the program for the future: ____

____

The sessions were organized well.

Not at all true 1 2 3 4 5 Very true

I would like to continue my involvement in the ATLAS program.

Not at all true 1 2 3 4 5 Very true

I would encourage my friends and/or classmates to participate.

Not at all true 1 2 3 4 5 Very true

What was your overall impression of this science program?

Very poor 1 2 3 4 5 Excellent

Please give a short explanation for the rating you gave:

What is at least one thing you learned from this program?

Please give a short explanation of your understanding of emergence:

Please comment on your feelings about working with a mentor scientist and educator through this program:

Please add any additional comments or suggestions here, especially with regards to the ways that Jr. Explorers could be more included in the program:

Appendix J:

ATLAS Program Evaluation (Parents)

Thank you for taking several minutes to give feedback about the ATLAS program

Over the course of this program, my child learned to "think like a scientist."

Not at all true 1 2 3 4 5 Very true

Over the course of this program, my child's interest in science increased.

Not at all true 1 2 3 4 5 Very true

According to my child, sessions were organized well.

Not at all true 1 2 3 4 5 Very true

My child is interested in doing another ATLAS program.

Not at all true 1 2 3 4 5 Very true

I would encourage other parents to have their children participate in the program.

Not at all true 1 2 3 4 5 Very true

What was your overall impression of this program?

Very poor 1 2 3 4 5 Excellent

Please give a short explanation for the rating you gave:

What is something your child learned from the program?

Please add any additional comments or suggestions here (including any topics you think should be covered).

If you are willing to give a personal testament about the program, please include your name:

Appendix K:

ATLAS Example Community Event

Smithsonian
Science Education Center

scienceeducation.si.edu