

# Polar Fun and Games

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## WHY POLAR FUN AND GAMES?

Fewer than one in four Americans (23%) are currently in a formal educational setting—a school, college, or university (U.S. Census 2018). Many of the 77% who are not in school, have a distorted view of the Polar Regions—literally distorted as the typical Mercator projection stretches Antarctica into an enormous white band in the south, and Greenland looks larger than Africa in the north. As recently as 2008, climate change was not typically part of K-12 curriculum (Kastens and Turrin 2008). The greatest strides have been accomplished with the 2013 introduction of the Next Generation Science Standards and the inclusion of climate change in their Disciplinary Core Ideas for instruction (NGSS 2013), but this occurred well after most Americans graduated and NGSS has not been fully adopted by all 50 states. Taken together, these factors call for creative methods for delivering both polar and climate education to the broader public.

The Polar Learning and Responding Climate Change Education Partnership (PoLAR CCEP I and II, 2010-2018), supported by the National Science Foundation (Grant #s DUE-1043271; DUE-1239783), focused on the development and evaluation of novel educational approaches ranging from simulations to games, in order to engage people in learning about the changing Polar Regions and to inform public understanding of, and response to, climate change. Through direct, facilitated experiences, and indirectly through other media, these educational resources and approaches reached millions of participants ranging from Alaskan leaders, educators and community members, the general public, parents/caregivers and their children, to teachers for grades 5-16 serving a broad socioeconomic range of students. Here we link each of the *Polar Literacy Principles* with selected activities developed and researched by the PoLAR project and available on the project website ([www.thepolarhub.org](http://www.thepolarhub.org)).

## GENERAL-PUBLIC SURVEYS

Surveys helped the PoLAR project to identify information needs, gaps, and misunderstandings among the general public. The nationwide Polar, Environment, and Science (POLES) survey, involved 1,411 random-sample telephone interviews with U.S. residents in August and November/December 2016 (Hamilton 2016, 2018). The Granite State Poll (GSP) involves telephone interviews of about 500 New Hampshire residents four times annually. Despite their

single-state basis, GSP results resemble nationwide POLES results on polar topics (Hamilton 2016).

Broadly speaking, the POLES and GSP surveys indicate that although most people know that polar ice is melting, they lack more specific knowledge about which ice, or why this matters. Figure 1a-d. (see page 11) illustrate this with four questions from POLES:

(a.) Which of the following three statements do you think is more accurate? Over the past few years, the ice on the Arctic Ocean in late summer...

- covers less area than it did 30 years ago. (*correct*)
- declined but then recovered to about the same area it had 30 years ago.
- covers more area than it did 30 years ago.

(b.) Which best describes the North Pole?

- Ice a few feet or yards thick, over deep ocean. (*correct*)
- Ice more than a mile thick, over land.
- A rocky, mountainous landscape.

(c.) Which would do the most to raise sea level, if it melted?

- Arctic sea ice
- Greenland and Antarctic land ice (*correct*)
- Himalayan glaciers

(d.) Which country has territory and thousands of people living north of the Arctic Circle?

- United States (*correct*)
- China
- Estonia
- Britain
- none of these

Although most people know that late-summer Arctic sea ice covers less area in recent years (1a.), fewer than half recognize that the North Pole is on sea ice (1b.), and even fewer understand that Greenland and Antarctic land ice could have far greater effects on sea level (1c.). Only 18 percent know that the U.S. has territory with thousands of people in the Arctic (1d.); even among Alaska residents, this rises to just 51% (Hamilton et al. 2017). Detailed analysis reveals that people respond to the “Arctic ice compared with 30 years ago” question as if asked for their opinions about climate change. Other questions in Figure 1a-d behave more like neutral knowledge (Hamilton 2015, 2018).

PoLAR Activity	Polar Literacy Principles
Kahoot! Polar Quiz (Turrin et al. 2018)	Principles #1-7
Polar Puzzles - Arctic and Antarctic jigsaw puzzles (Turrin and Pfirman 2018)	Principle #1 - The Arctic and Antarctic regions are unique because of their location on Earth. Principle #2 - Ice is the dominant feature of the Polar Regions.
Polar Explorer - Sea Level webapp and Apple store download for iOS devices (Ryan and Turrin 2018)	Principle #3 - Polar Regions play a central role in regulating Earth's weather and climate. Principle #5 - The Poles are experiencing the effects of climate change at an accelerating rate. Principle #7 - New technologies, sensors, and tools— as well as new applications of existing technologies—are expanding scientists' abilities to study the land, ice, ocean, atmosphere, and living creatures of the Polar Regions.
EcoChains - Arctic and Antarctic card games (Lee et al. 2018)	Principle #4 - The Polar Regions have productive food webs.
Arctic and Antarctic SMARTIC - role playing games (Pfirman et al. 2017, 2018) The Arctic's Last Ice Area - kiddie pool demo (Pfirman and Turrin 2018)	Principle #5 - The Poles are experiencing the effects of climate change at an accelerating rate.
Polar Voices - podcasts (Murray et al. 2018)	Principle #6 - Humans are a part of the Polar system. The Arctic has a rich cultural history and diversity of Indigenous Peoples.

**KAHOOT! POLAR QUIZ**

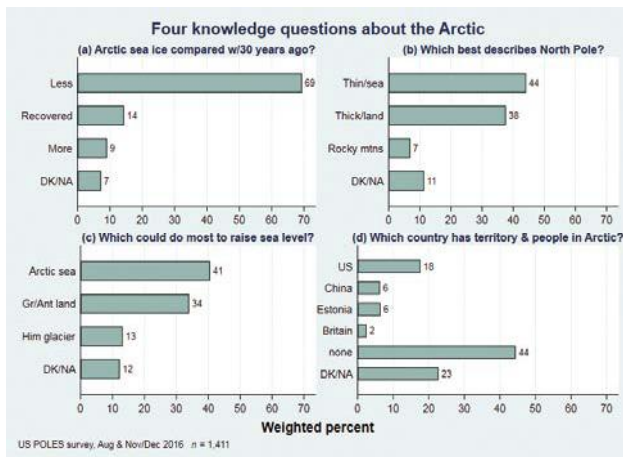
The Polar Regions play a significant role in the global climate system through impacts on both our global ocean and atmosphere, however, this remains largely untaught in schools. To address this gap, we worked with Kahoot! a novel and engaging learning platform, to bring some key polar climate processes to the classroom and the public. Kahoot! is a game-based learning platform used by almost 50% of all U.S. teachers and monthly by more than 50% of U.S. students (Kahoot 2018). We developed a set of 10 Climate Challenge quizzes and focused one on impacts of climate change on the Arctic and Antarctic (Turrin et al. 2018).

The Polar Kahoot! launched at the start of school September 2018 and by April 2019 had been played by almost 110k players. We included questions 1a-c from the POLES survey (Hamilton 2016) using slight variations in length and word choice to accommodate the Kahoot! user base and platform design, along with topics like the role of albedo in our climate system, impacts on humans and other species from changes in polar climate, and where we see evidence of change. The Polar Kahoot! can be used to introduce a longer lesson about polar climate science, as a stand-alone teaching activity, as an assessment, or as an introduction to other PoLAR activities.

Initial results indicate that this Kahoot! was used primarily as a classroom teaching and assessment tool, mostly in middle and high schools, throughout the U.S., and around the world. It was also posed as a challenge at several festivals and informal gatherings. Compared to the full range Climate Challenge quiz sets, the Polar Kahoot! posted the lowest response accuracy at 33% versus an average of 43% for the rest (Pfirman et al. submitted). This suggested the polar material was unfamiliar to the participants, reinforcing the need for Polar Literacy Principles. All seven Polar Literacy Principles are represented in the thirteen kahoot questions, which are freely available online for others to use (Turrin et al. 2018).

**POLAR PUZZLES**

Fewer than half of U.S. residents realize that the North Pole is located in an ocean basin (Figure 1b.), meaning that the Arctic is primarily an ocean covered by a surface of floating sea ice; that the South Pole in contrast is on thick ice over land; or that land ice has much greater importance than sea ice for sea level change (Figure 1c.; Hamilton 2016, 2018). These basic geographic understandings are critical in both framing the changes in climate being experienced by both the Arctic and Antarctic, and in how these changes connect to the rest of the world.



**FIGURE 1A-D.** Response to four Arctic knowledge questions on the nationwide 2016 POLES survey. Courtesy of Hamilton

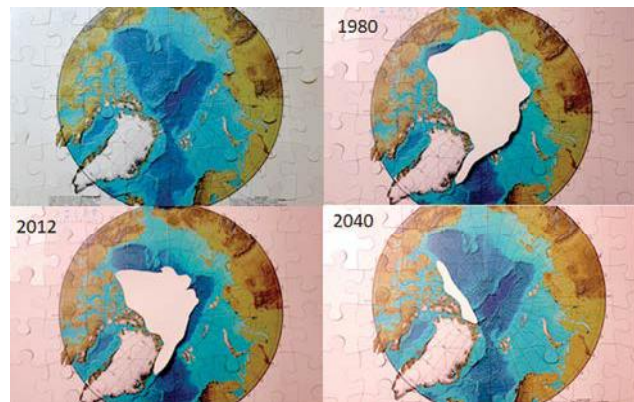
To address this gap, participants build a jigsaw puzzle of the Arctic Ocean bathymetry (Jakobsson et al. 2012). They are drawn into the rich blue colors of the map, which highlight the fact that much of the Arctic region north of the Arctic Circle is part of the ocean, with the North Pole actually located where water depths are 4200 m.

The physical building of the landscape is used to drive home the understanding that the Arctic is in an ocean basin with a relatively thin covering of ice. The activity ties directly to Polar Literacy Principles #1 and #2.

This activity has been used successfully with hundreds of individuals in outreach events for participants of all ages. Additionally, it has been modified for use in formal classroom settings with middle to high school students (Turrin and Zaima 2018).

### POLAR EXPLORER: SEA LEVEL

People are confused about what causes sea level rise (Figure 1b.), although most are aware that it has some connection to changes in polar ice. Their confusion arises from the different types of ice and whether they are land-based or floating in the ocean. Perhaps because of the amount of press covering the loss of Arctic sea ice, people have a tendency to conflate loss of sea ice with sea level rise. But, Arctic sea ice only “replaces what it displaces” as it is already floating. The Polar Regions’ major contribution to sea level rise is land-based ice; however, sea level rise results from multiple interactions between the ocean, atmosphere, glaciers, polar ice sheets, gravitational attractions, temperature, and even ongoing isostatic rebound of the Earth’s crust. Given this level of complexity, multiple drivers, varied rates of change and impacts, and spatial and temporal differences, we chose to incorporate interactivity into our education platform.



**FIGURE 2.** Base jigsaw puzzle in top left depicts Arctic Ocean bathymetry. 1980 September sea ice overlay covers twice the area as the 2012 extent. Sea ice extent projected for September 2040 is limited to small patch, the Last Ice Area, located north of Canada and Greenland. Courtesy of Pfirman

Polar Explorer: Sea Level is an interactive app (Ryan and Turrin 2018) that brings together data from both physical and social sciences through a map format allowing participants to interact directly with the data, zooming in and out to explore it thoroughly, literally placing the data into the hands of the public through data maps (Sider 2016). The app ties to Principles #3, #5E, and #7.

Data are organized around ‘big questions,’ which engage and empower audiences in learning directly from a wide range of digital climate science data. The app has been used successfully in a variety of different learning environments, including community events, teacher workshops, and classroom experiences for middle school through undergraduate students. The positive response of users resulted in a webapp version being developed to widen its reach (<http://www.polar-explorer.org>).

### ECOCHAINS CARD GAMES—ARCTIC AND ANTARCTICA

The role of sea ice in the polar food webs is critical and with climate change driving change in sea ice, the entire food web is being altered. Most people are aware of a connection between sea ice and polar bears, and large majorities agree that Arctic ecosystems and wildlife should be high priorities (Figure 3). Beyond that, however, they have little understanding of Arctic or Antarctic food webs.

The EcoChains card games (Lee et al. 2018) developed by the PoLAR CCEP II: EcoChains: Arctic Crisis, EcoChains: Arctic Life ([ecochainsgame.com](http://ecochainsgame.com); Wu and Lee 2015), and EcoChains: Antarctica address Principle #4. Each player is responsible for building and stewarding food webs extending

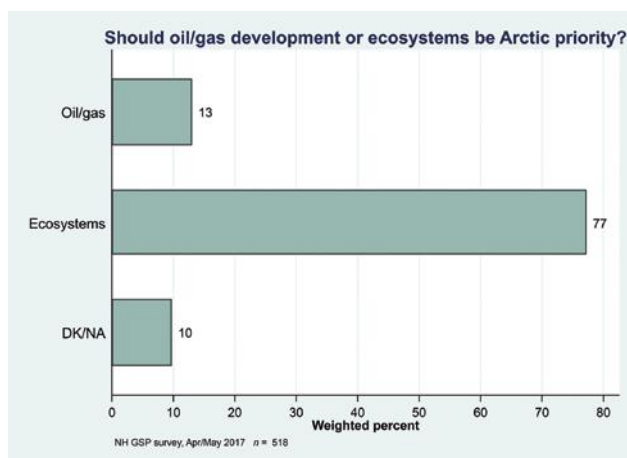
from sea ice to sea ice phytoplankton, zooplankton, fish, seals, either polar bears (Arctic) or penguins (Antarctic), and humans in the face of stressors such as overfishing and sea ice melt caused by rising greenhouse gases. Players learn the critical role of sea ice in supporting polar habitats, and see how the ecosystem will shift as ice diminishes and which species will survive.

The card games have been used with thousands of people, ranging from demonstrations at museums and science fairs to the classroom. Middle and high school activity guidance is available (<https://thepolarhub.org/core-projects/ecochains.html>).

### ARCTIC SMARTIC (STRATEGIC MANAGEMENT OF RESOURCES IN TIMES OF CHANGE)

As we look to the future where the Polar Regions are increasingly accessible for transit and resource development, there are many options for the Arctic nations and the global community to consider (Newton et al. 2016). There are already pressures for development of oil, gas, minerals, and trans-arctic shipping with Arctic residents split over interests in new opportunities at the same time that environmental change is undermining cultural practices. Scenarios for high demand for resource development with unstable governance could lead to an Arctic Race, while resource utilization under stable governance could lead to an Arctic Saga-type scenario (Arctic Marine Shipping Assessment 2009).

Arctic SMARTIC is a role-playing simulation (Pfirman et al. 2018) that helps participants understand the priorities of various Arctic stakeholders and develop future oriented



**FIGURE 3.** Should development of new oil and gas resources, or protection of Arctic ecosystems and wildlife be a higher U.S. Arctic priority? New Hampshire 2017 survey. Courtesy of Hamilton

strategies. This downloadable resource (Pfirman et al. 2017) addresses Principle #5, specifically 5A and 5F.

The activity goal is to create a multi-use Arctic management strategy for ca. 2040. The approach is based on the real-life resolution of a disputed area between Norway and Russia in 2010 (Harding 2010).

The Antarctic version is based on a future collapse of both the Antarctic Treaty and the Southern Ocean Marine Protected Area. These two sets of management regulations currently provide protections to Antarctica's natural and physical resources. Antarctic SMARTIC players find themselves without these protections, and participants must work together to manage valuable ecosystems suddenly thrust under intense usage pressure.

Arctic SMARTIC and Antarctic SMARTIC have been run with thousands of people in formal settings, from middle school to graduate level, as well as informal settings with lifelong learners in museum programs and science festivals. We rarely get to step outside our own role and look at something from another angle. SMARTIC gives us that chance and allows all to draw on prior knowledge and experience as we work together to respond to complex problems.

### THE ARCTIC'S LAST ICE AREA

Looking into the future, summertime Arctic sea ice will decline over the next several decades as the Earth warms. However, there is one region where summer ice will persist longer than anywhere else in the Arctic. This region, now known as the Last Ice Area (Pfirman et al. 2008, 2009, WWF 2019), is located north of Canada and Greenland. The ice there is thicker now because the wind and oceanic currents transport ice to this region from the central and Siberian Arctic regions, where it thickens due to winter freezing on the ice underside and ridging. Because wind and ocean currents are likely to be similar in the future, and because thick ice is harder to melt through in one summer than thin ice, this region is anticipated to remain a habitat for ice-associated species for decades longer than elsewhere in the Arctic.

The Last Ice Area activity (Pfirman and Turrin 2018) addresses Principle #5, specifically 5A and 5F. Resources needed for this demonstration can be found at Pfirman (2014). The foundation is a kiddie pool with blocks—or even overware!—labeled as Greenland and Norway (Figure 5) which can be filled with water (harder to manage) or used dry. Styrofoam is used for sea ice, and a plastic polar bear, walrus, seal, and helicopter—to represent researchers—can be purchased online.





**FIGURE 4.** Lifelong learners playing Arctic SMARTIC at the American Museum of Natural History. Courtesy of Turrin

Thousands of people have participated in this demonstration, ranging from small children to adults, mainly through science festivals and community outreach events. It is extraordinarily popular, among the most highly rated activities we developed, causing it to be requested for inclusion each year by groups hosting Earth Day and climate communication events. Children even return to see it in subsequent years. By including a poster, (available with the materials at Pfirmann 2014) for larger context behind the interactive, you can engage adults in a more in depth discussion regarding the science and what we can do to respond to the loss of Arctic ice, both through reducing greenhouse gases to slow warming and in managing Arctic development to protect this special habitat.

### POLAR VOICES

The Arctic has been populated for more than 40,000 years and yet most Americans do not realize that the U.S. has thousands of people living north of the Arctic Circle (Figure 1d.). The Arctic communities are on the ‘frontlines’ of climate change and their long history of living with the ice gives them personal stories and experiences that are important to share with the rest of us. Additionally, Arctic residents and western scientists need to learn from each other as they connect information about the changes that are occurring in our Polar Regions.

PoLAR Voices is a project that allows us to hear directly from both scientists and polar residents (Quinney et al. 2015, Moloney et al. 2016, and Murray et al. 2018). While there are many voices in the climate change conversation, it can be hard for the public to determine what those changes actually mean. Through listening in as PoLAR Voices breaks down



**FIGURE 5.** Kiddie pool set up to demonstrate the impact of Arctic sea ice loss on species such as walrus, seals, and polar bears. Courtesy of Turrin

the science of climate change and the direct experience from people living and working in the Polar Regions, we gain different perspectives. This resource addresses Principle #6.

The podcasts have been broadcast on Alaskan radio and are currently hosted by the Arctic Institute of North America on their website as a collection (<https://soundcloud.com/arcticinstituteofn-america>). The podcasts are less than 10 minutes in length making them useful in a classroom environment or for a supporting home assignment. The material is best for a middle school and older audience.

### THOUGHTS REGARDING IMPLEMENTATION

Both surveys of the adult public (Hamilton 2015, 2016, 2018, and Hamilton et al. 2017, 2018) and the Kahoot! player results—mostly by students—indicate an overall lack of polar knowledge in the U.S., supporting the critical need for including the Polar Literacy Principles in both formal and informal education settings. The PoLAR CCEP portfolio of projects provides ways to engage a variety of audiences in learning about the Polar Regions through fun and accessible resources. The PoLAR CCEP II included an extensive research and evaluation program around the effectiveness of the developed resources (Bachrach et al. 2017), some of our findings are included in the recommendations below:

#### Recommendations:

- 1.) Resources should be used for all audiences as they span ages and venues; for example, while EcoChains was designed for players age 10 and up, we found that in facilitated settings such as science festivals, 7-8 -year olds were riveted.

- 2.) Multiple resources can be used during an event/ program. Activities were purposefully designed to use a variety of engagement approaches: visual/aural/tactile, cooperative/competitive, and to make visible, tangible, and personal currently hidden aspects of polar systems (under ice communities, feedbacks and long-term processes, future scenarios, etc.).
- 3.) These innovative resources should be used as conversation starters: “more than half of those who are interested in global warming or think the issue is important “rarely” or “never” talk about it with family and friends” (Maibach et al. 2016), at the same time that family and friends are second only to scientists as trusted sources of information (Hamilton 2016).
- 4.) Be alert to the research opportunities that are, in turn, inspired by interacting with different audiences. The Last Ice Area demonstration led to a research agenda (Pfirman et al. 2008, 2009) that informed the August 2019 establishment of the Tuvaijittuq Marine Protected Area (<https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/tuvaijittuq/index-eng.html>).
- 5.) We recommend surveying scientists immediately after participating in outreach events to reflect on how the experience might impact their research.

## RESOURCES

All resources are available from the PoLAR Hub website: <https://thepolarhub.org>

## REFERENCES

Additional articles, and references and abstracts for all contributions are available on Polar-ICE ([https://polar-ice.org/nmea\\_current/](https://polar-ice.org/nmea_current/)) and NMEA (<https://www.marine-ed.org/s/Polar-Ice-Resources-Current.pdf>) sites.

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