



MULTIMEDIA RESEARCH

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Antarctica's Climate Secrets
Flexhibit Formative Evaluation
With Presenters and Visitors



Report for
Nebraska Educational Telecommunications
University of Nebraska State Museum
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INTRODUCTION

A Flexhibit is a digital package of high resolution banner graphics, video podcasts, and inquiry-based activities accessible via the Web. The FLEXible exHIBIT package provides leaders of after-school groups with materials to educate youth about a science content area. Student participants become experts in the Flexhibit content and then host a culminating public event where they present and interpret their science exhibit displays for their community.

The *Antarctica's Climate Secrets* Flexhibit package features an international science research project. The ANDRILL project- ANTarctic geology DRILLing- is recovering sedimentary rock cores from beneath Antarctica's ice to learn that continent's climate history. The package covers five themes: Antarctica Today; Antarctica's Ice on the Move; Reading Antarctica's Rock Cores; Tiny Clues to Antarctica's Past; and Decoding Antarctica's Climate History.

Nine students at Easton Middle School (EMS) in Easton, MD, participated in *Antarctica's Climate Secrets* after-school activities over a period of seven weeks in the Fall of 2007. The youth group was led by Stacey Hofmann, Extension Educator of 4-H in Talbot County, along with three Easton Middle School teachers. As part of their activities, the students developed exhibits for a community event at EMS as part of an annual waterfowl festival. Eight of the nine students communicated what they had learned to festival visitors at five exhibit stations that presented content reflecting the five themes of the Flexhibit package. This report documents the impact of the Flexhibit experience on the EMS students and the Flexhibit visitors.

PROCEDURE

Nine 6th and 7th grade EMS students completed a survey about their knowledge of Antarctica both before and after their seven-week experience. The survey was finalized before the Flexhibit activities were developed and not modified to reflect only activity information; thus, in some questions, students were tested about information that they had not covered in their sessions. The post-survey also gathered the students' reactions to their participation in the Flexhibit. The sample included five Caucasian girls, two African-American girls, one Asian boy, and one Caucasian boy.

Middle school youth and older visitors to the Flexhibit at the waterfowl festival completed one of five different survey cards (5.5" x 8.5") as they were leaving the Flexhibit space. Each card type was a different color and included two to three questions drawn from a set of open-ended opinion questions and closed-ended content questions about Antarctica and ANDRILL. Cards were randomly distributed, so it is possible that visitors completed survey questions for a station that they did not actually experience. Survey cards were completed by 134 respondents. Adults, ages 18 to 72, comprised 84% of the sample. Youth, ages 7 to 17, comprised 16% of the sample. The five different survey cards were filled out by comparable samples of 24 to 28 visitors.

FLEXHIBIT PRESENTERS

A few days after the Flexhibit community event, participating students were asked four questions:

1. What was the main idea that you wanted people to learn from your station?
2. What do you think worked really well in your experience of the Flexhibit event?
3. What do you think did not work well in your experience of the Flexhibit event?
4. What can be done to improve the Flexhibit event?

To attract visitors for part of the day's event, Station 5 (right photo) was placed in the hallway outside the main exhibit classroom. Station 5 presented a banner (Decoding Antarctica's Climate History) and the students' finished product from Activity 5A (Charting Temperature Changes). The exhibit illustrates how Antarctica's climate has changed over the past 50 million years and helps viewers predict what it will be like in the future. The student who presented at this station said he wanted people to learn "the pattern of the temperatures." He did not give an opinion about what did or did not work well in the event.



Upon entering the classroom, visitors saw Station 1 (left photo) which included a banner (Antarctica Today) and a student-built interactive exhibit (blubber gloves and insulated clothing) associated with Activity 1B (Animal Insulation). Station 1 also displayed "postcards" from Antarctica, a stack of blank "postcards" for visitors to write on, three globes, and a foamcore model of Antarctica showing its relative elevations. The presenters at Station 1 said they "wanted them to see the insulation in the different fabrics" and "learn more about Antarctica." The two students reported that "everyone liked the blubber activities." One student felt there was a problem with "the bags having a hole in them," and the other student was concerned about "not knowing what to say." To improve the event, one suggested "a bigger room," and the other recommended getting "more people to come."

Moving clockwise in the room, Station 2 (right top photo) presented a banner (Reading Antarctica’s Rock Cores), laminated photos about the drilling process, student-constructed whole and split “mess free” model rock cores, and a student-built interactive drilling rig from Activity 3A (Drill a Model ANDRILL Site). The two students who presented at this station “wanted people to learn why and how they drill the andrill in Antarctica” and “what the main purpose was for the scientists to drill up the rock core.” Both thought “how the stations were organized” worked well at the event, but both also felt the “location” and “being at the waterfowl festival” did not work well and recommended using the “gym or cafeteria.”



Station 3 (right bottom photo) featured a banner (Tiny Clues to Antarctica’s Past) and included the finished student products from Activity 4 (Dead Diatoms Do Tell Tales!), with a trough of buttons and four simulated rock core sections with gravel, sand, and whole and broken beads representing fossil diatoms. A poster containing a key to the model diatoms was attached to the front of the display table. One presenting student wanted people to learn “what a diatom is and what they are meant for,” whereas the second student wanted people to learn “what the buttons are for.” One student suggested adding “a real diatom under a microscope so people can really see what a diatom is.”



Station 4 featured a banner (Antarctica’s Ice on the Move) and included the products of students’ participation in unit 2 activities: a large wooden trough constructed on a slant board with model glaciers and shaved ice, and a slanted paint tray with an “ice sheet” showing “when the ice meets the sea.” The presenting student at this station wanted visitors “to know more about glaciers-like how they form.” In reflecting on what worked well or not, this student thought “the drill station worked really well” but “no one was watching the pod-casts.” She recommended being “a little more organized” to improve the event.

Results: Self-rated Impact

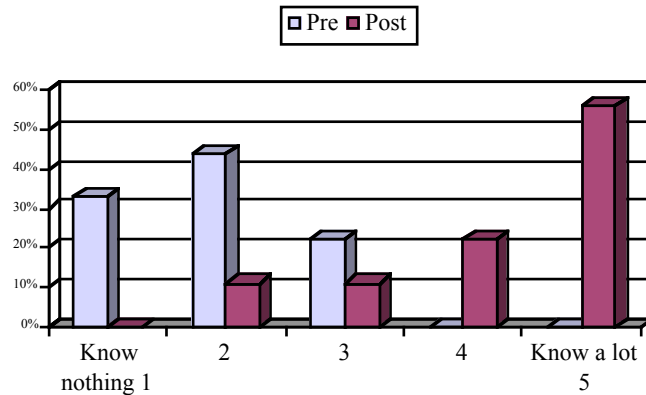
Easton participants were asked how much they agree or disagree with three statements about impact of their experience. Table 1 indicates that students were split on whether or not the experience motivated an interest in a science career, but the majority felt more confident in teaching others and wanted to learn more about what scientists do.

Table 1. Impact of Flexhibit Experience

	Strongly Agree/Agree	No Opinion	Strongly Disagree/Disagree
I became more interested in a science career because of my experience with the Flexhibit activities.	33%	44%	22%
I became more confident in teaching others because of my experience with the Flexhibit activities.	77%	11%	11%
The Flexhibit experience made me want to learn more about what scientists do.	55%	33%	11%

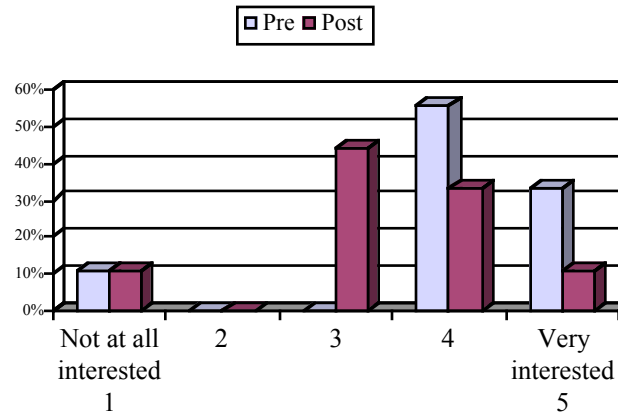
Both before and after their experience, the students rated how much they feel they know about Antarctica. Figure 1 shows that the students felt significantly more knowledgeable after their experience. A Wilcoxon signed-rank test found a significant difference between before and after the sessions (N=9, $z=-2.5$, $p=.012$).

Figure 1. Knowledge of Antarctica



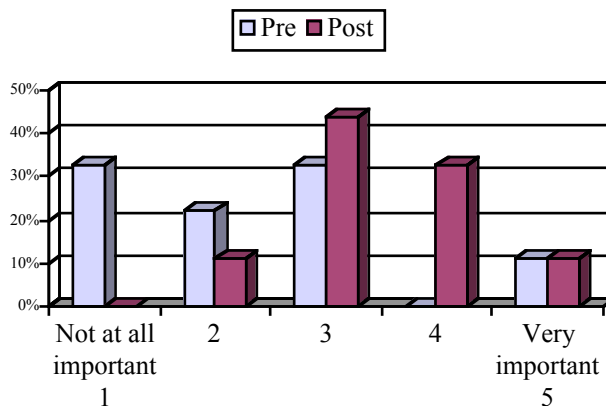
Before the sessions began, Easton students rated their interest in learning about Antarctica, and after their sessions, they rated their interest in learning more. Interest in learning about Antarctica was high before the sessions and did not change significantly after experiencing the Flexhibit activities. See Figure 2.

Figure 2 Interest in Learning about Antarctica



Also before and after participating in the Antarctica sessions, the nine students rated how important Antarctica is to their lives. Figure 3 below shows some movement towards rating Antarctica more important after their experience; however, a Wilcoxon signed-rank test on the data reveals no statistically significant change.

Figure 3. Importance of Antarctica



Results: Knowledge

Top-of-the-Mind Knowledge

To establish what is foremost in students' understanding about Antarctica, respondents were asked to describe Antarctica to someone who has never heard of the place. Both before and after the sessions, students tended to describe Antarctica as "cold," "coldest," and "icy." Before, but not after the sessions, students described Antarctica as "south" and having "penguins." Students more frequently described Antarctica after the sessions as being a "desert" or the "windiest, driest place." Also, a few misconceptions disappeared in the post-descriptions. For example,

- Pre: “It doesn’t have land. It’s made out of ice. It’s the biggest desert in the world.”
Post: “It’s a big place. It has glaciers, ice shelves, sea ice, and it’s the biggest desert in the world.”
- Pre: “The coldest place in the world, very icy, gets a lot of snow every year.”
Post: “A very cold place in the world.”
- Pre: “Icicy, cold, it has water, and penguins live there.”
Post: “The coolest, windiest, and driest place.”
- Pre: “It’s big and cold.”
Post: “It is the coldest, windiest, driest place on earth.”

Descriptive Facts

Before and after their Flexhibit experience, students were asked a series of multiple choice questions to establish their knowledge of basic descriptive facts about Antarctica today. Table 2 shows that both in pre and post surveys, all respondents knew that Antarctica is south of their home, has glaciers and penguins but does not have forests. From their activities, a significant number of students gained knowledge that Antarctica has mountains and valleys,¹ and a majority of the students also knew that Antarctica has seals (67%) but does not have polar bears (67%).

Table 2. Factual Knowledge

Questions and multiple-choice answers	Pre-Flexhibit % correct	Post-Flexhibit % correct
Where is Antarctica in relation to where you live? South of my home	100%	100%
Which of the following can be found in Antarctica? Glaciers Forests [false] Lakes Mountains and valleys Volcanoes	100% 100% 44% 33% 11%	100% 100% 22% 78% 33%
What animals can we find today on land and in the water at Antarctica? Penguins Walruses [false] Seals Whales Polar Bears [false]	100% 44% 33% 33% 22%	100% 33% 67% 22% 67%

If we give one point for each correct answer for these eleven questions, the pretest mean score is 6.2 and not significantly different from the posttest mean score of 7.2. However, the Flexhibit activities and banners did not discuss lakes, volcanoes, forests, polar bears, or walruses.² With these five questions removed, the pretest mean score is 4 and the posttest mean score is 4.7 out of a possible 6 points. There is again no statistically significant knowledge increase for the sample as a whole. Because of the high pretest knowledge base, the increase would have had to come in the knowledge that seals and whales live in Antarctica and this content is not emphasized in unit 1. The two students who presented “Antarctica Today” content at the community event answered 10 of 11 and 8 of 11 questions correctly, perhaps indicating that students learn the content better when they are responsible for communicating it to others.

¹ Wilcoxon signed-rank test: N=9, z=-2, p=.05

² A picture of a walrus is suggested under “things needed” in Activity 1B but walruses are not mentioned otherwise.

Antarctica's Ice

Students answered one multiple-choice question and a series of agree/disagree statements to evaluate change in knowledge about ice at Antarctica. Table 3 indicates that most students changed their understanding from a correct concept about ice movement prior to their experience to an incorrect one after their experience. Looking at individual answers, only one student (the student who presented this information at the event) gained the knowledge that most ice on Antarctica is always frozen but also slowly moving. Observations of students working on Activity 2A (Make a Model Glacier) indicate confusion as to the content goal of this activity.³ The description of the activity says “model the accumulation of snow and summer melting,” and students possibly concluded from the activity that “most Antarctic ice melts in the summer and freezes again in the winter.” The concept that Antarctica’s immense ice sheets are always frozen and slowly moving due to gravity is not clearly communicated in unit 2 activities.

Table 3. Antarctica’s Ice

Question and correct multiple-choice answer	Pre Flexhibit	Post Flexhibit
In your view, which one of the statements BEST describes the ice of Antarctica today?		
Most ice on Antarctica is always frozen but also slowly moving. [Best]	67%	44%
Most Antarctic ice melts in the summer and freezes again in the winter.	11%	56%
Antarctica is one enormous fixed and stable block of ice.	11%	0%
No answer	11%	0%

Table 4 shows the percentage who gave “agree/strongly agree” or “disagree/strongly disagree” answers to six statements about Antarctica’s ice.

Table 4. Antarctica’s Ice

Statements	Pre Flexhibit	Post Flexhibit
An ice shelf is attached to the land but floats out on the ocean. [true]	22% agree	67%
Ice shelves are made of fresh water. [true]	11% agree	33%
Sea ice is formed from salt water. [true]	56% agree	33%
Ice sheets are on land. [true]	33% agree	11%
Freezing ocean water forms ice sheets. [false]	11% disagree	11%
Sea ice, ice sheets and ice shelves describe different kinds of ice that float on the ocean. [false]	0% disagree	0%

Looking at individual responses from pretest to posttest, only two statements showed a positive, but not significant, change toward a correct answer:

- five of the nine students, including the presenting student, gained the knowledge that “an ice shelf is attached to the land but floats out on the ocean;”

³ See Johnson, A. Oct. 12, 2007, *Antarctica’s Climate Secrets* Easton Flexhibit Site Observations, Oct. 4 & 9, 2007. See also Flagg, B. & Hofmann, S. Dec. 6, 2007, *Antarctica’s Climate Secrets* Flexhibit Leader’s Review.

- three of the nine students, including the presenting student, gained the knowledge that “ice shelves are made of fresh water.”

Activity 2C, When Ice Meets the Sea, supports the learning of these two statements effectively. On the other hand, definitions of sea ice and ice sheets are apparently not effectively supported in unit 2.

If we give one point for each correct answer in Tables 3 and 4, the pretest and posttest means are both 2.0 out of 7 possible points. Students might have been confused by the ‘false’ statements in Table 4, but even without the two false statements, the pre and posttest means are not different.

Antarctica’s Climate

Students answered a series of agree/disagree statements to evaluate their knowledge about Antarctica’s climate. Table 5 shows the percentage of students who gave “agree/strongly agree” or “disagree/strongly disagree” answers to six statements, both before and after the Flexhibit experience. Looking at individual responses, there was positive change for five of the six statements:

- six of the nine respondents gained the knowledge that the statement “Antarctica has always been extremely cold and covered with ice” is incorrect;
- five of nine students gained the knowledge that “in its history, Antarctica has had huge shifts in climate, switching many times between cold and warm climates;”
- four of the nine students gained the knowledge that “understanding Antarctica’s past climate conditions helps us understand earth’s future climate;”
- three of nine students gained the knowledge that two statements are incorrect, “climate conditions in Antarctica only affect the climate about Antarctica itself,” and “Antarctica has a wet climate.”

The presenter of unit 5 content at the Flexhibit event answered all 6 statements correctly, again supporting the interpretation that being responsible for communicating to others increases focused knowledge acquisition.

Table 5. Antarctica’s Climate

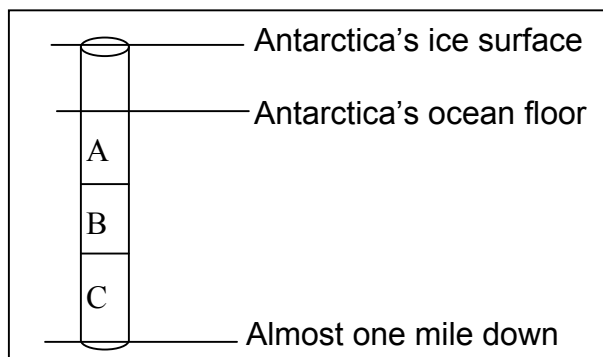
Statements	Pre Flexhibit	Post Flexhibit
If all the ice in Antarctica melts, then sea levels around earth will rise. [true]	100% agree	89%
Understanding Antarctica’s past climate conditions helps us understand earth’s future climate. [true]	44% agree	89%
Climate conditions in Antarctica only affect the climate around Antarctica itself. [false]	44% disagree	78%
Antarctica has always been extremely cold and covered with ice. [false]	22% disagree	89%
In its history, Antarctica has had huge shifts in climate, switching many times between cold and warm climates. [true]	22% agree	78%
Antarctica has a wet climate. [false]	11% disagree	33%

Giving one point for each correct answer, the pretest mean is 2.4 and posttest mean score is 4.6. The impact of the Flexhibit unit 5 activities on understanding Antarctica’s climate is statistically

significant.⁴ The false statement of “Antarctica has a wet climate” should not have been a problem for students because in their descriptions of Antarctica (see p. 5-6), three students describe the place as a “desert” and two describe it as the “driest place.” However, the activity of shaving ice for snowfall may have led students to focus on Antarctica as being “wet,” or perhaps the banner statement “driest place on earth” may not translate easily into the negative concept of not being a wet climate.

Understanding Rock Cores

Two questions addressed students’ understanding of rock cores. The first question asked respondents to identify the oldest part of the core in the drawing below, upon imagining that scientists use a large drill rig to core into sediments beneath the ocean about Antarctica. Prior to starting sessions, all but one student correctly chose C as the oldest part of the core, and after the sessions, all students chose C. At both time periods, students chose C because “it’s at the bottom and has been there the longest.” No student mentioned layers in explaining their choice.



A second question about the science of rock cores asked students to choose which of five components in an Antarctic rock core tell scientists about the history of Antarctica’s climate. All five components tell scientists something about climate history. Table 6 presents data from the multiple-choice question. A majority of students did not choose any of the five correct answers on the post-test, although a significant number of students acquired the knowledge that “layers of fine-grained sediment” tell scientists something about climate history.⁵ Giving one point for each correct answer, the pretest and posttest mean scores are 1.0 and 1.1, respectively, out of a possible 5.

Table 6. History of Antarctica’s Climate as Revealed by Rock Core

Question and multiple-choice answers	Pre Flexhibit	Post Flexhibit
Looking in an Antarctic rock core, which of the following tell scientists about the history of Antarctica’s climate?		
Layers of fine-grained sediment	0%	44%
Mixtures of rocks of all sizes	33%	22%
Fossils of marine animals	33%	11%
Fossils of marine plants	22%	22%
Volcanic ash	11%	11%
None of the above [incorrect]	44%	56%

⁴ Paired samples *t* test: $t(8) = -5.429, p = 0.0006$

⁵ Wilcoxon signed-rank test: $N=9, z=-2, p=.05$

The four students who presented activities from units 3 and 4, which cover this content, chose “none of the above” as an answer in Table 6. This result is contrary to our previous findings that presenting at the event increases knowledge about one’s assigned content area. It is possible that the terminology used in the question tripped the students up; however, all the terms but “fine-grained” and “volcanic ash” are used in the activity text. It’s more likely that unit 3 and 4 activities require so much construction work that the key learning outcomes of these units get lost in the doing.

FLEXHIBIT VISITORS’ REACTIONS

Upon leaving the Flexhibit, 134 visitors answered two to three opinion and content questions.

Results: Appeal

Two of the five post-visit survey cards asked about appeal: *What did you like most about your experience with the Antarctica program in this room? What did you like least about your experience with the Antarctica program in this room?* Adult visitors listed the student presenters as what they liked most about the Flexhibit, finding them knowledgeable, enthusiastic and confident. The majority of respondents liked everything about their experience, but 15% complained that the room was too small for the number of exhibits and people.

What Was Liked Most

One student and 26 adults explained what they liked about the Flexhibit:

- 44% were impressed with the student presenters’ knowledge, interest, and confidence; for example,
 - “The knowledge these kids possessed was great! Good research.”
 - “The one on one interaction with children and their knowledge of the subject.”
 - “Kids’ enthusiasm”
 - “That the kids are sincerely interested in the project. They did a great job!”
 - “The students did all the presenting. They were knowledgeable and confident.”
- 19% described particular exhibit demonstrations (“snow exhibit,” “drilling of cores,” “the model demonstrations, especially sediment transport”).
- 15% liked the visuals (“pictures,” “postcards,” “poster”).
- 15% liked everything.
- 11% noted the hands-on experiences (“the which is warmer”).

What was Liked Least

Two students and 24 adults received cards with the *like least* appeal question:

- 58% liked everything and did not describe what they liked least.
- 15% complained of the physical setup (“room too small,” “exhibits too close,” “smell”)
- 8% wanted more exhibits.

- 8% were disappointed that they did not have enough time to learn more.
- 8% were concerned with the exhibit content (“feeling the cold,” “seeing what may happen in the future”).

One survey card asked an open-ended question of *what was the most interesting thing you learned from your experience with the Antarctica program in this room?* Visitors’ answers included content from all Flexhibit stations except #4 about diatoms. Responses covered Antarctica’s temperature range, animal insulation, rock core drilling, and ice observations.

Most Interesting Things Learned

Seven youth and 20 adults received the post-visit card with the question about most interesting thing learned:

- 33% did not answer this question.
- 19% noted something about Antarctica’s past temperature; for example,
 - “I think that the temperature station was interesting because I got to see that even in Antarctica, it’s hot.”
 - “It wasn’t a cold area/continent like it is today.”
 - “Change in environment over millions of years seeing no ice to covered in ice.”
- 15% learned about animal insulation; for example,
 - “Insulation on birds.”
 - “The one that showed that blubber insulates the best.”
 - “The insulation value of feathers.”
- 15% mentioned the rock core; for example,
 - “Mining rig.”
 - “The rock core drilling project was very impressive.”
 - “Sediments are left behind by melting glaciers and are studied.”
- 15% found information about ice most interesting; for example,
 - “Moving of the glaciers.”
 - “That every year a new layer of ice forms on Antarctica in the winter, and that layer melts in the summer.”

Results: Knowledge

On each of the five post-visit survey cards, respondents were asked one or more open-ended, multiple-choice or agree/disagree questions related to information presented in the Flexhibit. Visitors did not necessarily look at all five stations, so the survey questions may have asked about content that they were not exposed to in the event.

In an earlier front-end survey, seventh-grade students and adult NOVA⁶ viewers were queried similarly about their knowledge of Antarctica. Their data provide a control group for our Flexhibit visitors and are presented below in comparison to the post-event survey data.

⁶ NOVA is a weekly PBS science television series.

Descriptive Facts

Respondents were asked a series of multiple-choice questions to establish their knowledge of basic descriptive facts about Antarctica today. Table 7 presents percent responses from the Flexibit adult visitors (treatment group) compared with front-end study responses from seventh graders and NOVA adults (control group). Only two youngsters completed Flexibit survey cards for these questions and so are not included in the data table. The Flexibit adults show the same pattern of responses as the control group but did not come away with descriptive knowledge about Antarctica at a level equivalent to the front-end control group respondents.

Table 7.⁷ Factual Knowledge

Questions and multiple-choice answers	Flexibit Adults (N = 26)	Front-end Adults (N = 102)	Front-end Youth (N = 92)
Where is Antarctica in relation to where you live?			
South of my home	65%	94%	90%
North of my home [incorrect]	23%	6%	10%
West of my home [incorrect]	4%	0%	0%
East of my home [incorrect]	0%	0%	0%
What animals can we find today on land and in the water at Antarctica?			
Penguins	79%	97%	93%
Seals	63%	80%	71%
Whales	42%	81%	67%
Polar Bears [incorrect]	33%	22%	76%
Walruses [incorrect]	17%	39%	64%

Animal Insulation

Flexibit visitors answered an open-ended question about how animals keep warm in Antarctica. This question was not asked in the front-end study. Table 8 presents the responses of Flexibit adult visitors; again, we had only two youth respondents so they are not included in the data table. Half of the adult respondents suggested blubber or fat as animal insulation.

Table 8. Animal Insulation

Question and open-ended answers	Flexibit Adults (N = 26)
How do animals keep warm in Antarctica? ⁸	
Blubber or fat	50%
Fur	27%
Feathers	19%

⁷ Percentages in all tables in this report are rounded. Percentages in tables may not add up to 100 because visitors did not answer the question.

⁸ This is an open-ended question to which respondents could give more than one answer.

Antarctica's Ice

Respondents were asked one multiple-choice question and a series of agree/disagree statements to evaluate their knowledge about ice at Antarctica. Table 9 presents data from the multiple-choice question comparing Flexibit adult visitors with seventh graders and NOVA adults of the front-end study. Only two youngsters completed Flexhibit survey cards for this question and are not included in the data table. The Flexhibit visitors are comparable with the front-end respondents with respect to their knowledge about ice on Antarctica. Note that most adult visitors answered this question correctly, whereas most EMS students answered incorrectly (see p. 7).

Table 9. Antarctica's Ice

Question and correct multiple-choice answer	Flexhibit Adults (N = 26)	Front-end Adults (N = 102)	Front-end Youth (N = 92)
In your view, which one of the statements BEST describes the ice of Antarctica today?			
Most ice on Antarctica is always frozen but also slowly moving. [Best]	73%	82%	69%
Most Antarctic ice melts in the summer and freezes again in the winter.	27%	9%	19%
Antarctica is one enormous fixed and stable block of ice.	0%	9%	12%

Table 10 shows the percentage of respondents who gave “agree/strongly agree” or “disagree/strongly disagree” answers to six statements. Again, the Flexhibit visitors are similar to the front-end respondents with respect to their knowledge about ice. The Flexhibit youth, in particular, were able to identify four of six of the true and false statements better than the front-end survey youth and also better than the EMS students themselves (see Table 4). Perhaps visitors studied the banner definitions.

Table 10. Antarctica's Ice

Statements	Flexhibit Youth (N = 7)	Flexhibit Adults (N = 20)	Front-end Adults (N = 102)	Front-end Youth (N = 92)
An ice shelf is attached to the land but floats out on the ocean. [true]	57% agree	75%	76%	57%
Sea ice is formed from salt water. [true]	43% agree	65%	51%	45%
Ice shelves are made of fresh water. [true]	43% agree	60%	59%	28%
Ice sheets are on land. [true]	57% agree	55%	44%	36%
Freezing ocean water forms ice sheets. [false]	43% disagree	20%	40%	17%
Sea ice, ice sheets and ice shelves describe different kinds of ice that float on the ocean. [false]	43% disagree	15%	25%	11%

Antarctica's Climate

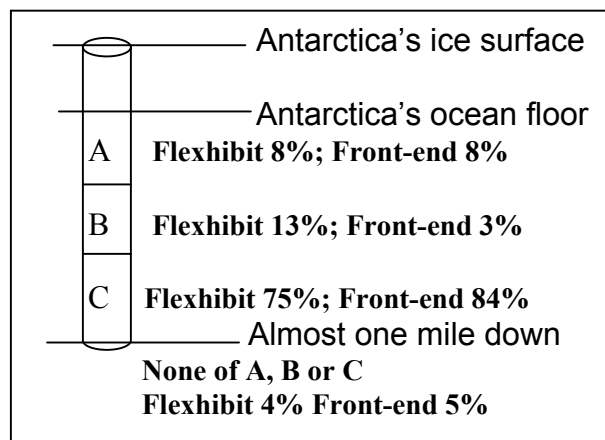
Respondents responded to a series of agree/disagree statements to evaluate their knowledge about Antarctica's climate. Table 11 shows the percentage of Flexhibit visitors and front-end survey respondents who gave "agree/strongly agree" or "disagree/strongly disagree" answers to six statements. The Flexhibit visitors percentage of correct responses are similar to the front-end respondents with respect to their knowledge about Antarctica's climate, except for a misunderstanding by visitors that Antarctica's climate is wet, not dry.

Table 11. Antarctica's Climate

Statements	Flexhibit Youth (N = 6)	Flexhibit Adults (N = 22)	Front-end Adults (N = 102)	Front-end Youth (N = 92)
If all the ice in Antarctica melts, then sea levels around earth will rise. [true]	67% agree	100%	94%	79%
Understanding Antarctica's past climate conditions helps us understand earth's future climate. [true]	83% agree	95%	92%	71%
Climate conditions in Antarctica only affect the climate around Antarctica itself. [false]	50% disagree	86%	90%	52%
In its history, Antarctica has had huge shifts in climate, switching many times between cold and warm climates. [true]	67% agree	64%	57%	41%
Antarctica has always been extremely cold and covered with ice. [false]	17% disagree	64%	66%	32%
Antarctica has a wet climate. [false]	17% disagree	32%	72%	23%

Understanding Rock Cores

Two questions addressed respondents' understanding of rock cores. The first question asked respondents to identify the oldest part of the core in the drawing below, upon imagining that scientists use a large drill rig to core into sediments beneath the ocean about Antarctica. Three-quarters of Flexhibit visitors (N = 24) answering this question correctly chose C as the oldest part of the core. The drawing below compares Flexhibit and front-end survey respondents, again showing similar response distributions.



The one Flexhibit respondent who gave a reason for choosing A explained, “The layers form from the top.” Those who chose B did not provide reasons for their answer. The majority (75%) of the visitors chose C as the oldest part of the core, but explanations for this answer reflect relatively simplistic interpretations for why C is the oldest.

- 21% provide an explanation that describes action of layers of some sort being deposited over time; e.g.,
 - “law of superposition!”
 - “layers build on older layers”
 - “because ice expands and pushes old earth down farther”
 - “because it is at the bottom and snow and ice stacks up”
 - “sediments falls”
- 38% simply declare that C is “deepest” or “lowest” without further explanation.
- 17% gave no explanation.

A second question about the science of rock cores, presented on a separate survey card, asked visitors to choose which of five components in an Antarctic rock core tell scientists about the history of Antarctica’s climate. All five components tell scientists something about climate history. Table 12 presents data from the multiple-choice question comparing Flexhibit adult visitors with seventh graders and NOVA adults of the front-end study. Only two youngsters completed Flexhibit survey cards for this question and are not included in the data table. Most Flexhibit adult visitors agreed that “layers of fine-grained sediment” and “mixtures of rock of all sizes” would help tell the story of Antarctica’s climate, whereas the majority of adults surveyed in the front-end survey correctly favored all five choices.

Table 12. History of Antarctica’s Climate as Revealed by Rock Core

Question and multiple-choice answer	Flexhibit Adults (N = 24)	Front-end Adults (N = 102)	Front-end Youth (N = 92)
Looking in an Antarctic rock core, which of the following tell scientist about the history of Antarctica’s climate?			
Layers of fine-grained sediment	71%	78%	45%
Mixtures of rocks of all sizes	71%	60%	28%
Fossils of marine animals	54%	77%	62%
Fossils of marine plants	50%	78%	52%
Volcanic ash	21%	64%	12%
None of the above [incorrect]	0%	9%	17%

DISCUSSION

Visitors to the *Antarctica's Climate Secrets* community event were most impressed by the student presenters, describing them as knowledgeable, enthusiastic and confident. The majority of respondents liked everything about their experience, although 15% complained that the room was too small for the number of exhibits and people. Visitors noted learning interesting things from four of the five stations, including information about Antarctica's past temperature, animal insulation, rock core drilling, and Antarctica's ice. In response to post-visit knowledge questions, the Flexhibit visitors showed percentages of correct responses that were similar to or slightly lower than the respondents to our front-end survey. The fact that visitors did not necessarily answer questions that related to the stations that they actually viewed will have influenced the knowledge data; however, we should recognize that it is also difficult to communicate a clear and memorable message in an informal learning environment, even for experienced exhibit presenters.

Students who participated in the Easton Middle School after-school sessions felt that their experiences in activities and a community event had successful outcomes for them personally. The majority of participants felt more confident in teaching others and wanted to learn more about what scientists do. Students felt significantly more knowledgeable about Antarctica and their interest in learning about the area remained high after the culminating event. One-third of the group reported becoming more interested in a science career because of their experiences with the Flexhibit activities. From their experiences, students demonstrated via pre-post tests some knowledge acquisition but also some confusion about what they were supposed to learn and teach to others.

Descriptive facts. Prior to beginning the after-school sessions, all students already knew that Antarctica is south of their home, has glaciers and penguins but does not have forests. Significant improvement was measured in student knowledge that Antarctica has "mountains and valleys" but not "polar bears." The two students who presented "Antarctica Today" obtained the two highest post-test scores with regard to the descriptive facts about Antarctica as compared to their classmates. [It should be noted, for the summative evaluation, that information about lakes, volcanoes, forests, polar bears, and walruses is not included in the banners and activities, and the factual knowledge questions should be modified, if used.]

Antarctica's Ice. The student sample improved (not significantly) in knowledge about "ice shelves" but did not gain a good definitional understanding of "sea ice" and "ice sheets." Moreover, after their Flexhibit activities, some students changed their understanding about ice movement from a correct concept to an incorrect one. The only student who gained the knowledge that most ice on Antarctica is always frozen but also slowly moving is the presenter of "Antarctica's Ice on the Move." The main messages of unit 2's activities are not clearly communicated to the students.

Antarctica's Climate. The impact of unit 5 activities on understanding Antarctica's climate is statistically significant. Students gained knowledge about past climate conditions and the importance of Antarctica's climate. The presenter of "Decoding Antarctica's Climate's Secrets" obtained a perfect score on the climate questions.

Understanding Rock Cores. Students understood that the lowest part of the rock core is the oldest part, but the majority did not understand what components in an Antarctic rock core tell scientists about the history of Antarctica's climate. A significant number of students improved in their knowledge that "layers of fine-grained sediment" tell about climate history; however, the four students who presented activities from units 3 and 4 were unable to recognize any of the five rock core indicators related to climate history.

The *Antarctica's Climate Secrets* after-school curriculum was most effective in improving student confidence about their own knowledge and their ability to teach others. Half of the student presenters learned better the content which they were to communicate to the public. This finding supports the Flexhibit feature of having a culminating community event. Reviewing and clarifying the key intended learning outcomes for units 2, 3, and 4 will also improve student knowledge acquisition where it is currently weakest.