Short- and long-term effects in the school system of a research immersion experience for science educators: An example from ANDRILL (Antarctic Geological Drilling)

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ABSTRACT

Since its first field season (2006–2007), the ANDRILL (Antarctic Geological Drilling) program has implemented an innovative educational and public outreach (EPO) program known as ARISE (ANDRILL Research Immersion for Science Educators), which has actively involved a group of selected educators in every phase of the research, from participation in field activities to discussion of the scientific results. This method of research immersion has led to an impressive list of achievements, including the development of quality outreach initiatives and diverse educational materials, the involvement of a large number of schools using these resources, the creation of an international network of strongly motivated polar geoscience educators, and the realization of new and unexpected professional opportunities for educators. In Italy this program initiated a specific project (progettosmilla.it), in accordance with the objectives of the ARISE Program. Thanks to the use of both a wide range of instruments (online and material) and the network of personal relationships provided by teachers involved in the program, ARISE has resulted in many short-term accomplishments. The development of new partnerships with local and national institutions has led to a number of middle- and long-term processes, rarely seen in similar EPO projects, resulting in the attainment of other goals. Research immersion experiences promote close interactions between teachers and scientists, and provide the potential for accomplishing other long-term educational outcomes. The shared development of educational resources by scientists and educators through ARISE has created an opportunity to advance scientific education within schools and, through outreach, in the general populace.

INTRODUCTION

The ANDRILL (Antarctic Geological Drilling, http://www.andrill.org/) program is a multinational initiative, involving collaboration among the Antarctic programs of Germany, Italy, New Zealand, and the United States. It comprises more than 200 scientists, engineers, technicians, students, and educators from the four partner nations, and aims to recover stratigraphic records along the Antarctic margin with use of a hot water drilling system integrated with sediment and/or rock coring and drilling technologies. Both of ANDRILL's inaugural drilling projects, the McMurdo Ice Shelf (MIS) and Southern McMurdo Sound (SMS) projects, reached their scientific objectives and resulted in the two deepest drill holes on the Antarctic continental margin (Figs. 1 and 2), together recovering 2400 m of nearly continuous and high-quality sediment core, with core recovery at record levels (98% of the penetrated rock strata). ANDRILL's two new drill cores are the longest and most complete geological records from Antarctica.

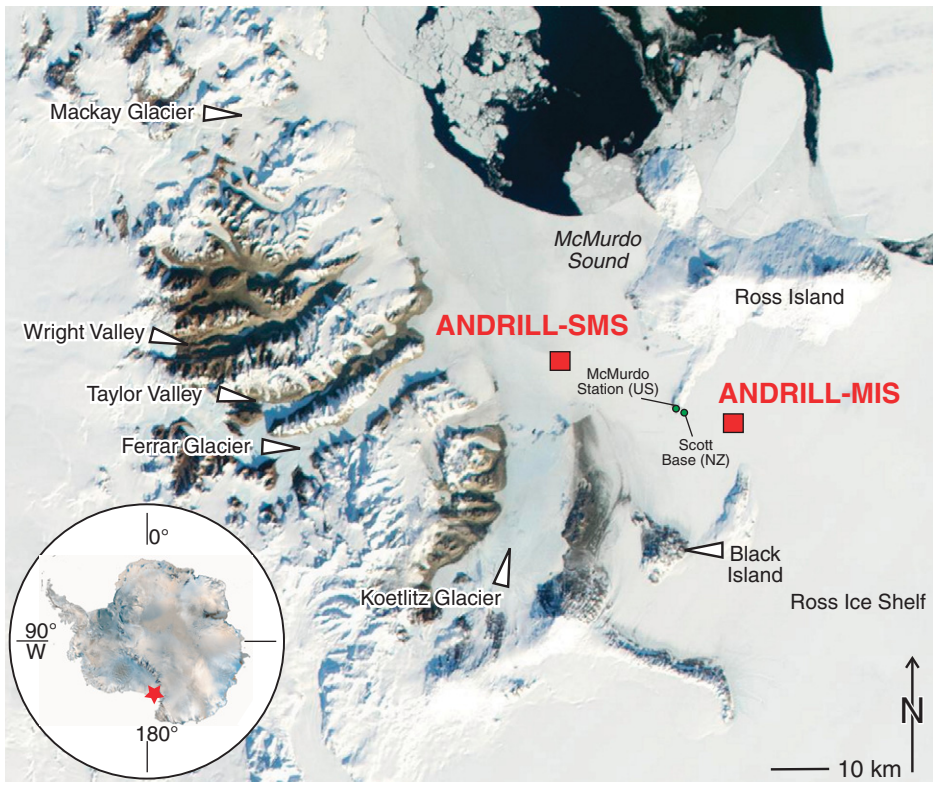

Figure 1. Location of the Southern McMurdo Sound (SMS) and McMurdo Ice Shelf (MIS) drill sites and key geographical features in SMS.

Geosphere; December 2011; v. 7; no. 6; p. 1331–1339; doi: 10.1130/GES00678.1; 8 figures.

Figure 2. ANDRILL (Antarctic Geological Drilling) rig in late 2007 (Southern McMurdo Sound, SMS Project), operating on floating sea ice (~8.5 m thick) platform.

The ANDRILL MIS Project (drilled in 2006) recovered a 1284-m-long core from a site situated on an 85-m-thick section of the Ross Ice Shelf (Fig. 1). Drilling at this site recovered a record of a dynamic cryosphere over the past 13 m.y., evidencing the glacial and climate variations of the West Antarctic Ice Sheet (Florindo et al., 2009; Naish et al., 2007a, 2007b, 2009). In 2007 the ANDRILL SMS Project recovered a 1138-m-deep core from a drill site located ~25 km from the American McMurdo Station and New Zealand Scott Base (Fig. 1), on sea ice (~8.5 m thick) floating on the Ross Sea above 380 m of water. Drilling at this site recovered an expanded geologic section that records the history of ice-proximal, shallow-marine paleoenvironmental variation during the Middle Miocene, a variation thought to represent a fundamental step in the development of the cryosphere during the Cenozoic (Florindo et al., 2009; Harwood et al., 2009a, 2009b; Warny et al., 2009; Fielding et al., 2011).

The ANDRILL research project contributed to the Fourth International Polar Year (http://www.ipy.org), a time of focused international activity aimed at making progress in all the polar sciences. The last International Polar Year was in 1957–1958; during that time, a large number of nations coordinated and expanded their polar research efforts and worked to enhance public awareness of polar issues. As a key component of its overall scientific program, ANDRILL developed an extensive and innovative education and public outreach program known as ARISE (ANDRILL Research Immersion for Science Educators; http://www.andrill.org/iceberg/arise/index.html) (Harwood et al., 2006; Huffman et al., 2009). ARISE generally aims to involve both educators and the general public and provide them with information about the objectives, methods, and outcomes of the ANDRILL research activity (Huffman et al., 2009).

This article illustrates the short-, middle-, and long-term impacts of the ARISE Program, primarily as observed in the scholastic system of Italy and more generally with respect to Earth system sciences education. The experiences of an Italian secondary school teacher who took part in the international ARISE Program are described. The analysis of these outcomes is combined with data presented in recent international reports about the status of school systems and polar science education to present some conclusions about the ARISE Program, and similar educational and public outreach (EPO) programs, and the intrinsic potential of immersion experiences for the teaching profession.

ARISE PROGRAM

The ARISE Program for sciences educators was developed by the international ANDRILL program and became a flagship example of EPO for the International Polar Year. It was designed along the lines of previous immersion experiences for teachers, such as the TEA (Teachers Experiencing Antarctica and the Arctic; http://tea.armadaproject.org) and ARMADA Projects (http://www.armadaproject.org). ARISE consisted of gathering, for each drilling campaign, a team of science educators from the four ANDRILL partner countries, under the coordination of an EPO officer. In all, 14 science educators were selected: 6 of them from the ARISE 2006 team (Fig. 3) and 8 from the ARISE 2007 team. The selection procedures were established by the individual countries involved and were based on the candidate applications, which included specific proposals for communication projects that each candidate would undertake if they were selected to be part of the ARISE Program.

The ARISE Program consisted of two successive phases: (1) providing the teachers selected for the ARISE team with background information about the ANDRILL program and scientific research techniques in general, and more specifically, information about the range of polar sciences involved in the International Polar Year; and (2) definition of individual project goals, methods, and desired outcomes for each of the educators involved in the ARISE Program, with focus on the potential impacts to their schools and communities, within a suitable time frame to be accomplished, as described in each proposal.

The ARISE team was integrated into the overall ANDRILL scientific research team preparing for the scientific drilling project, and provided an intensive immersion program that took place before, during, and after the expedition to Antarctica, which occurred during the austral summers of 2006 and 2007, activities being supported from the American McMurdo Station.

The primary objective of the ARISE Program was to ensure that every teacher would carry out two main types of activities: (1) to support some aspect of the daily routine operations as a member of one of the science discipline groups into which the overall ANDRILL team was divided, and (2) to carry out their own proposed communication project. (A record of the ARISE team experiences and activities is available at http://www.andrill.org/education/.)

ANDRILL EDUCATION AND OUTREACH PROGRAM IN ITALY: PROGETTOSMILLA.IT

Progettosmilla.it was the project chosen to represent Italy in the inaugural drilling project (ANDRILL MIS Project); Italian members took part in the first ANDRILL expedition and in all stages of the ARISE Project. While initially progettosmilla.it was expected to end in June 2007, the project continued for another year, providing off-ice support for the ARISE educator from Italy (Graziano Scotto di Clemente), who participated in the ANDRILL SMS Project.

Figure 3. The ARISE (ANDRILL [Antarctic Geological Drilling] Research Immersion for Science Educators) 2006 team. Back row, left to right: Julian Thomson (New Zealand), Betty Trummel (USA), Alexander Siegmund (Germany), LuAnn Dahlman (USA); front row: Vanessa Miller (USA), Matteo Cattadori (Italy).

In Italy there seems to be a direct relation between teacher motivation and academic results (Barbieri et al., 2007). More specifically, in the area of the popularization of science, low teacher motivation is considered a possible cause for the decrease in interest in scientific subjects shown by students (European Commission, 2007). Even though Italy places among the top countries in the world in terms of quantity of vocational updating material for teachers (Organisation for Economic Co-operation and Development, 2009), teachers are seldom offered the opportunity to carry out educational and/or vocational training activities aimed at increasing motivation.

Some of the supporting elements considered in the creation and planning of progettosmilla.it were: (1) the high percentage of Italian teachers using resources downloaded from other websites to integrate with and complete their lessons (Cavalli, 2000; Cavalli and Argentin, 2010), and (2) the high percentage of teachers expressing the need for more vocational professional development activities focused on teaching issues for each subject.

The chief goal pursued by progettosmilla.it was to involve both students and teachers in an experience with great motivational potential, such as shared participation in an important scientific research expedition to Antarctica, that provided the opportunity to exploit the use of the web and other new technologies, with particular emphasis on synchronous communication, such as chat, video, and audio conferences.

On the basis of these observations about the Italian scholastic system, progettosmilla.it attempted to include remote (virtual) participants in the ANDRILL field experience, encouraging them to be active and involved in all the aspects of the scientific process of the research. Some other goals that were continually pursued from the beginning of the project were:

- to enable teachers to use active methods in class to explain the scientific themes of ANDRILL and to highlight the importance of the Antarctic continent for understanding the integrated nature of the climate system;
- to offer teachers, researchers, and institutions an opportunity to demonstrate the benefits of mutual cooperation;
- to encourage and support teachers to adopt new technologies (e.g., web chat and audio and video conferences) in different professional situations;
- to create opportunities for international cooperation and cultural exchange with students and science teachers from the ANDRILL partner countries;
- to support educational initiatives carried out by other members of the ARISE team and by entities (e.g., institutions, schools) and/or participants (e.g., international, national, local) involved in the general field of polar sciences.

All of these objectives were consistent with the main ANDRILL ARISE initiative (ANDRILL Science Management Office, 2006).

METHODOLOGY

The method adopted for teachers participating in progettosmilla.it was based on a research model called Action Research, in which teachers become the main players in the practice of education and teaching. Considering that the author of the project is an experienced teacher, and constantly interacts with teachers who use the model, one can observe how progettosmilla.it perfectly matches the definition of Action Research given by Ebbut (1985) in which the method is described as the systematic study of attempts to improve educational practice by groups of participants by means of their own practical actions and by means of their own reflection upon the effects of those actions.

The method of adventurous storytelling, using the typical blog communication style, was selected and adopted by progettosmilla.it to actively engage students. This method is similar to communication projects carried out by various mountaineers, sailors, explorers, and others during adventurous activities. The use of blog diaries can help maintain student attention at a high level and lengthen their focus on each single event described in the blog; the representative website for these kinds of communication diaries is http://www.explorersweb.com.

The full range of instruments created and used by progettosmilla.it from October 2006 to June 2008 is described here. All services were provided free of charge for the participating schools located throughout Italy, and included the following.

Project Website

A project website (http://www.progettosmilla.it) was the primary tool used to host the services and products and achieve the basic goals of the project. It consisted of 140 pages html, multimedia resources (1200 photos and 40 audio and video files), and a section dedicated to every class involved in the project. All explanations concerning ANDRILL matters were provided with the constant supervision of researchers from the scientific team. An English version of the website was set up to facilitate consultation with ARISE colleagues. Because the website was also intended to serve as evidence of the work completed by schools, all the participating schools were listed in the "classes" section. Here, each class had their own page summarizing the main information about themselves

(e.g., participants, activities, and products). Illustrative statistics about access to the web domain (e.g., unique visitors and page hits) for relevant time intervals are shown in Figure 4.

Teacher Resource Folders

A set of teacher resource folders dealt with the selected study themes. These resources, which were freely downloadable via the website, consisted of a main "Index Document" together with other tools that were deemed useful for the teacher to prepare lectures, laboratory experiments, computer simulations, and other teaching activities. At the end of the biennium, a "Teacher Resource Folder" was set up for each of the following topics: Climate and Climate Change; Antarctic Explorations; Micropaleontology and Paleoclimatology; Drilling Technology; Antarctica: Man and Environment; Absolute and Relative Dating; Ocean Circulation; Antarctica and Tectonics.

Educational Kit

An educational and popular communication kit (e.g., brochure, poster, CD data, and video) describing both the ANDRILL research and information about Antarctica in general was created by the project partners. They included the National Institute of Geophysics and Volcanology (INGV, Istituto Nazionale di Geofisica e Vulcanologia), the National Programme of Research in Antarctica (PNRA, Programma Nazionale di Ricerca in Antartide), and the National Museum of Antarctica (MNA, Museo Nazionale dell'Antartide).

Blog

A blog described research events and life in Antarctica.

Chat and Videoconference Sessions

Chat and videoconference sessions among the participating schools were carried out according to a specific schedule and involved a minimum amount of preparatory work for the group of students involved. In the two years considered, ~15 activities of this type were carried out.

Meetings with Schools

Meetings with schools, in collaboration with the local teacher, were held. The aim was to explain both the content of the ANDRILL research and the basic concepts of polar sciences. ANDRILL researchers attended several of these meetings. Part of the meeting time was always set aside to check the improvement in student work toward the final goal. For 2006–2008, all the partner schools (~60) had ~100 meetings. The geographic distribution and frequency of meetings is shown in Figure 5. More than 2000 11–18-yr-old students, from 18 Italian provinces, were involved in these activities. In all, ~100 Italian teachers participated in the entire range of activities, including courses (see following).

Occasional Online Competitions

Participants took articulated tests, posted on a web platform, using e-mail to answer questions published on the website.

Interactive Educational Animations

These animations were realized in collaboration with IPRASE (Istituto Provinciale per la Ricerca e la Sperimentazione Educativa) in Trento, an institution specializing in producing interactive educational tools. One of these, representing a simplified model of the advance-retreat behavior of the ice shelf and ice sheet coupled system based on preliminary data (Fig. 6), was developed with the scientific review of David Pollard of Pennsylvania State University, a member of the ANDRILL Ice Sheet and Climate Modeling Team.

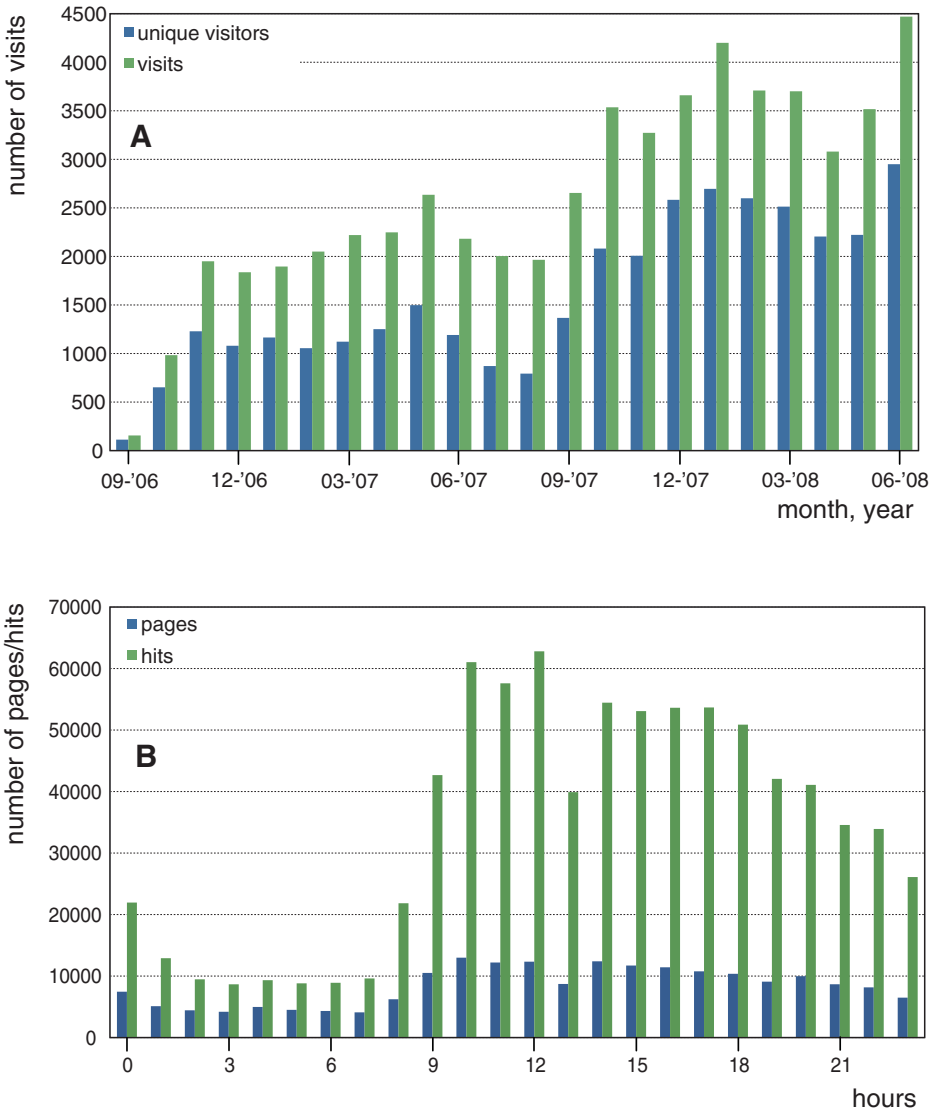

Figure 4. A) The www. progettosmilla.it (see text) server access data, divided per single visitors and number of visits. The data refer to the time period between September 2006 and June 2008. B) The progettosmilla.it server access data, divided per user access time slot. The data refer to the time period between September 2006 and June 2008.

Figure 5. Geographical distribution of the schools in Italy that took part in the 2006–2007 and 2008–2009 editions of progettosmilla.it (see text).

Laboratory Experiments and Lessons

A number of simple experiments based on academic guidelines provided by partner schools were developed during the expedition to Antarctica and were subsequently recorded as short videos that were posted on the project website in the media section. These videos were watched by classes of students to deepen their knowledge of various scientific concepts and lessons.

Online Support

Online support (e-mail) for individual students by discipline experts provided students with personal knowledge and information that could be shared during tests and final examinations.

Final Project

Participating classes were asked to prepare a final project illustrating the scientific topics that were discussed in order to further increase their degree of commitment to the program.

Refresher Course for Teachers

In collaboration with the Tridentine Museum of Natural Sciences, a refresher course for teachers was conducted during the 2008 scholastic year. This course, which addressed both ANDRILL and polar sciences topics, was titled "Antarctica and ANDRILL: Free Territories for New Paths of Sciences." This 15 h course alternated theoretical lessons on polar themes presented by researchers with practical sessions that introduced useful educational instruments for discussing these themes in classrooms.

Some of the instruments mentioned above were used to carry out activities for users abroad, to support and cooperate with other ANDRILL ARISE projects: for example, collaborative meetings with schools in Christchurch (New Zealand) and Crystal Lake (Illinois, USA) (Fig. 7).

SMILLA PROJECT TIMING

During the two-year period when the project was fully underway (2006–2007 and 2007–2008), progettosmilla.it involved participating classroom groups on a year-round basis, according to a specific schedule, and provided support for each stage of their involvement.

To reach the goals of the project more thoroughly and effectively, progettosmilla.it offered and/or encouraged the use of some of the above-mentioned instruments for the involvement of each class. The main stages are listed here.

1. Online registration. The interested teacher was invited to make two choices: the desired field of study (selected based on personal counseling with the ANDRILL and/or polar sciences researchers), and the type of final product the classes were deemed capable of completing successfully.

2. Resource material for teachers. Each teacher received an educational kit, via regular mail, and a "Teacher Resource Folder" via the web.

3. Successful completion of an educational task. The teacher continued to work in full autonomy (with the continuous long-distance support of progettosmilla.it) on deepening the selected educational theme. The project, at this stage, offered the educator and students a full range of services available online.

4. Personal meeting. Each participating school had personal contact with an Italian ARISE teacher at least once.

5. Development and use of the final product. Classes were encouraged to create final products that could be used in different contexts, e.g., final exams, open-day events, local temporary exhibitions, and discussions concerning scholastic subjects (environmental education, school and research, and polar years).

RESULTS

Short-Term Results (September 2006–June 2008)

Even though a structured efficacy estimation of the project for the time range considered was not carried out, some factors, at least, point to a few hypotheses concerning the quality of work completed so far.

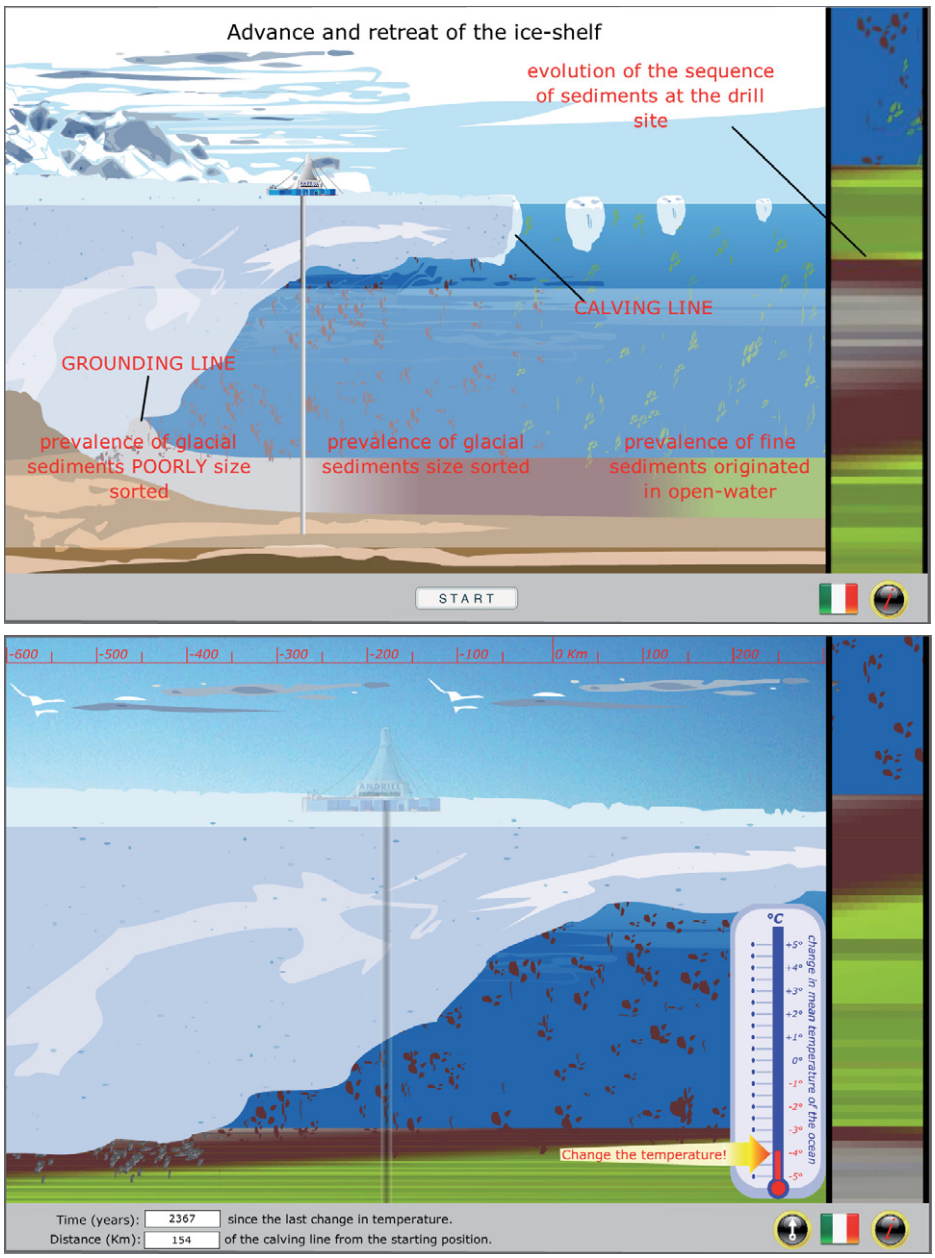

Figure 6. Video screenshot showing an interactive animation of the West Antarctic Ice Sheet advance and retreat from the ANDRILL (Antarctic Geological Drilling) McMurdo Ice Shelf Project drill site, as climate (temperature) has been changing through time (published at http://www.progettosmilla.it/mmedia/anim/and-advretr.swf).

1. After the first year, a high percentage of schools (12 out of 25, or 48%) renewed their affiliation with the second-year activities.

2. Of the 66 participating schools, 46 (i.e., 70%) completed the project with a final product (of some sort).

3. Access to the project website by teachers and students continues to increase (Fig. 4).

An analysis of the user traffic data for the www.progettosmilla.it website in the time range considered (September 2006–June 2008), dividing them according to their time of access, points to a peculiar distribution, represented in Figure 4. The user access distribution is remarkable for an educational website, which traditionally would be accessed most in the morning hours, i.e., class time. Instead, there is also intense access in the afternoon and evening hours, meaning that the users are probably motivated to check the website in their spare time, apart from scholastic activities.

Long-Term Effects (June 2008–Present Day)

One of the partners of the first phase of activities, the Tridentine Museum of Natural Sciences (MTSN; http://www.mtsn.tn.it/), in summer 2008, wished to incorporate progettosmilla.it into its educational offerings. This represented a significant change to the original model, not just a modification to carry the project into the following years, but rather the chance to work full time to implement progettosmilla.it, thanks to a specific agreement between the scholastic administration of Trento and the MTSN. The MTSN is an institution with a very active educational service department, whose activities, often extremely innovative, engage ~70,000 students each year.

From June 2008 onward, progettosmilla.it went on to complete and integrate the previous work on the outreach activities of the ANDRILL program. In this phase new educational projects were also developed, referred to as ANDRILL inspired: these are the ICLEEN (Interrogarsi su Clima ed Energia), Ortles, and SPES (Summer Polar School for Science Teachers) projects, described in detail in the following. All three follow the inspirational principles of ANDRILL ARISE and were created together with the Tridentine Museum.

In the following years, the former ANDRILL outreach activities gradually decreased in intensity as the new services and activities gained momentum and increased, taking over in priority.

The most recent synthesis and integration activities of the program include the following.

1. Implementation of a third year of progettosmilla.it programming through 2009, and ANDRILL seismic survey field activities related to the ANDRILL Offshore New Harbour Project (http://www.andrill.org/science/onh), involved member schools taking part in the videoconferences set up by ANDRILL ARISE and Italian students and teachers joining in the Flexhibit educational community.

2. Collaboration with specific International Polar Year projects and support of educational activities carried out by educational entities during the International Polar Year involved conducting chats and videoconferences with the Italian schools involved in these projects, and drafting a contribution for the book *Polar Science and Global Climate: An International Resource for Education and Outreach* (Kaiser et al., 2010).

3. There were two further offerings of the refresher course "Antarctica and ANDRILL: Free Territories for New Paths of Sciences."

Figure 7. Students from Christchurch (New Zealand) try on Antarctic clothes during a meeting hosted by teachers of the ANDRILL (Antarctic Geological Drilling) ARISE (ANDRILL Research Immersion for Science Educators) team. These meetings took place prior to the expedition in Antarctica.

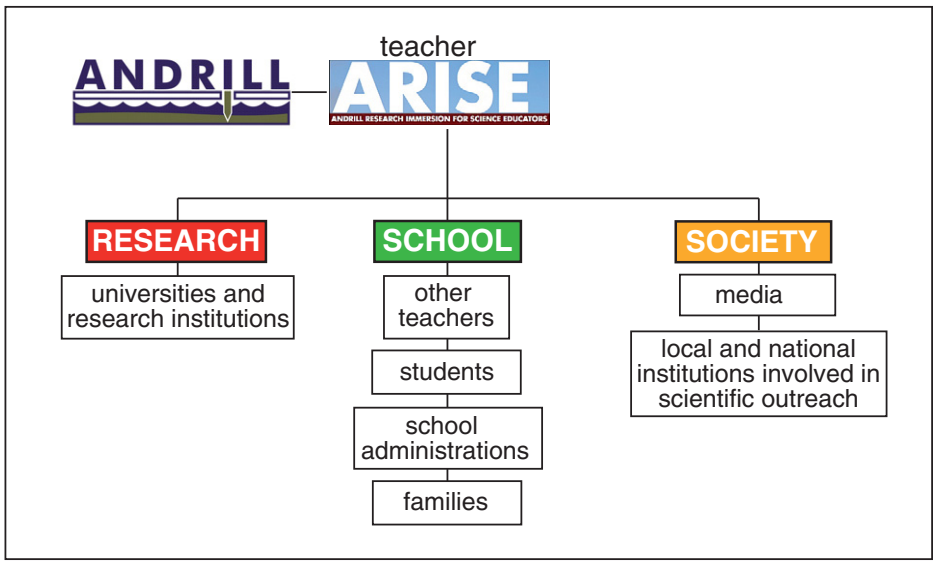

Figure 8. The network of relations developed through the lifetime of progettosmilla.it (see text).

The first, and most engaging, activity for progettosmilla.it was the full translation from English to Italian and printing, with the funds from the Italian Ministry of Research, of the Flexhibit (flexible exhibit) educational activities kit, created by LuAnn Dahlman, a member of the ANDRILL ARISE 2006 team (Dahlman, 2008, 2009 [Italian edition]). The Flexhibit kit, which was perfectly integrated with progettosmilla.it with respect to educational content and methods, includes a book, a DVD, and five posters, and enables the participating school to set up (independently and in its location) an exhibition made of interactive exhibits addressing various themes of the ANDRILL program's scientific research and exploring the role of Antarctica in global climate change. Teachers from the progettosmilla.it program carried out two summer workshops (Earth Science Department of the University of Parma, July 2008; University of Siena, September 2009) to promulgate the use of the Italian translation of the Flexhibit kit; ~500 copies of the Italian version of the kit have been delivered, and at least 20 exhibitions of this kind have been organized in Italy.

The new ANDRILL-inspired activities are gradually gaining momentum; their common feature is that, although they are not directly linked to the ANDRILL research, they are inspired by one or more of the principles the former ARISE Program was built upon: structured cooperation between teachers and researchers, teacher immersion in scientific research, targeted and innovative use of new technology, and, generally, investigating new approaches to Earth science education. Following are some of the main projects of this sort.

ORTLES PROJECT

The educational project most closely related to what was done for ANDRILL in Italy (still in progress) is called Ortles (after the South Tyrol, Italy, glacier). This glacier, the most widely extended of the Eastern Alps, is currently being studied by an international team composed of the Universities of Venezia, Pavia, and Padova, and the Ohio State University through the Byrd Polar Centre. These researchers believe that the Ortles glacier could contain, at its base, a precious glaciologic record of paleoclimatic information, probably threatened by phenomena related to downward diffusion and percolation of water from the ice above. Having appreciated the results of the cooperation with ANDRILL, the Ortles research team turned to progettosmilla.it to implement a similar education and public outreach project.

SPES

The SPES (Summer Polar School for Teachers) is reserved for Italian science teachers and funded by the Italian Ministry of Education, the Italian Antarctic Program, and the National Museum of Antarctica. It took place in Genova in July 2011 and is scheduled for July 2012, with 12 teachers selected to take part. Teachers learn about the theoretical aspects of polar themes (with researchers) and the educational tools most suitable to treat them in class (with polar teachers). At the end of the summer school, one of the attending teachers is selected to take part in a scientific expedition the following austral summer, where he or she will create a specific education and public outreach project for schools.

ICLEEN

ICLEEN (Interrogarsi su Clima ed Energia) is the most ambitious of the ANDRILL-inspired projects. Created by the MTSN, it consists of an information database of resources for an active teaching program of Earth system sciences. The service has been online since December 2009 (http://www.icleen.museum) and is managed by a small community of teachers and researchers working in a sophisticated and personalized (LifeRay, Inc.) software environment. Created as an aid for lesson preparation, it allows the selection, review, and publishing of resources already used by teachers. The service, which also publishes resources under authorization of the U.S. National Science Teachers Association (http://www.nsta.org), was created in accordance with international procedures and standards and was awarded the eLearning Award 2010 first prize, assigned by the European Schoolnet (http://www.eun.org).

CONCLUSIONS

Progettosmilla.it is the Italian educational project carried out within the ARISE Program, the immersion-based EPO program of the ANDRILL international scientific research program. Originally meant to last for only one scholastic year, it was extended and expanded, and in a few years it gained the status of Permanent Scientific Communication Project in Italy. The ARISE Program, and more specifically progettosmila.it, are based on the key idea of a possible and worthwhile partnership between teachers and researchers to realize new forms of scientific popularization. Exploiting this idea and the available resources and services, additional objectives and methods were created (above all, the web-based type) and adapted by the Italian school system. Afterward, the project simply exploited the network (Fig. 8) of professional relations of teachers, fashioned the network shown here, and followed an ecological model, as done in similar situations (Office of Space Science–Space Science Advisory Committee Education/Public Outreach Task Force, 1996). The outcomes and results of the process implemented for progettosmilla.it include the following. (1) Evidence of the high percentage of schools that took part in the project on an ongoing basis, the number of schools that created a final product, and the web statistics of high access per time slot by users of progettosmilla.it suggest that the project succeeded, over the short term, to attain both the general goals of the ARISE Program and the more specific ones, particularly those aimed at increasing teacher and student motivation. (2) Important processes of assimilation and integration with other ARISE projects have been taking place over the middle and long terms. A framework has been established to support new and lasting forms of the fundamental idea (the Ortles, SPES, and ICLEEN Projects). All these conditions remained active even after the completion of the initial Italian participation in the ANDRILL ARISE Program.

This evidence underscores the capacity of teachers to play an essential role in an EPO program, to be in charge of the complex work of translation of the scientific experience into educational practice (Koszalka, 2004), and to make significant changes in the educational activities of local schools. Both goals were reached thanks to the use of new methods and the persistence of the program participants. This experience also provides further confirmation of what was stated in the so-called Rocard Report (European Commission, 2007): "Teachers are key players in the renewal of science education."

If one considers the events and outcomes described herein within the wider framework of emerging needs for both school education and research, e.g., better exploitation of existing resources, more widespread and incisive distribution of educational initiatives, upgrading the professional status of teachers in society, and the general rationing of financial resources, one will most likely conclude that teachers are a widespread, precious, and unchangeable resource who can contribute significantly to the realization of new models of science communication with the general public and society as a whole. Teachers play a key role in science education and communication of current scientific research to the public and the next generation of students.

ACKNOWLEDGMENTS

The ANDRILL (Antarctic Geologic Drilling) program is a multinational collaboration between the Antarctic programs of Germany, Italy, New Zealand, and the United States. Antarctica New Zealand is the project operator and has developed the drilling system in collaboration with Alex Pyne at Victoria University of Wellington and Webster Drilling and Exploration. The U.S. Antarctic Program and Raytheon Polar Services Corporation supported the science team at McMurdo Station, while Antarctica New Zealand supported the drilling team at Scott Base. Scientific studies are jointly supported by the U.S. National Science Foundation, New Zealand Foundation for Research Science and Technology, the Italian Antarctic Research Program, the German Science Foundation, and the Alfred Wegener Institute. The manuscript benefitted from constructive reviews by anonymous reviewers.

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Manuscript Received 28 February 2011
Revised Manuscript Received 24 June 2011
Manuscript Accepted 21 July 2011