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Communicating the science of IGCP 591 to the public

KATHERINE LEWANDOWSKI

Abstract: Selling the broader impacts of science to funding agencies has become a necessity in a time when competition for grant money is high. While involving students in research is still important for maintaining a pipeline of trained scientists, the bar has been raised and it is increasingly incumbent on us to communicate to the public what is so important about our work. To be competitive in the search for funds, there must be a plan for the science funded to be disseminated to the public. The education and outreach plan for IGCP 591 attempts to appeal to this broader audience by incorporating plans for disseminating research findings through easily implementable classroom modules, and building a global network of museums through which the public can visit interactive exhibits both virtually and in person and learn in a less formal setting.

Keywords: IGCP 591; education and outreach; formal science education; informal science education.

Introduction

Today, science funding is constantly under attack. As a result of decreasing availability of funds through both national and international agencies, scientists must present a plan for disseminating their science that actually communicates and demonstrates the importance of it to the broader public. They must show that their science will touch the life of the average citizen in some way. Many nations also have incentives for institutions and/or scientists helping to develop a more scientifically informed public in an effort to eventually achieve scientific literacy of their citizens.

International Geoscience Programme (IGCP 591): The Early to Middle Paleozoic Revolution has developed a strategy for communicating involved scientists' findings to the general public in multiple ways. As an educational specialist, I helped develop the plan. To be most effective at reaching out to the public, plans involving informal science education outlets (such as museums) and formal education outlets (such as activities for classroom use) are being developed. The bulk of this paper will investigate these plans in detail.

The state of science education in the USA

Project IGCP 591 – the Early to Middle Paleozoic – is a multinational project; a brief background of the state of science education in the USA helps to set the stage for our Education and Outreach Plan, since it was first outlined in a grant proposal to the US NSF. Science education in the USA is currently in a transitional period. The National Science Education Standards (NSES) were released in 1996 by the National Research Council (NRC). As a result of the publication of the NSES, most US states

subsequently proposed their own state standards based on the national standards. Educational reform has been ongoing and 45 US states have adopted the Common Core State Standards Initiative [National Governors Association NGA (2010a, 2010b)]. Part of the goal for this initiative is to make the state standards more uniform and to make learning more integrative across disciplines. Introduced more recently is the Next Generation Science Standards, which is a much-needed reform of the NSES, based on the three dimensions discussed in the NRC Framework (2012). These dimensions are as follows: (1) Science and Engineering Practices, which encompass how a scientist or engineer carries out his/her work; (2) Cross Cutting Concepts, which are concepts that run through all the scientific disciplines, such as patterns, similarity, diversity, and cause and effect; (3) Disciplinary Core Ideas, which are unique to each of the physical sciences, life sciences, earth and space sciences, and engineering, technology and applications of science (NRC 2011).

Within this iteration of US educational reform, emphasis is on inquiry and hands-on learning. Problem-based learning is a teaching and learning strategy that has become more and more popular as research has been published establishing its effectiveness (Krynock & Robb 1996; Gordon et al. 2001; McBroom & McBroom 2001; Sungur et al. 2006). It is a pedagogical strategy first developed for learning in medical schools that requires students be given an “ill-defined” problem and work to solve it (Barrows 1986; Gallagher et al. 1995; Sungur et al. 2006). The problem is always rooted in a realworld situation, and as research ensues about the problem, its definition may change (Sungur et al. 2006). In addition, the Nature of Science and science as a human endeavor continue to be important themes in science education in the US secondary curriculum.

Global science literacy

The purpose of science education in the USA is broader than simply recruiting the next generation of scientists. The goal, as developed in the late 1980s and 1990s, has been toward scientific literacy (Rutherford & Ahlgren 1991; American Association for the Advancement of Science 1993; NRC 1996) and ultimately developing informed citizens who can integrate and evaluate sources of scientific data in their everyday lives (NGA 2010a, 2010b; Stage et al. 2013). The vision of a “competent outsider” has been proposed to embody the ideal graduate of the US secondary science curriculum (Feinstein 2011; Feinstein et al. 2013). Within the science education community, it has long been known that we must make science relevant to our students. Not every student will love science just for the sake of science. However, if the students are shown how and why science is important in their lives, a larger population of them will gain an appreciation of it and become better informed citizens. As a result of conducting research into how different groups interpret science, it has been discovered that many people interact only with science in order to gain very specific information related to a certain situation (Irwin & Wynne 1996; Roth & Barton 2004; Feinstein et al. 2013). They need to be given the

skills to be able to evaluate the sources they turn to (e.g. Internet, scholarly journals and public media) to investigate the problem.

Scientific literacy is not only a national goal for the US but also an initiative in European nations and more recently in China. Just as there are advantages to incorporating a plan for disseminating research science to the public in the USA, the European Union (EU) and China are also incentivizing science communication to the public in their nations. Within the 7th Research and Development Framework Programme (FP7), which was the main tool by which the EU funded European research and technological developments up until 2013, there were themes (Science in Society and International Cooperation) within the Capacities Specific Programme which encourage and reward scientists who effectively communicate their science to the public (Patko's 2008). Every EU member grants science communication prizes; the most prestigious of these prizes is the Descartes Prize, which is awarded to the best candidate across Europe (Patko's 2008). The European Commission also publishes a guide to communicating science for scientists, demonstrating their interest in informing the public of research findings (Carrada 2006). There are also internationally and nationally funded education and outreach programs within Europe that have been quite successful, as evidenced by the Antarctic Geological Drilling Project (ANDRILL), which has involved scientists, students and elementary and secondary educators from Italy, Germany, the UK, New Zealand, the USA, the Republic of Korea, Brazil and Japan. The very strong education and outreach plan of that program is one reason for its great success.

Science literacy has also been an important goal within China. The nation would like to ensure achievement of this goal by 2049, which is the centenary of the creation of the People's Republic of China (Hepeng 2002). The China Association for Science and Technology (CAST) is committed to helping achieve scientific literacy (Hepeng 2002). China has gone as far as offering tax breaks for organization that promote science communication, such as science museums, planetariums and laboratories in colleges and research institutions that are open to the public; the hope is that this will enhance the public understanding of science (Ning 2003). While China has more than 400 science museums, the vast majority of them are located in the more-developed eastern portion of the country (Ning 2003). The National Natural Science Foundation of China is organizing international exchanges and promoting science literacy to encourage their scientists to become involved in dissemination of research results (Hepeng 2006). In an effort to achieve their goal of science literacy by 2049, the CAST has vowed to double the number of science communicators by 2020 (Jie 2010). These new science communicators, who will be trained in science writing, research and development, and science industry management, will work in rural areas of the country and in science museums. In addition, the government will reward superior science communication groups and individuals in rural areas (Jie 2010).

This brief background will serve to help the reader better understand how the education and outreach plan for IGCP 591: The Early to Middle Paleozoic Revolution is being developed. The details are explained next.

Informal science education

Informal science learning, for the purposes of this paper, simply refers to any science learning that takes place outside the traditional classroom (Hofstein & Rosenfeld 1996). We spend the bulk of our lives outside a formal science setting, thus it makes sense to target informal science outlets for impactful science learning. Informal Science Education Institutions, which may include museums, aquariums, science centers and nature centers, to name a few, have a mission to communicate science to the public (Kisiel 2013; NRC 2013). These types of institutions often “support open-ended, interest-driven, and personally relevant experiences that can contribute to visitors’ understanding of and connections with science” (Kisiel 2013). These outlets allow interested parties to become actively engaged in science through exhibits that draw them in and educate them. Museums and other informal science outlets are perceived by the public as not only good sources of educational resources, but also excellent sources of entertainment and enrichment (Ramey-Gassert & Walberg 1994; Wojnowski 2006). In essence, they are seen as more “fun” than the traditional classroom.

To that aim, the scientists working on IGCP 591 have recruited a global network of museums to participate in the education and outreach plan. Museums and organizations from around the world: The Palaeontological Museum at Nanjing Institute of Geology and Palaeontology in Nanjing, China; The University of Iowa Museum of Natural History in Iowa City, Iowa, USA; Museo de Paleontología at the Universidad Nacional de Córdoba, Córdoba, Argentina; the Orton Geological Museum at The Ohio State University, Columbus Ohio, USA; the Milwaukee Public Museum in Milwaukee, Wisconsin, USA;

Museo Geominero in Madrid, Spain; and NGO Geoguide Baltoscandia, have either contributed letters of support for the project or communicated personally with me at the 3rd IGCP 591 meeting in Lund in 2013 about the project and are collaborating and helping to develop a plan for the broader impacts of IGCP 591. Presently, the plan is for the museums to collaborate to put together a virtual/digital exhibit that can be accessed online at any of the museums’ websites. There will also be links to activities that can be completed using those online collections. In addition, exhibits highlighting the findings of IGCP 591 and the core science behind it will be developed at each museum for visitors to the physical museum.

Museums also serve the essential research function of curating and managing collections that are available to researchers in perpetuity. A student who learns about these collections as a result of the broader impacts mission of this project could potentially work on them as a researcher in the future. Our ultimate goals for the museums are for them to: (1) link to a still-to-be developed educational website, (2) develop a digital collection that would be available to anyone with an Internet connection and (3) arrange a traveling exhibit that would cycle through the

participating institutions. As a result of these projects, the diverse public will have a chance to learn about the science being developed by a global network of researchers in a variety of geological disciplines.

Formal science education

In addition to using museums as a vehicle for communicating the science resulting from IGCP 591 to the public, part of the education and outreach plan includes resources for use within the traditional secondary science classroom. Learning that occurs within a traditional classroom setting is considered formal science education for the purposes of this paper.

Teaching modules will be developed to communicate the science discovered through this project in addition to exploring background concepts needed to understand that science. Targeting middle and high school students, these modules will consist of background information, lists of suggested reading, supplementary web resources, and a variety of activities developed specifically for this project that explore biotic events (invasion of vertebrates onto land, evolution through the Paleozoic, changing paleoecology and adaptation), chemical events (investigating the cycling of nutrients and paleoproductivity), climate events (the impact of Milankovitch cycles and changes in ocean circulation) and chronostratigraphy (relative dating, chemostratigraphy, astrochronology and the geologic time scale). A variety of learning styles will be incorporated into the activities including questions of the day, educational games and laboratory activities incorporating the use of math and graphing. An interdisciplinary approach will be taken, so that they may be appropriate for physical science and chemistry classes, earth and space science classes, and biology/life science classes.

These modules will be developed with input from all project participants and then ultimately organized by me. Educational materials produced by this project will be made publicly available via space provided on the current IGCP 591 website and all modules and related information will be freely available to the public. The materials that are generated will undergo a process of evaluation involving scientists to assess the accuracy of the content, as well as an evaluation process involving secondary science teachers to help us evaluate the effectiveness of the materials. Pre-service teachers, through their science teaching methods class at Eastern Illinois University (EIU), and undergraduate independent study students at EIU will be involved in the development of all education and outreach materials. These materials will be piloted in public school classrooms in the USA and will be modified based on feedback from those classrooms. There will also be an online option for teachers using the materials worldwide to provide feedback so that activities can be improved as well. Exhibits, in the form of informational posters, will also be developed that can be downloaded and hung in secondary classrooms with teaching modules included on one side of the poster and graphics on the other side relating to the discoveries made through this project.

The IGCP 591 website will have links to a website hosted by EIU with the educational materials. A blog will also be developed for the project to share different

aspects of the science. It is hoped that involved scientists will volunteer to blog, sharing their thoughts on the science, their research and so on, to give the public a view into the lives of scientists. As part of this project, we will also include a form on the website, to enable individuals to ask questions of experts (Ask-A-Geologist) about their work and to give us feedback on the modules.

Professional development for secondary teachers

In order to assist in the dissemination of the educational modules and to engender deep understanding of the material by secondary teachers, an education workshop will be held at Illinois State University. Illinois State University has a rich history in teacher education, beginning as a normal school; the infrastructure necessary for supporting a workshop of this size already exists at Illinois State, making it a good choice of locations. This workshop is still in need of funding; thus, we do not know when the workshop will run. Forty secondary teachers will be chosen to participate through a selection process as yet to be determined. As incentive to attract secondary teacher to participate, Continuing Education Units will be offered for professional development credit through Illinois State University.

The workshop will consist of a 5-day experience on-campus at Illinois State. For each day of the workshop, background material will be provided, activities will be demonstrated and the teachers' new skills will be practiced. Discussions with participating scientists will be an important component. A binder for all participants will be prepared and handed out at the beginning of the workshop with pertinent materials, background readings, activity sheets and answer keys provided. The teachers will learn how this science is carried out. The first day of the workshop will cover time and the stratigraphic record. Day 2 will focus on climate, and day 3 will be a field trip to important localities nearby to see the rocks and collect fossils and discuss depositional environments, field relations, sampling strategies, etc. Day 4 will focus on biology and paleontology. The participants will have a chance to identify the fossils collected the day before, in addition to discussion, activities and demonstrations on pertinent concepts and topics. The last day of the workshop, day 5, will begin with a half-day visit to a local museum, where they will become more familiar with the importance of museums in earth science research. A behind-the-scenes tour of the paleontology collections will be arranged, as well as a visit to the public part of the museum to see the exhibits. Finally, discussions will be held to help the teachers synthesize and integrate what they have learned over the course of the week.

Summary

A successful plan for disseminating the science that results from IGCP 591: The Early to Middle Paleozoic Revolution will require participation as either developers or as students by scientists, undergraduate students, graduate students, postdoctoral

fellows, secondary educators, secondary students, the public, museum staff and our education specialists. It is essential to stress the relevance of the science coming out of the project to the public. The way in which we develop the activities and exhibits for museum and classroom use must be innovative and creative. We wish them to appeal to teachers and students in diverse settings (different countries, different socio-economic settings and different ability levels). In writing this paper, I am calling on scientists and educators involved in IGCP 591 to help develop the broader impacts and disseminate their science to the public.

The more scientists directly involved in the broader impacts, the better the information that goes out to the public. Please contact me if you are interested in participating in the education and outreach side of IGCP 591.

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