Education & Outreach for a MARGINS Successor Program

On October 29-30, 2009, nineteen scientists and educators met in Northfield, MN to provide guidance to the possible form of an educational component in a MARGINS successor program. The meeting was motivated by recommendations from the MARGINS Decadal Review that encouraged enhanced educational activities, with a goal to prepare this Vision Statement in advance of the MARGINS Successor Planning Workshop scheduled for Feb. 2010. Participants consisted of members of the MARGINS Education Advisory Committee, Steering Committee, past participants in MARGINS Educational workshops, as well as leaders of partner programs and earth science education experts. This Vision Statement summarizes their recommendations.

I. Focus and Goals of a MARGINS Successor Education and Outreach Program

The NSF MARGINS program has been effective in bringing together multi-disciplinary communities to work across the shoreline on complex earth systems investigations. Education and outreach (E&O) activities in a successor program to MARGINS should support the research community of PIs in achieving coordinated broader impacts, and should contribute to public understanding of the Earth and the nature of geoscience. Based on recent experience, this can be accomplished most effectively by targeting audiences at the undergraduate and graduate level. This approach capitalizes on scientific achievement within the program and takes advantage of the university setting of most PIs. In the K-12 and informal arenas, an exploratory set of activities could be developed through partnerships with existing programs.

The first decade of MARGINS served the graduate student community well, given the small resources devoted to education. MARGINS educational activities have resulted in a suite of "mini-lessons" that bring MARGINS discoveries and major research datasets into undergraduate classroom instruction; a popular Distinguished Lecturer series that targets a diverse set of institutions that would otherwise have had limited exposure to the program; a post-doctoral fellowship program that has helped foster a new generation of MARGINS PIs; and a variety of efforts at workshops and professional meetings to provide professional development to several generations of geoscience graduate students. As a sign of success, many individuals who started in the MARGINS community as students are now leading MARGINS scientists.

We suggest that the successor program should enhance current successful efforts, and expand in a few key directions:

- Produce a series of experiences in the pathway from undergraduate to graduate education including an REU program, expanded international experiences and a "bridge" spanning the transition from undergraduate to graduate education.
- Build a vital next-generation interdisciplinary community of independent scientific leaders through graduate student awards, new programs of graduate symposia, and the postdoctoral fellowship program.
- Support PI activities: directly help develop broader impacts for proposals and projects, sponsor faculty development activities, and expand the mini-lessons portfolio to reflect the full scope of research and teaching opportunities afforded

by the undergraduate curriculum.
- Explore opportunities to expand MARGINS successor E&O to public and K-12 audiences through strategic partnerships and event-based science presentations.

These enhancements will complete the "student to PI to community leader" professional development trajectory.

Accomplishing these goals will probably require a full-time staff member dedicated to educational activities, and likely outside funding for some more ambitious undertakings. This person should work within the central office to support both the investigator and student community, and work with education specialists to grow the strong partnership between basic science and earth science educators.

II. Focus on Undergraduates - REU and Other Programs for Undergraduates

A MARGINS successor program should sustain and grow the present undergraduate-centered efforts, with a goal to entrain students and faculty in geoscience departments that do not have graduate programs. Also, it could promote undergraduate research in interdisciplinary science that would create a natural pipeline into graduate education.

IIa. REU Program

We recommend that the flagship program for undergraduate education be an REU program introducing students to MARGINS strengths in interdisciplinary research. Our REU program will be based on the successful IRIS model of distributed hosts with important modifications for the unique aspects of the MARGINS community. Key features will be:

- At least 2-3 distributed sites will host individual or groups of students.
- Sophomores and juniors will participate in order to include students and instructors from 2-year colleges and colleges without graduate programs.
- The students' advisors from home institutions will be actively involved in the research.
- Cohort building of the entire REU group across the sites will be emphasized through a week of introductory activities at a central site, which may include the novel use of ship-based or field camp-based experiences.
- Support from a central Office or designated affiliate will coordinate activities. One possible model would be to link the initial MARGINS successor REU to the IRIS site REU or similar programs.
- The MARGINS successor office will track the REU students after their summer program so that that community can be encouraged to participate in the bridge programs (see section IIc).

IIb. International Experiences

A successor MARGINS program will have activities in many countries with numerous international colleagues. New programs could encourage and help PIs in obtaining

International Research Experiences for Students (IRES) or Doctoral Dissertation Enhancement Projects (DDEP) grants. An IRES or DDEP grant would support a coordinated group of undergraduate and/or graduate students working on MARGINS-related research in the partner country as they work directly with their international collaborators and students. There are also opportunities in the area of International Service Learning. One example is the USAID Higher Education for Development (HED) program that fosters partnerships between USA universities and their partner institutions in host countries. The MARGINS successor office can provide coordination and support to facilitate obtaining grants, and encourage education and outreach activities by individual PIs at international sites and with international collaborators.

IIc. Bridging Experiences

Some "bridge" experiences could fill the gap between undergraduate and graduate school. Current programs generally overlook this interval, funding for research opportunities is scarce and few career-building activities have been developed at this stage. A MARGINS successor could organize a short course or summer field camp that students would take immediately after they graduate with their B.S. degree. A field camp could emphasize the hands on, interdisciplinary tools and data acquisition that students will use in their graduate research. The activity could include both land-based and ship-based experiences, perhaps supported by external funds (e.g., CCLI). Another bridge activity would be to help PIs to obtain supplemental grants to fund incoming graduate students during the summer before they start their graduate career.

III. Build Student / Post-doc / Early-Career Community

MARGINS research involves an interdisciplinary team-based approach to studying systems using multiple methods, with notable success in fostering this approach in graduate students who then continue on to become MARGINS PIs. These efforts could be enhanced by further development of two programs, the Postdoctoral Program and a new Graduate Student Forum.

IIIa. Graduate Student Forum and Pre-Meeting Symposium

Current graduate student community building events supported by the MARGINS program include a student forum and, notably, student prizes at the fall AGU meeting. Since 2003, 25 students have been selected by judges as winners or honorable mentions. The Student Prize awards are viewed as honors that are highly valuable on students' CVs. This program should continue.

To further provide students with opportunities for interaction, the MARGINS successor program could develop a structured 1-day graduate symposium, typically occurring before a larger MARGINS meeting or workshop. As one model, this symposium could include oral and poster presentations, organized by more senior graduate students or mentors. The experience will provide leadership opportunities for senior students and first-exposure opportunities for more junior students, which will help in developing both

groups as independent scientists and effective communicators. The meetings could include career development opportunities, such as talks on proposal writing or postdoctoral opportunities (especially the MARGINS postdoctoral program) as well as group discussions about how to succeed as a graduate student. Online social networking (e.g., Facebook, Twitter) could be promoted as an additional low-to-no-cost avenue for student communication and enhanced program awareness.

Funding opportunities in the IGERT (Integrated Graduate and Research Traineeship) program could be explored for student workshops and graduate fellowships.

IIIb. Postdoctoral Program

The MARGINS postdoctoral program has been highly successful in providing a pathway between graduate school and academic positions. To the awardees, the named postdoctoral fellowship is viewed as a prestigious honor, and is recognition of early independence, established capability, and high scientific potential. Although participants have done exceedingly well, there has been a small applicant pool which should be expanded. Participation might be increased by communicating more thoroughly with the graduate student population (see IIIa). Also, the NSF solicitation process could be modified in two ways to increase its competitiveness:

- Increasing application deadlines to twice per year (autumn and spring), with expedited review and decision process, thus removing direct competition between regular MARGINS PIs and the postdoctoral applicants.
- Ensuring that applications be written by the graduate student and submitted directly to NSF. The newly developed NSF-EAR postdoc program may serve as a good structure.

IV. Develop Educational Resources and Foster Faculty Involvement: Mini-Lessons

Over the last 5 years of the MARGINS program, efforts to integrate discoveries from MARGINS science with teaching fundamental concepts in geoscience have been propelled by development of web-accessible classroom and teaching laboratory activities and visualizations called 'mini-lessons'. Mini-lessons capitalize on cyberinfrastructure resources to integrate MARGINS data and research findings into broadly applicable educational materials. The engagement of undergraduate educators has ensured that the materials developed were well-suited to their audience, and participation by MARGINS PIs ensured cutting-edge content.

Several approaches could enhance the effectiveness of mini-lessons:

- Mini-lessons should address curriculum needs.
- Team approaches to the development of mini-lessons, or curricula comprising mini-lessons, could be fostered to engage career and 2-year college faculty.
- Gaps in the existing mini-lesson collection should be filled.
- Some mini-lessons should be designed for easy adoption into lower division, gateway courses. Such courses are often taught by faculty outside of their

expertise, therefore, these mini-lessons must be self-contained educational resources.

- Continue formalizing the assessment of materials across the undergraduate curriculum for content accuracy and pedagogical effectiveness.
- Improve dissemination of mini-lessons through professional organizations, meetings, workshops, professional journals, and education and outreach resources.
- Construct a Developer's Toolkit compiling best pedagogical practices and resources for developers (e.g., GeoMapApp, EarthChem) and access points to basic research results.

V. Expand E&O Through Strategic Partnerships

An informal (e.g. museum) and/or K-12 education component could be an exciting new direction for the E&O program. The arena is large, and a program is probably best developed through partnerships with existing science organizations, consortia, and/or PIs of long-term geoscience education projects who have existing informal or formal education programs. This approach could yield a major increase in the visibility of MARGINS and MARGINS successor science and scientists for a relatively modest investment.

Va. Partnered "Event- Based" Presentations

One promising model for this approach is the development of "event-based" presentations, planned informal/formal educational events featuring audience-appropriate and engaging MARGINS successor science concepts, scientists-in-action, interesting investigative techniques, and/or exploration efforts. Developed through partnerships with groups focused on outreach, the MARGINS successor office would coordinate the science content with PIs for these events. The partner organization would be responsible for the event itself, including advertising and organization, and logistics. The goal of the event is both the communication of science content and the formation of science career role models for K-12 students, undergraduates, graduate students and the general public.

Engaging events for informal education could include live communications with scientists, and opportunities for event participants to control or provide input on investigations. Additional materials, such as podcasts and video-clips could be captured and incorporated in the event. The central office can coordinate the collection of material from PIs, whereas the partner organization would contribute its expertise in designing and presenting content. Possible partners include: GLOBE, IODP, the JASON Project, COSEE, TXESS Revolution, and the National Ocean Sciences Bowl.

Vb. Other Partnership Opportunities

This expanded effort also provides opportunities to partner with geoscience education programs and education PIs (curriculum developers and professional development providers) to adapt mini-lessons (section IV) to the K-12 audience for use by teachers to prepare their students to understand an event. In addition, the central office could

collaborate with teacher networks to offer training (face-to-face or online) to teachers who will host these events so that they are equipped with a deeper understanding of the science, and thus better able to communicate content and describe career paths to their students. Opportunities also exist to partner with geoscience education researchers and educational psychologists who could initiate and carry out projects to measure the impact of this type of educational outreach on teachers and students, and museum audiences. Examples of potential K-12 education partners include national and international teacher networks such as NSTA, the National Earth Science Teachers Association (NESTA), and GLOBE, as well as museums.

VI. Managing and Supporting an Effective Education Program

An enhanced commitment to education and outreach by the MARGINS successor program is contingent on effective coordination by the central office. MARGINS began efforts in education and outreach in 2004, first by adding education representatives to the steering committee, then by developing the MARGINS Education Advisory Committee (MEAC) coordinated by a half time office staff member. Much of the educational effort has been a bottom-up approach, involving only those PIs who have an interest in this type of outreach.

The 2009 Decadal Review Committee recommends greater visibility and awareness of the program both within the broader geosciences community and the general public. Currently, a half-time education staff position in the MARGINS office has responsibility for all educational programs described in Section I, as well as less formal activities (managing online presentation material and other educational content on the web site; coordination with the data management group; writing education pieces in the twice yearly newsletter; etc.). Increasing the scope of an E&O program as described above requires added responsibilities including:

- Establishing partnerships between MARGINS PIs and experts in educational activities and outreach;
- Coordinating with other research initiatives and programs and in particular seek out and serve as contact point for partnerships in informal and K-12 E&O;
- Providing a support structure and services for potential PIs in designing and achieving broader impacts in their proposals;
- Provide logistical and administrative support for the REU effort and possible “bridge” activities;
- Coordinate Graduate Forums and other graduate cohort-building activities;
- Initiate pilot programs to leverage new research into exploratory educational vehicles; and
- Coordination of a more formal E&O advisory structure.

We believe that this effort will be best achieved through one dedicated full-time education specialist within the Office of the MARGINS successor program. Also, many of the more ambitious programs will require additional funds outside the regular MARGINS program, for example for Site REU programs, through the CCLI for course

content improvement, and perhaps through IGERT for graduate mentoring and traineeships. As demonstration of this approach, MARGINS successfully obtained CCLI funding to support the present mini-lessons program.

We recognize the challenge of this commitment in an office that changes location every three years. However, the strength of the program to date reflects the engagement of the research community in the education efforts. This has been accomplished by extensive involvement of the MARGINS office and research leadership in the education programming, which is made possible by the management of these programs in the central office. The partnership with SERC in creation of the mini-lessons provides a model for bringing stability to long-term programs. SERC can continue to host the mini-lesson collection and cyberinfrastructure supporting the contribution, review and dissemination of mini-lessons while the MARGINS office moves from place to place. Concurrently the MARGINS office remains responsible for engaging the community in the development of these lessons, for decisions regarding their content, and for the scheduling of workshops or other faculty development opportunities. A similar model might be used for management of the other large programs envisioned above.

VII. Summary Statement

The successor MARGINS program will be uniquely positioned to help train the next generation of interdisciplinary scientists, while expanding the reach of MARGINS science into the broader community. The programs outlined in this vision statement will form a unifying broader impacts strategy for the successor program and will create a pipeline of students that reaches from within the K-12 community all the way to early-career faculty. We foresee that K-12 outreach will utilize partnerships with already successful programs. At the undergraduate level, the MARGINS program has been successful at introducing students to MARGINS science through vehicles such as mini-lessons. Additional experiences such as a MARGINS REU program and opportunities to participate in international research and service learning programs further enhance the undergraduate experience. Engagement in the mini-lessons program of early-career and 2-year college faculty at institutions not currently engaged in MARGINS research will provide a mechanism for broadening the pool of students benefiting from these programs and entering the pipeline. Graduate students entering MARGINS research fields will have new peer-mentoring opportunities at dedicated meetings and throughout the year via social networking sites. The MARGINS student prize will continue to reward the top graduate students for their exemplary work. At the end of the pipeline, Ph.D. students will be encouraged to apply for the highly successful MARGINS postdoctoral program, and early-career scientists will be provided with tools to create proposals with strong broader impacts. This comprehensive vision rests primarily on the engagement of the MARGINS community and a growing community of MARGINS geoscience educators in PI-driven activities and proposals.

Authors: **MARGINS MEAC members and participants of the Education Planning meeting**