Working with the Discipline – Developing a Supportive Enviornment for Education

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Much work has taken place with individual faculty to improve their understanding of teaching methods and their knowledge of available resources. As a result, one can observe today that there is much more awareness among STEM faculty of central education themes such as student learning and assessment. However, leaders in educational reform, like those who have presented in this workshop, are often frustrated that the changes are too small or made by too few. This essay looks at three different strategies for working within the scientific disciplines to improve the climate for educational reform: activities at professional society meetings; a large-scale professional development program focused on geoscience faculty; and a program specifically targeting geoscience departments. While each of these efforts has important impacts on the individual faculty and their ability to teach more effectively, here I discuss these efforts from the point of view of changing the environment in which faculty work, either within the discipline or with the department.

There is strong awareness that changes in teaching require an environment that is supportive of change, as well as a culture that engages in learning about teaching. This principle underpins the work of groups like the Carnegie Foundation (Shulman, 2004; Huber and Hutchings, 2005) and Project Kaleidoscope (PKAL, 2008). The importance of the institutional environment in supporting change has has been the focus of extensive work (Bok, 2006; Rhodes 2001, AAC&U, 2007; Sullivan & Rosin, 2008). The institution can create campus facilities suitable for high impact teaching practices (; PKAL, 2007; Kuh, 2008), and can provide resources for professional development and teaching. There is no question that the institution also has substantial influence in creating a climate that is supportive of quality teaching and that rewards teaching excellence. However, the success of this work depends in part on the wholehearted support of the faculty. While work within the institution provides one mechanism for engendering their support, the scientific disciplines provide a second. My colleagues and I have been exploring ways in which 'common knowledge', attitude, and expectations surrounding teaching, learning and education in the geosciences can be improved within the geoscience discipline.

Geoscience faculty, like most STEM faculty, are heavily influenced by their disciplinary peer group. Their peer group within the discipline (or subdiscipline) is an important source of respect and professional interaction. It is this group that passes judgment on papers and proposals, and critiques much of their professional work including external evaluations for promotion and tenure. It is also their disciplinary colleagues who have the most experience teaching the same courses and topics that they teach. Thus attitudes toward teaching held by their disciplinary peers have important influence on both the willingness of faculty to change their teaching practice, and on the ability of the disciplinary community as a whole to evolve excellent teaching practice for their

particular area of expertise. The disciplinary community also plays an important role at the department level. Discussions of curriculum and professional certification take place within the discipline and the prestige accorded to ones graduates is partly a disciplinary matter.

What would be the characteristics of a disciplinary environment strongly supportive of excellence in undergraduate education? In many ways, it would reflect the support that is given to scientific research: there would be many and varied opportunities to exchange, discuss and critique ideas and to work collaboratively; community members would take advantage of these opportunities as a natural part of their professional work; and the importance of teaching would be valued by all, a high standard of performance would be expected of all, and excellence would be applauded by all. I provide three examples from the geosciences that are designed to move the discipline in this direction.

Changing Common Knowledge: Work at Professional Society Meetings

Geoscientists, like many scientists, discuss their recent work at relatively large professional society meetings. In the geosciences the largest of these meetings are held by the Geological Society of America (GSA~7000 people), the American Geophysical Union (AGU~18,000 people), the American Meteorological Society (~ 3500) and the Ocean Sciences Meeting (~3000). There are also a variety of smaller meetings that involve subsets of the geoscientific community for example the Goldschmidt Conference (~ 2000 involved in studying geochemistry) and the American Quaternary Association (several hundred people from multiple disciplines). These meetings in aggregate are the face-to-face gatherings of the geoscience community. Thus, one could argue that the degree to which education is represented in these discussions is a measure of the importance of education in the work of the community. Increasing discussion of teaching at these meetings is an important opportunity to raise both the interest in, and level of expertise regarding teaching within the community.

For all of my professional lifetime, these meetings have had a strong educational component focused on the education and professional development of graduate students. Today, most students involved in geoscience PhD programs in the United States attend these meetings to learn about the state of current research, and to meet their future colleagues. The first presentation of work at these meetings is a right of passage for a graduate student, and these meetings play a critical role in inculcating both the values and behaviors that typify the profession. The organizers of these meetings are cognizant of the role that they play in the education of graduate students and explicitly consider the needs of these participants in designing the meeting. This strong emphasis on graduate student education within the professional societies reflects the fact that, in the post World War II era in the United States, scientific research and graduate education are extremely well integrated (Bush, 1945) and that the geoscience community values and promotes that integration. It also underscores that education is not and has not been missing from the interests or activities of the geoscience profession.

One of the most successful efforts to raise the prominence of undergraduate education has been through undergraduate research. Presentations by undergraduates doing scientific research are not new, however, as undergraduate research opportunities have become both more abundant, and a more integral part of the preparation of geoscience majors undergraduate, students have become a more important part of the program at professional society meetings. In addition to presentations in regular meeting sessions, both the AGU and GSA meetings have experimented with sessions that are designated for undergraduates presenting research results and both provide opportunities to meet representatives from graduate programs. The Council on Undergraduate Research has been active in both meetings, sponsoring sessions and providing training for faculty who are interested in initiating undergraduate research programs. The increasing participation of undergraduate students, driven in large part by the value placed on presentation of results as an essential part of undergraduate research, has increased the visibility of undergraduate education at these meetings. One direct measure of this increased visibility is increased discussion within the societies of funding for undergraduates to travel to their meetings, and of the role that undergraduates play in the Best Paper Awards for students. Thus undergraduate research is becoming increasingly well integrated with scientific research.

In contrast, what of the role of undergraduate teaching and of professional development for faculty as teachers in these meetings? Fifteen years ago, sessions addressing undergraduate education were few in number (0-4) at geoscience professional society meetings and undergraduate students were largely absent from our meetings. The National Association of Geoscience Teachers, was meeting at the Annual Meeting of the Geological Society of America with a cadre of committed faculty. However, the presence in the larger meeting was limited. Thinking about undergraduate education was not well integrated into thinking about research.

Over the past 15 years, we have seen a major increase in the presence of undergraduate teaching in these meetings and the participation of an increasing number of members in these discussions. This year, as in recent years, there are more than 20 education sessions at the Fall AGU meeting where more than 350 papers will be presented. 2% of the presentations will be in education sessions comparable to the number of papers in Geodesy or Mineral Physics. Reputedly, the single session receiving the most contributed papers at the 2008 Fall Meeting of the AGU is an education session on introductory geoscience courses. GSA has seen a similar increase in the number of sessions and papers.

Education sessions in these meetings play two important roles. One group of sessions allows geoscience education researchers, those whose scholarly work is investigating teaching and learning in the geosciences, to present and discuss their work. Sessions of this type at the 2008 GSA meeting included 'Geocognition: Researching Student Learning in the Geosciences' and 'Research on Geoscience Teaching and Learning in Experiential Environments'. These sessions were attended by 50-100 people drawn from geoscience, geoscience education, cognitive science, and education research. Just as much of the technical program supports the exchange of information and discussion of

geoscience research among highly specialized researchers addressing specific geoscience problems, these sessions move forward research in geoscience education. The increasing number of sessions of this type document the growth of geoscience education as a research area within the discipline.

A second type of sessions is aimed at disseminating the results of geoscience education research outward into the broader geoscience community while promoting sharing of teaching experience and expertise within this community. It is these sessions that are aimed at changing 'common knowledge' and altering the basic assumptions that the broad group of geoscience faculty bring to their teaching. Sessions of this type at GSA and AGU include 'Teaching Petrology and Structural Geology in the 21st Century' and 'Authentic Science in Education, the Public, and the Media: New and Expanding Roles for Scientists and Science Societies?'. They have been organized by committees or groups within the professional society, by the National Association of Geoscience Teachers and its professional development program 'On the Cutting Edge', and by individuals with high interest in particular issues. The content ranges from a focus on teaching methods and strategies, to the challenges facing the community in diversity, workforce, K-12 education and public understanding of science.

This strategy for raising the level of understanding in the community only works if the sessions collectively draw an audience that reaches well into the broad membership. Two strategies have been used with success: developing the session around a theme of high interest (for example Teaching Climate Change) and integrating papers on education and scientific research in the same session (for example, a paper on teaching about space science in a session on space science research). The Committee on Education and Human Resources has on occasion selected themes for meetings of the American Geophysical Union, for example Increasing Diversity or International Geoscience Education, and organized a suite of 3-7 sessions on related aspects of this topic to develop a 'buzz' at the meeting. Featured sessions and sponsorship by member constituencies have also been used to increase reach. For example, a featured session at the Geological Society of America on Teaching and Learning about the Earth brought together the reflections of highly regarded senior researchers, geoscience education research, and cognitive science. This session went through a proposal process and was reviewed by a subcommittee of the technical program committee. As is common for these sessions, GSA produced an edited volume based on the contributions to the session. This volume, "Earth and Mind, How Geologists Think and Learn About the Earth" (Manduca and Mogk, 2007) was the first edited volume addressing education published by the society. In addition to the draw of the session itself, both the proposal process and the publication process brought education and education research to the attention of leaders in the society and the success of both the session and the published volume (now in its second printing) reinforced their impression of the growing interest in these topics.

Oral sessions (fundamentally a collection of short lectures) and poster presentations offer excellent opportunities to build interest in a topic and to present data and arguments, but are not model pedagogies for fostering discussion or building teaching skill. A number of creative strategies have been developed to enhance the 'learning environment' for

faculty at professional society and to create resources that support implementation of good ideas. A special session of activity demonstrations offered in conjunction with an oral session at a regional meeting of the Geological Society of America requested that presenters submit descriptions of their activities to the NAGT website (NAGT, 2004) creating an on-line resource where interested meeting participants could obtain instructions and further information. The On the Cutting Edge program sponsored a series of "Illustrated Community Discussions" on topics that were of interest to the entire GSA membership including teaching about time and teaching in the field, which was held in conjunction with the meeting's opening reception; these events were well attended and produced large, thematic collections of educational methods, strategies and resources (On the Cutting Edge, 2004). Increasing numbers of educational workshops (offered by increasing numbers of groups and individuals) at professional society meetings are also being used to extend the range of opportunities to learn about teaching. Educational workshops are also being used at smaller meetings to focus specifically on teaching the science discussed at the meeting. For example, On the Cutting Edge has partnered with AMQUA to offer workshops on Teaching Climate Change and Teaching with Ice Core Data and with the Geochemical Society at their international Goldschmidt Conference to present workshops on Teaching Geochemistry. Several large research projects have begun offering educational workshops aimed at producing teaching materials that use their research results (Margins, 2007; EarthScope, 2005; Chronos, 2006)

In sum, we can document a growing presence of undergraduate students, an increase in services for undergraduate students, a growing geoscience education research community using the meetings as its professional venue, an increase in sessions aimed at diffusing research and promoting discussion of teaching among the geoscience professional community, and an increase in workshops aimed at enhancing teaching. What can be said about the impact of these activities in creating a disciplinary environment supporting excellence in education? First, there is no longer any opportunity to argue that undergraduate education and teaching are not an integral part of the disciplines professional activities. For those who are geoscience education leaders and researchers, there is a venue for their work, within the primary vehicles for professional geoscience exchange. This both validates their work within the discipline and enhances the opportunities for dissemination. Both GSA and AGU have added new awards for geoscience education in the past decade, further validating this work. For those faculty who are interested in improving their teaching, there are now a rich array of professional development opportunities, as well as, sessions where they can share their teaching expertise. In an expression of the importance of this work and the exchange of information about teaching, both GSA and AGU relaxed their rules limiting participants to a single presentation to allow a presentation on research and a presentation on education. The best integrated measure of the increasing appreciation of the importance of geoscience education (including efforts in K-12 education and public understanding of science and geoscience) is the rapid growth in the Education Division of the Geological Society of America. All members of GSA are allowed to join divisions that are aligned with their professional interest, the Geoscience Division was formed in 1980s and is now one of the larger divisions and is currently the fastest growing. Similarly, interest in

education at AGU has increased to the point that members can now join an education interest group.

It is fair to ask if the increase in interest in education reflects the increased activity at the meeting, or if the increased activity reflects the increase in education. It is clear that there are other drivers leading to an increased interest in education. These include concerns about the preparation of the workforce (NRC, 2006), teacher preparation, (NCMST, 2001); and public understanding of science (NSF, 1996; NRC, 1996); increasingly useful education research (NRC, 1999), and national interest in education accountability (Bok, 2006). The National Science Foundation has placed increased emphasis in broader impacts of primary scientific research as a criterion for funding , and educational impacts senso lato (broadly defined) constitute one of the most highly recognized measures of impacts. More faculty have found funding for professional work within education. All of these things are leading to both increased activity and increased interest at professional society meetings. However, it is clear that a growing contingent of geoscientists, perhaps with their interest piqued for these reasons, are learning about education and teaching through the professional society activities. Activities at professional society meetings are one of the important mechanisms that the community is using to incorporate and expand its knowledge of and work in geoscience education either through participation in sessions, conversations in the halls, or more passive endorsement via membership in the section or tacit approval.

Establishing a Culture of Professional Growth and Sharing: Working With Large Scale Professional Development Within the Discipline

The On the Cutting Edge project is a large-scale professional development program for geoscience faculty (Manduca et al., 2006). For the past six years, it has offered six or more topical workshops per year involving more than 1500 participants. These workshops including topics in career management, teaching current geoscience, and teaching with varying pedagogy such as 'Managing your Early Career', 'Teaching Hydrogeology', 'Course Design', and 'The Role of the Affective Domain in Teaching Geoscience'. The workshops are designed to engage participant in sharing expertise, developing and evaluating teaching materials, and learning from experts within and beyond the geosciences (Macdonald et al., 2004). A major focus of each workshop is developing on-line resources that share the workshop experience with faculty who could not attend. We estimate that 20% of geoscience faculty have participated in the workshop series, that 30-50% use the resulting website, and that 45% of geoscience faculty are aware of the program (Iverson, 2008). This is a large enough fraction of the faculty population to impact the disciplinary culture. What can we say about this impact? Results from the program evaluation (SERC, 2006) indicate three primary changes impacting the disciplinary environment.

A major change in attitude supporting changes in teaching practice: The importance of attitudes in underpinning change is increasingly clear (Gusky, 2000; Loucks-Horsley, 2003; Hollingsworth, 1989). One of the most important findings of our workshop evaluation is a change in attitude toward teaching. End of workshop instruments indicate

a prevailing change in participants' focus from 'what do I teach' to 'what are they learning'. Of 45 faculty interviewed a year or more after workshop participation, 70% described significant shifts in their attitude about the practice of teaching and study of learning that they attributed to their participation in the program. 26% indicated that the workshop reaffirmed their attitudes and beliefs about teaching and learning. Workshop participants leave with a belief that student learning should be the focus of their teaching, and that teaching is a skill that can be developed and for which there is a research base. Evaluation data confirms that these attitudes are supporting changes in teaching practice. 80% of interviewees can articulate specific changes that they made to their teaching as a result of workshop participation including introduction of new teaching methods, redesign of a course, and introduction of new content. This result was confirmed in a post-participation survey that sampled 40% of the total population.

What is the resulting impact on the disciplinary culture? When faculty are talking in the hall or at professional society meeting, there is more than a one in six chance that they are talking to someone who believes that student learning is the focus of teaching and has introduced newly learned pedagogies or content into their courses. After several such interactions, which are no longer unlikely to occur, it becomes clearer that improving teaching is a wide spread activity among your peers.

Expanded leadership: After workshops, participants strove to increase their role in educational activities, as participants and leaders in activities on campus, in the department or within the geosciences. They sought opportunities to work on outreach programs for local community education, pre-service or in-service science teacher programs, to lead regional workshops, to participate in sessions at professional society meetings or to publish in the area of geoscience education. They pursued (and in many cases were awarded) grants related to workshop outcomes. In an online-survey administered in 2005, 50% listed specific presentations, publications, grants, or grant proposals resulting, either directly or indirectly, from their participation in the program. In phone interviews, participants attributed this expanded leadership role in all or in part to their new attitude toward geoscience education and to being confident in taking an active role in this community. This increase in leadership and activity impacts both the disciplinary environment and the role of geosciences on campus.

What is the resulting impact on the disciplinary culture? When faculty are talking in the hall or at professional society meeting, there is roughly a one in ten chance that he or she is talking to a Cutting Edge participant who has recently engaged in some form of leadership activity in education be it organizing a project, giving a talk, writing a paper, or obtaining funding. Thus is becomes clearer that education activities and leadership are a central part of our professional work . Faculty can expect that their efforts in this direction will not be viewed as unusual, and that they will find colleagues who share their interests, understand their work, and appreciate its impact.

A culture of sharing: Over the past 15 years, the National Science Foundation and others have been concerned that faculty do not share information about their teaching and as a consequence frequently reinvent the wheel (Mogk and Zia,, 1997, Wattenberg, 1998,

Zia, 2001). The Cutting Edge workshops and websites together are designed to foster and support a culture where faculty are empowered to talk to one another about their teaching and have mechanisms for this exchange. We have assumed that there is widespread expertise and interest in teaching within our community, and this assumption has proved true. Presentations and poster sessions involving participants are an integral part of every workshop focused on pedagogy or content, and participants are a major source of expertise at these workshops. Each workshop has a focus on improving the on-line resources for those who cannot participate. In addition to presentations and resources developed for the workshop or derived from the workshop presentations, a major focus of the website is sharing information about the activities and courses developed by faculty. Our goal is to foster a culture in which faculty spontaneously share and make use of each others (Manduca and Mogk, 1999). There are now over 700 activities on the Cutting Edge website that have been contributed or developed as part of the workshop program. We have now begun to regularly engage workshop participants in reviewing each others activities as a mechanism for improving the activities themselves, as well as the participants ability to design and evaluate highest quality learning opportunities.

The combination of a website with rich resources and a workshop program that fosters the use of those resources has developed substantial use of the website. 85% of respondents to post-workshop follow up surveys indicated that they used the website. Common uses identified in interviews and focus groups are

1) returning to teaching methods or materials described at the workshop;
2) searching for teaching activities or ideas prior to teaching a particular topic; and
3) sharing information from the workshop with other faculty.

This extensive use of on line resources in preparing for teaching is a new behavior. Seven of eight faculty interviewed in 2003 indicated that they rarely went to the web for pedagogic information (Manduca and others, 2005). In a 2004 survey of geoscience faculty with a 39% response rate, only 10% of faculty using the web to find resources for teaching (Manduca and others, 2005). In 2007, more than 10,000 users visited the site six or more times. We estimate that 30% of these users are geoscience faculty based on a pop-up survey. This would indicate that approximately 50% of geoscience faculty are using the website . The larger Teach the Earth site, which includes resources developed by other projects including several projects funded by the National Science Digital Library was visited six or more times in 2007 by more than 25,000 users.

What has been the impact on the disciplinary culture? If a pair of geoscience faculty are discussing teaching, it is more likely than not that the conversation will refer to work of others in the community learned about through a workshop, a professional society session, or the web. In this environment, professional development and a scholarly approach to teaching become expected and interest in sharing your own teaching experiences and materials grows. On the Cutting Edge workshop participants now expect to be asked to publish materials on their own teaching on the website and understand the value of these resources. However, we have not yet reached the place where they spontaneously share their materials without a prompting event. Anecdotal

conversations clearly indicate that this is not for lack of good will, but reflects the strong competition for their time. If public documentation of teaching (Huber and Hutchings, 2005) becomes a more integral part of the evaluation of teaching, it seems likely that spontaneous contributions will increase.

In sum, a large scale professional development program like On the Cutting Edge, can impact the environment for teaching because its participants form a large percentage of the total population. This population is not restricted to early adopters (Rogers, 1995) and it is spread across the subdisciplinary structure. This spread has been enhanced by the systematic approach that On the Cutting Edge has taken to workshops addressing the various courses in the upper division curriculum. Thus, professional interactions are much more likely to lead to conversations in which one party has experience with pedagogies beyond lecture, is familiar with research on learning, is comfortable sharing teaching materials, or has engaged in leading educational activities. This is particularly important as geoscience faculty report that interactions with other faculty are one of the most important sources of information about teaching (Macdonald and others, 2005).

Building Stronger Departments: Enhancing Local Support for Effective Teaching

Departments have long been recognized as a critical agent in promoting, implementing and institutionalizing change (Tobias, 1992; Bok, 2006). Departments can design learning experiences at the scale of the major (Savina, 2007) and can develop a culture that supports learning (Hilborn and Howes, 2003). Given that geoscience faculty turn to their colleagues for information on teaching, departments are the most proximal source of support or discouragement for changes in this practice.

Departments are also intriguing because they sit at the intersection of institutional and disciplinary influences. The department is a critical part of the institutional structure both intellectually and administratively. However, the department is also a critical unit for the discipline: departments define and implement the program for majors which determines the preparation that students receive for all aspects of the geoscience workforce and for graduate school, a topic of central interest to the discipline. It is disciplinary colleagues who are called upon to provide external review of departmental programs.

In the past 5 years, the Building Strong Geoscience Departments program has been working in collaboration with the major professional societies (National Association of Geoscience Teachers, AGU, GSA, and the American Geological Institute) to strengthen discussions of departmental issues within the disciplinary communities. Prior to the implementation of this program, such discussions took place within atmospheric science (sponsored by AGU) and in a few subclusters of institutions. Open conversations at professional society meetings were rare though the AGU was engaged in starting conversations among heads and chairs in the geosciences and the American Geological Institute hosted occasional meetings of its Academic Affiliates.

The first goal of this program was to develop an open conversation among geoscience departments about the challenges they face. Geoscience departments are always under threat of closure, or redefinition through mergers with other departments, due to their relatively small size. Recruiting of students is always a topic of interest, particularly given the absence of substantial geoscience classes in the high school curriculum. Geoscience is also facing an exciting time of change driven by increasing interdisciplinary research, technical and computational advances, and by new demands for geoscience expertise to address issues from global sustainability to environmental impacts on health (Bralower and others, 2008). Early work in this program focused on establishing that geoscience departments have more in common than they realize and that all can benefit from sharing regardless of their department size or their institutional type (Building Strong Geoscience Departments, 2008a). A workshop for 30 faculty resulted in a letter sent by the participants to all geoscience heads and chairs making these points and including a document they developed describing characteristics of strong departments applicable to all. This was followed by a survey and discussions at professional society meetings to establish the collective needs and interests of geoscience departments. An advisory board was established to synthesize this information and recommend future directions. In sum, this work established an initial core community interested in working collectively on issues challenging geoscience departments, and identified the highest priority topics for future work. These included, recruiting, preparing students for the workforce, and developing strategies for interdisciplinary research and education.

Phase two of the project focused on establishing mechanisms for departments to collaborate around these topics of high interest. Building on research on professional development (Loucks-Horsley, 2003), as well as our experience with individual faculty members, we sought to create opportunities for sharing information about strategies currently in use and to enable collective brainstorming, synthesis and reflection. The initial program involved topical workshops addressing student recruiting, preparing students for the workforce, and developing strategies for interdisciplinary research and education (Building Strong Geoscience Departments, 2008b). The goal of each workshop was to document the strategies currently in use on the website, to discuss and synthesize these approaches, and to publish the results of the synthesis both in the literature and on the website. In addition the website was used to develop collections of relevant resources from similar efforts in other disciplines (e.g. Physics, Chemistry and Math) and from the literature addressing institutions of higher education and institutional change. These resource collections (Building Strong Department, 2008c) supported discussion at the workshop and were enhanced as a result of this discussion.

The evaluation of this second phase of work is currently underway (Iverson, 2007). It is clear from both end of workshop instruments and follow up communications that participants valued their workshop experience and that there are recognizable short term impacts at some institutions. A case study at a single institution demonstrates how specific ideas have moved from the workshop participant into the thinking of others on campus. While we anticipated that impacts on departmental program would require longer time scales than changes in teaching practice, our initial work also shows the

circuitous path of change. The changes that participants describe as highest priority in their action plans on leaving the workshop may or may not be the changes that they work on or succeed in implementing on return to campus.

To date 73 departments have been involved in this project. The project list-serv has 207 members. It has been successfully used to provide in-depth discussion of issues surrounding a push for departmental accreditation. 25 departments participated in a discussion which included all sides of the issue from the perspective of the full range of institutional types. A subset then participated in a multi-authored paper in a major news vehicle for the discipline (Bralower et al., 2008). It was also successfully used to obtain information on recruiting and employment in preparation for a session on workforce issues. The value is in the depth of responses which complements surveying techniques employed by the American Geological Institute (AGI, 2008).

The website has 700 users who have visited 3 or more times this year. Discussions with our advisory board and anecdotal conversations suggest that there is a relatively small dedicated group of users derived primarily from workshop participants.

In sum, this effort can claim to have developed a community within the discipline that is discussing departmental issues and sharing their collective wisdom internally. The results of this work have demonstrably raised the level of discussion of accreditation. It cannot yet claim to be reaching the majority of departments and it is in this area that we are currently focusing. Building or recommendations from our advisory board and from the literature (PKAL, 2002; Huber & Hutchings, 2005; Loucks-Horsley, 2003; Frost & Teodoresu, 2001; Cross & Steadman, 1996; Garet et al., 2001), new efforts are focusing on dissemination workshops involving departmental teams, as well as visiting teams going to departments. These workshops will make use of the resource collections and expertise developed at all of our previous workshops including materials on developing a departmental team in order to enhance the ability of the department to demonstrate the characteristics of thriving departments articulated at our first workshop.

A Robust Disciplinary Environment for Educational Work?

Looking at the combined impacts of the efforts described above, as well as the influence of many other NSF funded curriculum development and educational efforts, what can we say about the environment supporting change in teaching practice within the geosciences?

It is clear that geoscience education has become a more central topic in our professional work. A discussion of teaching with a research colleague is much more likely to take place today than 10 years ago. Anecdotal stories from leaders in research describe how important it is to them to be able to talk about their teaching to their colleagues who share their deep knowledge of a particular aspect of geoscience. Teaching and professional development of our teaching abilities are becoming a more natural part of our professional life within the discipline and more closely integrated with our research. They are viewed as increasingly important and are more valued. Thus, the climate for

work on teaching is improving. However, it is not yet as strong as the climate for research, there is much room for growth.

Supporting this increasing focus on gesocience teaching, there are now a wide variety of mechanisms are in place to exchange, discuss and critique ideas and to work collaboratively. These range from the informal to the highly reviewed. They are central to the professional work of the discipline, easily accessed and used extensively by at least 10-20% of faculty. Anecdotal stories from faculty teaching a subject for the first time (both early and latter career) report how valuable it has been to have a place to start as the struggle to develop the first pass at a course. The challenge here is to expand reach, use and accessibility.

Perhaps the most important conclusion is the synergy that is developed by work with individual faculty, departments, disciplines and institutions coming together. It is clear that the increase in interest at the disciplinary level reflects, reinforces, and enhances the work of professional development programs like On the Cutting Edge, of institutional efforts like those of NSF through the Broader Impacts Criteria, and of institutions focusing on professional development, liberal learning or a host of other topics. By working at these different levels we develop a reinforcing system that takes on a life of its own, moving beyond the impacts that we can currently imagine.

In 2004, On the Cutting Edge, in collaboration with the American Institute of Physics and the American Geological Institute, survey geoscience faculty to obtain a snapshot of current teaching methods, and to understand how geoscience faculty learn about and change their teaching (Macdonald and others, 2005). The survey results indicated that while teaching methods remained dominated by lecture, most faculty used a range of more interactive methods, albeit infrequently. This survey will be repeated in 2008 giving us an opportunity to measure more directly the integrated impact of our interests.

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