I.   PROJECT ACTIVITIES & FINDINGS

A. Goals & Objectives of this Effort.

Reflecting on fifteen years of experience in identifying, distilling and disseminating best practices for improving individual STEM courses and programs, enhancing scholarly careers of STEM leaders, and guiding campuses in shaping notable spaces for science, in 2003 PKAL leaders outlined a significant next step for our work. A proposal was developed and submitted to the National Science Foundation (NSF) requesting support for an initiative tackling transforming undergraduate STEM learning environment from the institutional perspective. (A grant, # 0341516, was awarded in 2003; herewith we present the final report to NSF.)

The case made in the request was that past national efforts to instantiate improved undergraduate science education have been targeted primarily at individual courses, programs, disciplines, pedagogies, and/or specific instructional technologies. Although such pioneering efforts have succeeded in improving isolated parts of the learning environment on an individual campus and/or promoted reform within a disciplinary field, most often there has been no intentional "scaling-up" in ways that would influence the culture of a campus over the long-term. The progress of institutionalizing approaches having documented positive impact on STEM learning by undergraduates in American classrooms and labs (changing the culture) was moving too slowly.

Our argument, however, was that the lessons learned from pedagogical pioneers over the past two decades about how to inform and advance efforts of "early adapters" within their peer communities could be adapted to inform the work of leaders in institutional transformation. Toward that end, we would identify a group of *forward-thinking institutions* whose experiences could advance a new generation of institutional "early adapters." We appropriated the language of *forward-thinking institutions* from the Business Higher Education Forum:

> *Higher education must redesign itself to meet the learning standards of today's world. Education must be engaging, flexible, and interactive. Forward-thinking institutions that can lead the way must pioneer innovative new efforts and become champions of redesign and learning* (2003).

Theories of *the evolution of innovations* trace the progress of innovations from isolated projects that require primarily commitment of individuals to the point of structural reform that requires institutional commitment (and hard money). It seemed timely to give attention to how *forward-thinking* institutions move on that continuum, as a step toward catalyzing efforts toward systemic renewal of the undergraduate STEM environment on a greater number of colleges and universities across the country.

A model for the evolution of intervention programs [is progressing from]:

- isolated projects
- department/school-based efforts
- formal coordination of discrete projects
- "centers" for coordination of STEM resources and efforts
- structural reform (American Association for the Advancement of Science, 1991).
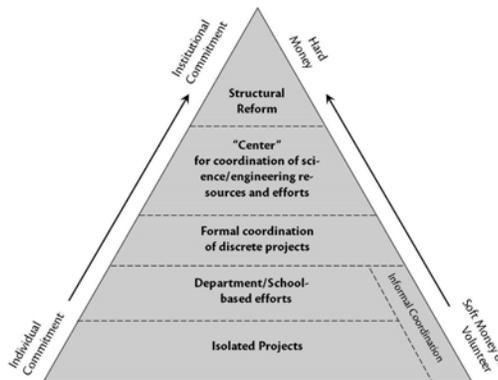
In thinking through how to use *forward-thinking institutions* as agents of change, we found the concept of "positive deviance" (PD) as developed by Jerry Sternin helpful (Pascale & Sternin, 2005). The PD concept is that any effort to make positive change at the local level will be more productive when there is deep understanding of how "positive deviants"— those with similar resources and in similar circumstances— are succeeding in addressing similar problems/opportunities.

> *The strategy of amplifying positive deviants is itself in accord with the pragmatic and "hands-on" precepts of scientific research. It emphasizes the key role of "outliers," whose example can empower a community or institution to achieve performance well beyond presumed limitations* (Hershbach, 2002).

In its essence, the PD concept is similar to theories of dissemination that have shaped PKAL's approach for many years. The case made to NSF was that since 1989, PKAL has been part of the growing national effort, supported in large part by NSF, to spotlight and promote the work of trailblazers having demonstrable influence in the world of undergraduate STEM. Lessons learned from PKAL's past efforts could be extrapolated to shape a broader undergraduate STEM reform initiative.

B. Project Strategies.

In late 2003, Project Kaleidoscope received a grant from the National Science Foundation (#0341516) in support of a three-year PKAL Leadership Initiative (PKAL LI). The larger project goal, as outlined in the proposal, was to develop an understanding of *what works* and why it works as academic STEM leaders progress through the stages of reform toward structural reform of the undergraduate STEM learning environment.

The strategies outlined in the proposal to achieve that goal were to:

- identify and assess practices, policies, and programs having demonstrable impact on an institution's long-term capacity to build and sustain a robust 21st century STEM learning environment for each undergraduate, no matter his or her career aspiration, with particular attention to shaping research-rich, interdisciplinary learning environments that serve 21st century students, science, and society

- analyze and distill best practices relating to leadership and leadership development at the campus level within the nation's undergraduate STEM community, with particular attention to the processes and politics of change, as well as to roles and responsibilities of leaders as individuals and as members of an institutional leadership team

- shape theories of leadership in institutional transformation (within the undergraduate STEM learning environment) that are illuminated by evidence from experiences of LI campuses, those involved as "outliers" and those emerging *forward-thinking institutions*

- describe and disseminate such findings widely so that future practice of STEM leaders is informed by these theories and findings.

C. Project Deliverables & Findings.

 i. There were two major project deliverables of this NSF-funded project, to:

- establish some base line information and data on what works in building and sustaining a culture in which a community of leaders works to shape and achieve their collective vision of robust student learning in STEM fields (a subset of this deliverable was to facilitate progress on participating campuses [LI institutions] toward achieving a culture in which leadership can flourish)

- assemble and disseminate resources that capture, inform, and advance the ongoing work of leaders in 21st century undergraduate STEM at the local and national level (*A Handbook on Institutional Transformation for 21st Century STEM Leaders*). The reports, data, and stories were to be drawn from experiences of individuals, institutions and organizations that contributed to and/or participated in the PKAL Leadership Initiative.

ii. The major findings of this project, as described more fully below (section III), exist on several levels. The first set comes from project evaluation, which included the work of an inquiry task force (ITF), a review of LI institutional portfolios in the PKAL National Office, and a Summary Survey. As described more fully below, evaluation findings included insights about:

- *the role of vision in moving toward meaningful change.* The development of a clear and simple vision was posited initially as one of the key strategies for creating meaningful change. But articulating a clear vision was difficult for several campuses, particularly when it was presented as an essential precursor to establishing goals and strategies for change. However, it was clear that the process of arriving at the vision was as important as the outcome of that process.

- *the commonality of barriers to meaningful change.* LI campuses represented diverse segments of American higher education, each with a particular mission and identity and its own peculiar circumstances and context. Although each had it own mix of formidable challenges, the LI community identified a common set of contemporary and systemic barriers that STEM leaders must address.

- *the breadth, variety, and commonality of strategies toward meaningful change.* Building from leadership theory and leadership practice, particular change strategies were promoted throughout the LI project. There is evidence from LI campuses that such strategies were becoming "promising practices" in overcoming systemic barriers and in moving confidently toward institutional transformation. The evidence is that the most "successful" LI campuses had developed an over-arching strategy to intentionally seek, pilot, adapt and assess such common strategies in ways that made sense for their community, given their current circumstances and culture.

- *the role of leaders within a culture of leadership.* Those taking responsibility for making a difference on LI campuses were self-reflective about their role as champions for desired and valued future for their community's STEM learning environment. The LI was designed to integrate discussions about roles and responsibilities of academic leaders into the work of tackling a specific opportunity facing their community. This was the answer to one of the questions that drove the LI project:

  How do you build and capitalize on a generation of leaders with the capacities for creative thinking, with the passion for making a difference for 21st century students, science, and society?

  The answer was by fostering a sense of community and by understanding that leadership is about relationships within a community of which one is a part. A community defined by a culture of leadership happens when opportunities are built into the system of conversations about things that matter— at all levels of the organization, at all levels in career stages of faculty and other members of the community.

iii. The second set of findings relate to the processes of planning:

- there is a generic planning process that can serve as a guide for leadership teams
- a template for planning is a significant aid to faculty groups with little experience, comfort, or interest in strategic thinking
- insights from research on how people learn is consistent with research on how collaborating groups affect meaningful change.

iv. The third set of findings relate to the process of building leadership networks, within single campuses and among a group of campuses, as orchestrated by an external agency such as PKAL

- *what works* is an intentional and systematic approach to identifying, assembling and coordinating the work of teams of institutional STEM leaders, when there is wide-spread awareness within the community of how and why that work is proceeding, and when that effort has external validation

- *what works* is an intentional and systematic approach to providing iterative opportunities for teams of institutional STEM leaders from forward-thinking campuses to meet, share experiences about overcoming common barriers, addressing and capitalizing on common opportunities, and when that effort is connected to a larger national initiative such as PKAL.

D. Project Leadership.

Those responsible for shaping the vision and scope of the PKAL activities for this project were Jeanne L. Narum, PKAL Director and Co-PIs: **Ishrat M. Khan**, *Professor of Chemistry*— Clark Atlanta University; **Elizabeth F. McCormack**, *Professor of Physics and Chair of the General Faculty*— Bryn Mawr College; **Robert E. Megginson**, *Associate Dean for Undergraduate & Graduate Education of the College of Literature, Science & the Arts*— University of Michigan-Ann Arbor; and **Alison I. Morrison-Shetlar**, *Dean of Undergraduate Studies*— University of Central Florida.

The Co-PIs also received support and council from the members of the National Steering Committee (http://www.pkal.org/collections/NationalSteeringCommittee.cfm).

As with all PKAL activities, a national cadre of volunteers made inestimable contributions to the project— planning and facilitating meetings, serving on project think-tanks, preparing and editing materials for meeting notebooks and/or web publications. In all cases, no stipend was provided for this contribution. Major contributions to this project also came from the host site campuses for the various project meetings. Approximately 278 individuals served in such volunteer leadership capacities, most participating in weekend meetings that required much time in both planning and attending. See links below to descriptions of meetings.

II.   MAJOR ACTIVITIES OF THE PROJECT

The three major project strategies were implemented through three primary project activities, Meetings, Evaluation, and Publications. Each evolved around key questions that reflected the larger project goals:

- what are the key attributes of an institutional culture that supports faculty and administrative leaders seeking to strengthen learning in STEM fields on their campus over the long-term, for all students?
- what are the patterns of success in developing a culture in which leaders flourish and where risk-taking, innovating, and reflecting become part of the institutional DNA?
- is attention to student learning goals an essential cornerstone for reform on forward-thinking campuses?
- what are the drivers for change motivating leaders in transforming the undergraduate STEM learning environment?

A. Meetings.

These key questions were addressed in a coordinated series of meetings: Leadership Roundtables, Colloquia, Institutes on Institutional Transformation, and Topical Seminars.

A conviction of PKAL leaders is that the pursuit of a driving question about issues that matter to the community is a key to achieving a major goal. Consistent with the "focusing on questions" approach throughout the LI project, a driving question was posed at each of these meetings:

- Roundtable on the Future, 2005.
  Question: *How can advances in cognitive and learning sciences about how people learn guide the work of academic leaders responsible for the quality and character of the undergraduate STEM learning environment?* (http://www.pkal.org/documents/LeadershipSeminarsLIFinalReport.cfm)

- National Leadership Colloquia, 2005 & 2006 & 2007.
  Question: *What can we learn from the experiences of leading agents of change about how research on learning advances efforts to: build and sustain a strong STEM faculty; design, implement and assess effective pedagogies; shape accommodating spaces; and determine essential institutional policies and practices?* (http://www.pkal.org/documents/LeadershipSeminarsLIFinalReport.cfm)

- Summer Leadership Institute, 2005.
  Question: *What are the roles and responsibilities of an individual (positional or non-positional leader) in championing meaningful and sustainable transformation of the undergraduate STEM learning community on a campus?* (http://www.pkal.org/documents/LeadershipSeminarsLIFinalReport.cfm)

i. Topical Seminars on Key Drivers for Change.

- Science for All—LI Seminars 2004/2006:
  Question: *To ensure the success of all students in the STEM learning environment, who needs to be at the table, what do you have to know about your students— their diverse learning styles, backgrounds and career aspirations? What should all graduates know and be able to do as a result of their engagement as an undergraduate STEM learner?*
  (http://www.pkal.org/documents/LIFinalReportScienceForAllSeminars.cfm)

- Interdisciplinary—LI Seminars 2004/2006:
  Question: *Can the process of shaping an interdisciplinary undergraduate STEM learning environment be a means of professional development of faculty, serve campus-wide priorities for student learning, and enhance institutional distinction over the long-term?*
  (http://www.pkal.org/documents/LIFinalReportInterdisciplinarySeminars.cfm)

- Research-rich—LI Seminars 2004/2006:
  Question: *What are key relationships and connections—between faculty, faculty and students, faculty and administrators; course sequences and spaces for learning; institutional budgets and priorities—that need to be in place to ensure a research-rich undergraduate STEM learning environment, and who are responsible for making these happen?*
  (http://www.pkal.org/documents/LIFinalReportResearchRichSeminars.cfm)

These 13 events during the grant period involved 1,157 individuals from 538 campuses. From this group, 644 were from LI campuses. Although all events were open, they were designed as a sequential set of three-year learning opportunities for campuses formally involved as PKAL LI institutions.

ii. Challenges. Each of these various meetings and events followed a similar format and explored similar issues. All addressed institutional change from the perspective of contemporary challenges facing 21st century STEM leaders: *what to teach*, *how to teach*, and *who to teach*.

- The *what to teach* challenge is how to bring 21st century science/technology into the undergraduate STEM learning environment, facilitate interdisciplinary learning, socialize students into the global S&T community, and prepare graduates to deal with real-world problems that call for scientific and technological solutions and their responsibilities as citizen.

- The *how to teach* challenge is how to ensure that research-based pedagogies (constructivist, contextual, student-centered, discovery-based) become standard practice in the 21st century STEM learning environment, used in ways that enhance the learning of all students, no matter their background, major, or career aspiration.

- The *who to teach* challenge is how to move from a central concern about producing candidates for STEM graduate schools to broader attention to "science for all," recognizing that the skills, capacities and self-knowledge that are desired outcomes from learning in 21st century STEM classrooms and labs are useful for a wide range of 21st century careers and of great value in preparing students for their roles as responsible citizens in a complex and changing world.

These challenges had been identified in the proposal to NSF as the context in which the PKAL Leadership Initiative would evolve. This framing of contemporary challenges was woven in our seeking patterns of success on "outlier" campuses— identifying *what works.* Our hypotheses were that *what works* is when there is:

- a clear *vision* about what 21st century students should know and be able to do as a result of their engagement in 21st century undergraduate STEM learning environments, a vision that reveals the community's understanding of key drivers for change.

- an understanding of the *politics and process of change* evident in how they deal with what PKAL unofficially has identified as the "big C's" of change: getting a community communicating and collaborating creatively while thinking about the cadence, cost, character, chaos and complexity of institutional change.

- a culture supportive of *collective leadership*, in which individuals made a *personal commitment* to move their community toward a desired and valued future.

iii. Kaleidoscopic Perspective. Further, *what works* seems to be when institutions (and individuals) take a kaleidoscopic perspective of their work in institutional transformation. This was one of the strongest messages made to LI campuses. While preparing this report to NSF on the PKAL Leadership Initiative, the perfect description of the PKAL approach, before and during the LI project, was brought to our attention:

> *Creativity is a lot like looking at the world through a kaleidoscope. You look at a set of elements, the same ones everyone else sees, but then reassemble those floating bits and pieces into an enticing new possibility. Innovators shake up their thinking as though their brains are kaleidoscopes, permitting an array of different patterns out of the same bits of reality. Changemasters challenge prevailing wisdom. They start from the premise that there are many solutions to a problem and that by changing the angle on the kaleidoscope, new possibilities will emerge. Where other people would say, 'That's impossible. We've always done it this way,' they see another approach. Where others see only problems, they see possibilities.*
>
> *Kaleidoscope thinking is a way of constructing new patterns from the fragments of data available— patterns that no one else has yet imagined because they challenge conventional assumptions about how pieces of the organization, the marketplace, or the community fit together.* (Moss Kanter, 2001.)

B. Meeting Strategies.

There was an implicit and sequential "curricular design" within the LI to move from basic questions in earlier meetings— about work of leaders in planning to plan and to build collaborating communities—toward more complex questions in later meetings— about organizational change: how leadership groups make decisions, deal with the politics of change, seek campus-wide ownership of reform, articulate and communicate a compelling vision, etc. A review of agendas from two meetings— the 2004 orientation seminar at Rensselaer Polytechnic Institute (RPI) (http://www.pkal.org/documents/TechnologyTransformingToolAgendaOutline.cfm) and the 2006 National LI Colloquia (http://www.pkal.org/documents/2006KCAgenda.cfm) illustrates the increased complexity of issues addressed at the various meetings.

The first seminar focused on fundamental questions about how a group becomes a leadership team: the challenges of connecting, collaborating and communicating. The story of the host site (RPI) illustrates how this worked out in practice on a campus recognized for its track record in pursuing and achieving transformative change. The 2006 National LI Colloquium extended that conversation, building from resources developed by participants in the 2005

Invitational Roundtable on the Future (http://www.pkal.org/activities/2005RoundtableOnTheFuture.cfm), who had leadership responsibility for this 2006 meeting.

As noted in the agenda posted on the web, an important aspect of this meeting was teams working together to describe and illustrate their vision of what a college or university would look like if student learning goals were the foundation and raison d'être for planning. The 2006 National LI Colloquium involved deeper exploration into how attention to student learning goals has implications for all institutional policies and practice, how one must take the kaleidoscopic perspective in thinking about developing faculty, budgets, programs and spaces.
Of particular value in sparking informed dialogue were Roundtable "products:" the *concept map* (http://www.pkal.org/documents/UniversityoftheFuture.cfm) and the *Rubik's cube* (http://www.pkal.org/documents/PKALCranbrookRubiksCube.cfm).

As standard with all meetings orchestrated under the PKAL umbrella, the design is to move participants from analysis to action, with each team or individual participant drafting an explicit agenda for action to guide their next steps as an agent/s of change. One of the *tools for change* that evolved during the project was a formal grid (vision, goals, strategies, and action) that teams were directed to use in shaping their agenda for action.

The value of such a formal skeleton on which to outline their ideas was to force hard thinking about what a goal really was and what their goals really were. The differentiation between goals, strategies and actions was also clarified as the grids were completed. (As noted below in the report from the project evaluation team, the challenge of clarifying visions, goals and strategies was quite difficult for many LI leadership teams.) The expressed intent of focusing on agendas for action was three-fold:

- to provide teams experience in communicating and collaborating off-campus with the counsel of an assigned consultant

- to have an artifact to present for critique by colleagues at the meeting

- to have a take-home artifact to share with colleagues to advance the effort toward collaborating and communicating.

i. Barriers. One dimension of PKAL's historic approach to galvanizing action is to focus on *what works*, on solutions rather than problems; another dimension is to eliminate or at least reduce the time-wasted in reinventing solutions to systemic problems. PKAL is about disseminating lessons learned, as noted above in the discussion of "positive deviant" and *forward-thinking institutions*. Realizing that systemic barriers on a single campus were common across the LI community made this exchange of lessons learned/promising practices an important part of the PKAL LI effort. Barriers in original applications included:

- instances of success in facilitating student learning are found only in pockets across our campus, with no formal vehicle for discovering them, for building on the resident expertise/interest that exists within our community

- no time for conversations that lead to the broader buy-in needed to arrive at a learning environment that is desired and valued, given the PKAL LI focus on environments that are interdisciplinary/ research-rich/serve all students

- lack of institutional knowledge about how people learn, together with no mechanisms to link such knowledge to development of program, faculty, budgets or spaces.

The approach in all meetings was to present for examination and adaptation what worked in other settings in overcoming similar barriers— what worked from the perspective of the process: who was at the table, what were the driving questions, how was the broader community engaged, etc. As the LI proceeded, the critical role of a questioning community became increasingly powerful. To illustrate, we present questions addressed by a sample of presentations by *positive deviant institutions* at one or more PKAL LI meeting:

- *Recognizing that contemporary tools and perspectives within the neuroscientific community make empirical investigations within the reach of today's undergraduate community, how can we teach neuroscience so that all students at Allegheny College have the opportunity to use these tools to come to understand how science, as a human enterprise, is internally connected and linked to other disciplines?*

- *Recognizing that the skills and capacities gained through a robust undergraduate STEM learning experience are essential learning outcomes for all our students, how can we raise the level of scientific and technological understanding of non-majors through an emphasis on collaboration in science (STEM) education across the sixteen campuses of the Associated Colleges of the South (ACS)?*

- *Recognizing that over 50% of all undergraduates in STEM fields are at community colleges, what kind of collaborations (between Harold Washington and other community colleges, four-year colleges and universities) can be developed to engage more community college students in the kind of authentic research that encourages them toward further study and to careers in STEM fields?*

- *Recognizing that there is a common set of laboratory skills and techniques across disciplinary boundaries, how can undergraduates at Harvey Mudd College come to see the connections between and within technical disciplines, to see science and engineering as a continuum, rather than as a set of discrete boundaries?*

- *Recognizing, from our own experiences and our study of research on how people learn, that the undergraduate research experience is a key to ensuring students adapt the "identity" of the scientist or engineer, what can we do to continue and enhance Hope College's research-rich learning environment?*

- *Recognizing the increasingly quantitative dimension of all STEM fields as they are practiced, where in their learning do our undergraduates at Macalester College have the opportunity to develop the quantitative understandings and skills directly applicable to their majors in the science disciplines?*

- *Recognizing that today's STEM students will have opportunity to become members of a global STEM community, how can we capitalize on the unique capacities of the University of Arizona (a Research I university) to give our undergraduates the kind of research-rich, international opportunities for learning that would ensure their successful socialization into that community?*

Further evidence of the coordinated and sequential planning of PKAL LI meetings (from Leadership 101 to a capstone Leadership STEM Experience) is that key individuals nationally-recognized for their expertise in theory and practice of leadership facilitated sessions at two or more meetings, and/or prepared resources for posting on the PKAL website. This was designed so that participating leadership teams from LI campuses attending multiple events could continue the iterative process of developing, piloting, implementing, and assessing their agendas for action:

- Melvin D. George, *President Emeritus—* St. Olaf College & the University of Missouri System Administration, served as "village elder" in presenting his thoughts and reflections on leadership in the national and local context at several of the meetings and at the five-day Summer Leadership Institutes that were an integral part of this initiative.
  (http://www.pkal.org/documents/LeadershipMeaningfulCareerGeorge.cfm)
  (http://www.pkal.org/documents/Vol4LeadersNeedToCommunicate.cfm)
  (http://www.pkal.org/documents/PoliticsOfEducationalChange.cfm)

- Arthur Lidsky, *President—* Dober, Lidsky, Craig Associates, was involved in several LI meetings, outlining the process of planning (http://www.pkal.org/documents/PlanningProcessLidsky.cfm). His persisting emphasis is on the time it takes to clarify a vision, bringing the right people together around the right questions, and the move to action. Lidsky's expertise was valuable through his formal presentations, as well as through his informal critique of agendas for action as they were being developed during the event.

- Donna Sundre, *Executive Director for the Center for Assessment & Research Studies and Professor of Psychology—* James Madison University, outlined for the LI community— in meetings and in web-postings, the steps toward building a collaborating and communicating community that takes student learning goals seriously
  (http://www.pkal.org/documents/Vol4CommunicationCommunicationCommunication.cfm).

C. Preliminary Findings— Meetings.

The important outcomes from our experience with the diversity of meetings connected to the PKAL LI initiative relate directly to one of the goals of this NSF-funded project— to uncover some *promising practices* in transforming institutions. They are:

- there is a generic planning process that can serve as a guide for leadership teams

- a template for planning is a significant aid to faculty groups with little experience, comfort, or interest in strategic thinking

- insights from research on how people learn is consistent with research on how collaborating groups affect meaningful change.

A further exploration of these *promising practices* follows:

- There is a **generic planning process** that can serve as a guide for leadership teams— no matter their particular current reality.

We began the LI experience with a pretty clear understanding of how such a process works when the "project" is planning new spaces for science, and we ended the LI experience with a formal statement of a PKAL Planning

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Process (http://www.pkal.org/documents/PKALPlanningProcess.cfm). The four key points of the planning process are that it:

- reflects contemporary pedagogical approaches
- centers on student learning
- develops leaders and an institutional culture of leadership
- focuses on *what works*.

These key points were distilled from stories and data from the many presentations by representatives of "positive deviant" institutions at one or more PKAL LI meetings, as well as from the experiences of *forward-thinking* colleges and universities formally involved as PKAL LI campuses.

- A **template for planning** is a significant aid to faculty groups with little experience, comfort, or interest in strategic thinking.

From the informal verbal instructions in regard to preparing an agenda for action that were used in the earliest meetings, a formal *vision/goals/strategies/ action* template was developed that most campus leadership teams ultimately found useful. As noted below (Section III C.), quite often the critical sticking point for meaningful planning was a lack of clarity of vision and a lack of understanding of the importance of a driving vision for organizational change. However, as also noted in other instances, it was precisely the presence of a powerful vision that enabled the leadership team to address the politics of change at the institutional level.

- **Insights from research on how people learn (HPL)** is consistent with research on how collaborating groups affect meaningful change.

What works is when they are confronted with a problem that is inherently connected to their day-to-day life (abstract discussions about leadership theory do not take hold). This is why stories and scenario-playing were so strongly emphasized in all PKAL LI meetings. They model how to nurture campus-wide discussions about student learning and encourage the creative, out-of-the-box thinking that leads to meaningful change. Sometimes even how to bring the known skeptics or "curmudgeons" into the process.

A second *what works* insight from HPL is that people learn best when they have the opportunity and responsibility to shape their own learning. This is why times for teams to work, individually and collectively, with or without a consultant, are such a prominent feature of all PKAL meetings. Another insight is the value of "going public:" of putting your ideas out for public comment, communicating orally, in writing and/or through illustrations; thus the emphasis at the end of each PKAL meeting is the "poster" reporting out session.

As the project proceeded, we became much more intentional in incorporating some contemporary, active-learning pedagogical approaches (case studies, group activities using a variety of learning tools, think/pair/share, the two-minute paper, pre-meeting questions, experiential learning, etc.) into sessions at all meetings.

III.   PROJECT EVALUATION

A. Evaluation Process & Approach.

Several means were used to gather and analyze evidence from participating LI colleges and universities about progress, or lack thereof, in moving toward their vision of "what success would look like:"

- Institutional portfolios developed in the PKAL National Office (2004 – 2007) for each institutional leadership team included:

  - the original application— vision and barriers
  - the iterations of their vision of success developed as the project evolved
  - their agendas for action developed at project meetings
  - periodic reports from the institutional team/individual members
  - a mid-project "reflections on leadership" survey of individual members of the teams.

- An evaluation team (Inquiry Task Force [ITF]) was established, with responsibility for:

  - reviewing institutional portfolios from LI campuses
  - selecting a cadre of LI campuses to be visited; designing rubrics for case studies to be developed prior to the visit
  - analyzing findings from the campus site visits made in 2007
  - distributing a final project evaluation survey in early 2008.

- Links to materials relating to project evaluation:

  - Themes for reviewing institutional portfolios, identifying and shaping ITF site visits (http://www.pkal.org/documents/ThemesForPKALReviewOfData.cfm)
  - Survey on Personal Reflections on Leadership, with comments
  - Final Leadership Initiative Survey (http://www.pkal.org/documents/LIFinalSurvey.cfm).

The steps toward formative and summative project evaluation were designed to test the original hypotheses of the PKAL Leadership Initiative, that *what works* is when there is:

- a clear *vision* about what 21st century students should know and be able to do as a result of their engagement in 21st century undergraduate STEM learning environments

- an understanding of the *politics and process of change* evident in how they deal with what PKAL unofficially has identified as the "big C's" of change

- a culture supportive of collective leadership, in which individuals made a *personal commitment* to move their community toward a desired and valued future.

B. The PKAL Inquiry Task Force (ITF).

These hypotheses served as the foundation for the work of the ITF, setting the stage for their exploration of the several dimensions of institutional transformation, those relating to: setting a vision, implementing goals and strategies relevant to that vision, and taking informed action.

i. Key questions.

In their two meetings to plan the evaluation and the site-visits, the ITF identified the following as key questions to explore during the site visits:

- What is your vision of success in building a robust STEM learning environment and what evidence is there that you are progressing toward that vision?

- Who has been/is involved in this work? What, if any, has been the role of senior administrators?

- Has shared learning emerged?

- What is the evidence that structural change is underway that will lead to the cultural change that becomes systemic and sustainable?

- What strategies and tactics are working? Why are they working?

ii. Members of the Inquiry Task Force (ITF).

The members of the ITF were **Jeffrey E. Froyd**, *Director of Academic Development in the Dwight Look College of Engineering and Project Director for the NSF Foundation Coalition*— Texas A & M University; **Nancy Jannik**— *Associate Vice President for Research, Graduate Affairs & Assessment*—Winona State University; **Adrianna Kezar**, *Associate Professor of Higher Education*— University of Southern California; **Ishrat M. Khan**, *Professor of Chemistry*— Clark Atlanta University; **Elizabeth F. McCormack**, *Professor of Physics and Chair of the General Faculty*— Bryn Mawr College; **Alison I. Morrison-Shetlar**, *Dean of Undergraduate Studies*— University of Central Florida; **Jeanne Nakamura**, *Research Director of the Quality of Life Research Center and Research Assistant Professor of the Drucker School*— Claremont Graduate University; and **Donna L. Sundre**, *Executive Director Center for Assessment & Research Studies and Professor of Psychology*— James Madison University.

The ITF members brought a range of experience and expertise to the project, which is reflected in the key questions for the evaluation and site-visits. For example, Kezar's work in *Understanding and Facilitating Organizational Change in the 21st Century* raised the key issue of how the culture of the institution affects change:

> *The research on cultural theories helps us to understand that institutional culture shapes the reason change emerges, the way the process occurs, and the change outcomes. Although many administrators are aware that the institutional culture and type shape organizational life, this may not translate into identifying unique change strategies based on the institution's history, traditions, and norms. It is advisable for institutions engaging in change to conduct an institutional self-audit or assessment of their culture* (2001).

From his analyses of the NSF-funded Engineering Coalitions, Froyd's insights about the value of qualitative research helped to establish the "qualitative research" process for site visits:

> *This methodology (qualitative research) has several defining characteristics. Its focus, first of all, is on understanding the meaning people give to their experience. Because meaning-making is a fundamental human activity, the best way to understand it is through personal interaction…it is important that the research go to the people being studied so that their context can be understood, a critical element since the meaning they give to their experience is shaped in multiple ways by their context. Qualitative research by nature is inductive, building rather than testing theory, and the knowledge it produces is highly descriptive* (Clark, Froyd, et al., 2004).

From her work with Mihaly Csikszentmihalyi, Nakamura brought insights about the role of individuals in accomplishing "good work" (in the PKAL LI context— leaders accomplishing institutional transformation):

> *In every historical era, many people have sought to carry out good work. It has always been true that some people do their work expertly but not very responsibly. People who do good work, in our sense of the term, are clearly skilled in one or more professional realms. At the same time, rather than merely following money or fame alone, or choosing the path of least resistance when in conflict, they are thoughtful about their responsibilities and the implications of their work. At best, they are concerned to act in a responsible fashion with respect toward their personal goals; their family, friends, peers and colleagues; their mission or sense of calling; the institutions with which they are affiliated; and, lastly, the wider world* (Gardner, Csikszentmihalyi, Damon, 2001).

iii. Positive Indicators.

Based on their professional expertise, the ITF members began their work with a review of institutional portfolios, drafting an initial set of "positive indicators." These were revisited following the site visits. Although there were significant differences in the scope of activities and/or progress achieved on the campuses visited, the ITF sought to determine factors that contribute to success as well as those that inhibit progress toward meaningful change. *What works* seems to be when there is:

- openness to change signaled by presidential vision and action which is evident in many ways, including appointments to senior administrative positions and philosophical and financial support for those taking a leadership role in institutional change.
- a sense of long-term stability with decisions made collectively and thoughtfully about each next step and new direction in the context of the institutional culture and mission, and where that approach to decision-making has contributed to a culture of trust.

- intentional weaving by leaders of a "tapestry of change," in some instances taking small steps (low-hanging fruit) and in others pursuing breath-taking and timely new initiatives.

- persistent attention to what students are learning and to the process of learning and teaching, an outcome evident even in how students talk about their learning experiences (active and engaged) and seem to be in sync with the larger institutional vision.

- visible evidence that "everyone is on board" in thinking about student learning— from facilities managers to library directors to assessment officers to faculty in all disciplines. This seemed to reduce the potential of individuals (faculty or departments) going it on their own. What works is when the quality of learning in STEM is the concern of the whole campus.

- visible evidence that the campus is intentional and sophisticated in identifying and adapting relevant work of peers, in order to be most efficient in regard to time and funds in the work of reform.

C. Main findings.

The insights and findings of the Inquiry Task Force are incorporated within materials presented below (Section V) that are being adapted for the work-in-progress *Handbook on Institutional Transformation for STEM Leaders,* one of the primary deliverables from this NSF-funded PKAL Leadership Initiative. Their main findings are:

- *the role of vision.* On some campuses reviewed, the development of a clear and simple vision was one of the key strategies for creating change. But articulating a clear vision was difficult for several campuses, particularly as an essential precursor to establishing strategies for change. *Recommendation:* the role of vision as a driver for institutional change is an area that needs further study and refinement.

- *the breadth, variety, and commonality of strategies toward meaningful change*. Although a central set of change strategies was promoted through the PKAL LI, campuses that seemed more successful had intentionally and visibly adapted and extended these strategies in ways that made sense for their culture and community. *Recommendation*: the power of collaborating "networks," (within and beyond a campus) as a means of affecting meaningful transformation is an area that needs further study and refinement.

- *the commonality of barriers to meaningful change*. LI campuses represented diverse segments of American higher education, each with a particular mission and identity, with its own peculiar circumstances and context. Although each had it own mix of formidable challenges, the LI experience afforded the opportunity for sharing and adapting promising practices in overcoming systemic barriers. *Recommendation:* further pilot efforts should be supported to explore the impact of dissemination theory on organizational change.

- *the role of leaders within a culture of leadership*. Those taking responsibility for making a difference were self-reflective about their role as champions for a STEM learning environment that would be more engaging, flexible, and interactive (BHEF). *Recommendation*: to continue and expand programs for leadership development in undergraduate STEM.

The ITF further noted that the goal of the project was to develop faculty leaders within the STEM community taking responsibility for building and/or sustaining a robust undergraduate STEM learning environment— research-rich, interdisciplinary, serving all students. Ultimately, this required informed action throughout the university/college directed toward meaningful change at the institutional level.

So what exactly does institutional transformation look like, from the perspective of the ITF?

A few examples from campuses visited and portfolios reviewed demonstrate the kind of changes we were able to document reflecting the impact of involvement in the LI on institutional change.

- **Different language and culture among students and faculty:** *One evidence of success in creating change is that a common language is used across campus to describe what is happening in the STEM learning environment. Students use a new language as they talk more about hands-on learning, cross-departmental learning opportunities. Students explain the value of working in teams with peers, feeling as though they were research colleagues with faculty, and about feeling responsible for their own learning. They are excited about how new programs and new spaces signal the institutional intent to strengthen student learning.*

  Non-STEM faculty comment on the ripple-effect of conversations about student learning, how discussions within the STEM faculty sparked rethinking about how students learn and thus how they teach within their discipline or division. Even administrators were aware of the new culture of learning. For example, one librarian reported how giving students more complex assignments to figure out on their own required more sophisticated information literacy skills; she sees this as a direct result of the involvement with PKAL.

- **New programs and initiatives reflecting the PKAL vision of undergraduate STEM learning:** *An undergraduate research conference hosted by the PKAL team in the fall of 2006 had a ripple effect across one campus, which also resulted in new language and conversations. The annual research conference was cited by students as one of the most powerful learning experiences for them personally. The changing of culture was evident as other departments began hosting similar opportunities for students to present their research, and as all departments began to explore the possibility of a senior capstone research experience for all students.*

  Faculty as well as students were speaking about the impact of the initial research conference, noting with particular pride the environmental research being done on land near the campus—service-

learning research. This was a compelling institutional story about the impact of the involvement with the PKAL LI.

- **New ways people think about their roles and operations:** *We knew that change had occurred when we were on campuses and individuals outside the science faculty were talking about the ideas from PKAL and how it fundamental changed their role— particularly staff and administrators. On one campus, the facilities manager, obviously influenced by the PKAL leadership team, was planning new facilities to create more collaborative and rich learning environments for students.*

  Campuses where the PKAL leadership team is making a visible difference are not just rethinking learning in STEM fields, but all of their curricular (and co-curricular) programs. On one campus, for the first time, humanities and science faculty were developing collaborative research projects, reporting that this is changing how they conceive their research— and that they like it!

D. Summary Survey.

The Summary Survey was distributed early 2008 in the process of preparing this report to NSF. Twenty-five LI campuses responded. Results from the survey must be viewed with the following in mind:

- data are self-reported by the leader of the LI team and may not reflective fully the broader campus view

- campuses varied in their level of participation in LI activities

- campuses had different starting points (baselines) in regard to the institutional characteristics addressed.

For example, a college included in the small percentage as having well-defined STEM learning goals at the beginning (2004/2005) would not indicate major change at the end of the LI project, whereas one that had not had well-defined learning goals initially could report much larger gains. It is also important to note that the scope of projects differed campus to campus, from those addressing institution-wide visions to those focusing primarily within STEM programs.

Summary Survey. Part I: Vision. Nearly 50% of the campuses disagreed or strongly disagreed with the statement, "there was a clear vision of student learning goals on the campus in 2004/2005; for the science division alone, the point of disagreement was 35%, with 30% reflecting status of individual department and programs. There was significant change over the course of the LI experience, with 74% of the campuses agreeing or strongly agreeing that there was a clear vision of student learning both at the institutional and divisional level; the percentage was even higher at the departmental level: 87%.

Summary Survey. Part II: Culture. 27% of campuses reported evidence of institutional attention to developing faculty and administrative leaders prior to their LI experience; there was a significant increase, to 63% post-LI. As indicated by the charts (http://www.pkal.org/documents/FinalLISurveyResults.cfm), when asked if they agree or disagree with statements such as: there is/was a cadre of influential champions taking responsibility for new approaches, for pre-LI, 36% disagreed/strongly disagreed; post-LI 18% disagreed/strongly disagreed. Responses to the question, do they agree or disagree with the statement that there is/was support from senior officers for new initiatives, for pre-LI, 50% disagreed/strongly disagreed; post-LI 24% disagreed/strongly disagreed.

Perhaps most interesting are the data indicating overcoming the significant barrier of the disconnect between planning for STEM transformation and larger institutional initiatives: at the beginning of the process, the response was: neutral— 41%; disagreed— 27%; strongly disagreed—9%. At the end of their LI involvement, neutral— 27%; disagreed— 23%; with 0% strongly disagreeing. To move from 23% connecting STEM transformation to institutional transformation to 50% by the end of the LI indicates the potential of orchestrated strategies to shape a culture in which leadership is nurtured over the long term. As noted in the exhibits, other questions revealed a similar momentum toward meaningful change.

Summary Survey. Part III: Planning Process. This survey question did not seek comparative data, but rather sought a snapshot of the current circumstance on that LI campus in regard to the work of a leadership team. Asked about characteristics of their leadership group, "yes" responses were:

- 74% includes individuals with diverse interests, expertise and spheres of responsibility.

- 87% understands the context for change, within and beyond the campus.

- 48% convenes regularly, intentionally working toward developing and implementing a plan of action.

- 57% clearly, broadly and often builds widespread ownership and engagement of the process.

- 74% is clear about who their students are, what students bring to and are to gain from their STEM learning experiences.

- 70% is conversant with contemporary research on learning and how that research can be reflected in their planning.

- 83% has experience with contemporary pedagogies of engagement that serve student learning goals.

- 65% is visible and evolving, appropriately engaging those in positional and non-positional leadership roles.

- 57% is reflective about roles and responsibilities of leadership teams.

- 74% has identified one or two contextual reasons for pursuing a new initiative.

- 79% is prepared to take risks and explore new approaches.

- 74% gives attention to everything, understanding the relationship pieces (programs/spaces/budgets, etc.) to the whole.

Summary Survey. Part IV: Facilities. Campuses were asked to respond to questions about whether their facilities were able to accommodate a research-rich, interdisciplinary learning STEM community serving all undergraduate students. This question was posed for the base year of 2004-05. Additional questions were given on what changes may have occurred during the project period. As with other questions, campuses had different baselines and certainly the scales vary considerably from smaller campuses that may have a single science building to larger campuses with potentially many buildings involving STEM programs. We do not presume the data reported refer to campuses across the country beyond the set represented in the PKAL LI survey.

A third of campuses reported their facilities accommodated contemporary pedagogies of engagement, while a third said their facilities did not. Nearly half said that their facilities enhanced a research-rich undergraduate STEM learning environment, but 38% did not. In enabling an interdisciplinary undergraduate STEM learning environment, 43% of the campuses felt they did not. A similar percentage (47%) indicated their facilities did not foster a sense of community and attracting and sustaining the interest of all undergraduates in STEM learning, while only 29% responded positively. Based on these responses, the importance of facilities and the barriers inadequate facilities represent are evident. For the campuses involved, 48% had planning underway for new spaces in 2004-05 and 50% indicated planning for new spaces began during the LI project. Construction of new spaces was underway on 20% of the campuses surveyed in 2008.

Summary Survey. Part V: Community. Campuses were asked to report on the contributions made to the work of the LI team. Making regular contributions were the deans (50%) and department chairs (45%). A wide range of offices from the president, to chief academic officer, to admissions and development provided visible and tangible support, although at 25% or less. Nonetheless, when requested those offices tended to respond positively.

To look at the responses in another way, if you look at the responses for who did not contribute, the percentages are highest for admissions officers and student affairs personnel (65%) and lowest for deans (5%) and department heads (0%). Presidents, chief academic officers, physical plant officers, chief financial officers and others were typically in the range of 35-40% not involved.

IV.   PROJECT ACTIVITIES— PUBLICATIONS

A. *PKAL Volume IV: What works; what matters and what lasts.*

This web-based Handbook is the major publication emerging from this NSF funded project. Other publications—in print and on the web—include *Leadership: Investing in the Future: Building Institutional Leadership for Natural Science Communities* (http://www.pkal.org/documents/LeadershipHandbook.cfm) and the *2006 PKAL Report on Reports II: Recommendations for Urgent Action* (http://www.pkal.org/documents/ReportOnReportsII.cfm).

The rationale for printing these two reports was to encourage wide discussions about the roles and responsibilities of academic leaders, as well as to place the work of leaders taking responsibility for the quality and character of undergraduate learning in STEM fields in the larger national context.

PKAL Volume IV was designed as a resource for current and rising leaders with responsibility for the strength of the nation's programs in STEM fields in the undergraduate setting. The electronic publication (http://www.pkal.org/collections/VolumeIV.cfm) provides easy access to promising practices in shaping institutional cultures that nurture and support leaders (faculty and administrators) taking responsibility for building and sustaining robust undergraduate STEM learning environments. From 2004 on, hundreds of different resources were posted on PKAL Volume IV under a wide range of umbrella topics that mirrored directly the major themes of the PKAL LI.

There were noticeable spikes in traffic before and after a specific PKAL LI event, as participants were asked to review resources before-hand and present post-meeting outcomes of their continued planning efforts. This was to encourage a ripple effect of conversations about critical issues relating to leadership in institutional transformation on individual LI campuses and beyond the discrete LI community.

This publication is modeled after previous PKAL publications intended to inform and advance the work of STEM leaders. It is grounded in the vision and mirrors the scope and format of *PKAL Volume I: Building Natural Science Communities* and *PKAL Volume III: Structures for Science— A Handbook for Planning Facilities for Undergraduate Natural Science Communities*. It includes practical advice from the trenches, provocative and reflective essays from leaders and on leadership, interviews with people making a difference, and investigative stories from the work of pioneering agents of change as well as forward-thinking colleges and universities. Materials from corporate communities, as well as from the broad national community of stakeholders from the academic and scientific community were incorporated into PKAL Volume IV.

As with all past and present PKAL activities and publications, the goal of this "work-in-progress" publication is to identify promising and best practices dealing with both the theories of leadership and organizational change and with the process of translating those theories into action. As mentioned earlier in comments about the "why?" of this project, the persisting PKAL approach is to identify what works and spotlight such efforts in a manner to facilitate wider exploration, adaptation, implementation and assessment of such practices.

Materials for editing and posting were captured through:

- *examining efforts of a select group of colleges and universities identified by the project steering team as institutional "outliers," as well as of individuals recognized for catalyzing systemic change on their home campus.* These individual and institutional "outliers" were invited to report on their work at one or more project meetings (seminars, roundtables, institutes); their stories became a part of the PKAL LI archive, with some prepared for inclusion in the *Handbook.*

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- *reviewing reports and data from PKAL-active campuses making visible progress toward institutional reform.* This was a major challenge for the co-pi's and the broader project team: to cull relevant insights, ideas, and best practices from the PKAL archive/community.

- *monitoring experiences of leadership teams on a select group of forward-thinking campuses selected as PKAL LI institutions.* Their applications to participate described :

  - a particular institutional challenge/opportunity to achieve systemic improvement of undergraduate STEM they would address during their LI participation
  - why, given current circumstances, it is timely to tackle that challenge/opportunity
  - barriers to be overcome in addressing that challenge/opportunity
  - their vision of *what success would look like*
  - the institutional commitment for their participation as a PKAL LI institution
  - the potential members, roles and responsibilities of the PKAL LI leadership team on their campus.

We also found a rich treasure trove of applicable resources, many of which were out-of-print and others only accessible to individual segments of the higher education community–but all little used at the grass-roots. To illustrate, a 1977 essay in an AAC (now AAC&U) publication on *Organizational Reform is Not Enough* (http://www.pkal.org/documents/Sagen_OrganizationalReform.cfm) surfaced late in the project, and was promoted as a succinct, still relevant analysis of key issues to be addressed in the process of change.

The work-in-progress publication of the *Handbook* was virtual, with regular postings presenting materials prepared for and emerging from project meetings and other events. During the course of the project, traffic increased significantly on the PKAL web site; we present pageview data from March 1 – 31, 2008 to illustrate the use of the web site. All postings are public and are available for downloading and use without charge. We receive regular requests for the use of these materials.
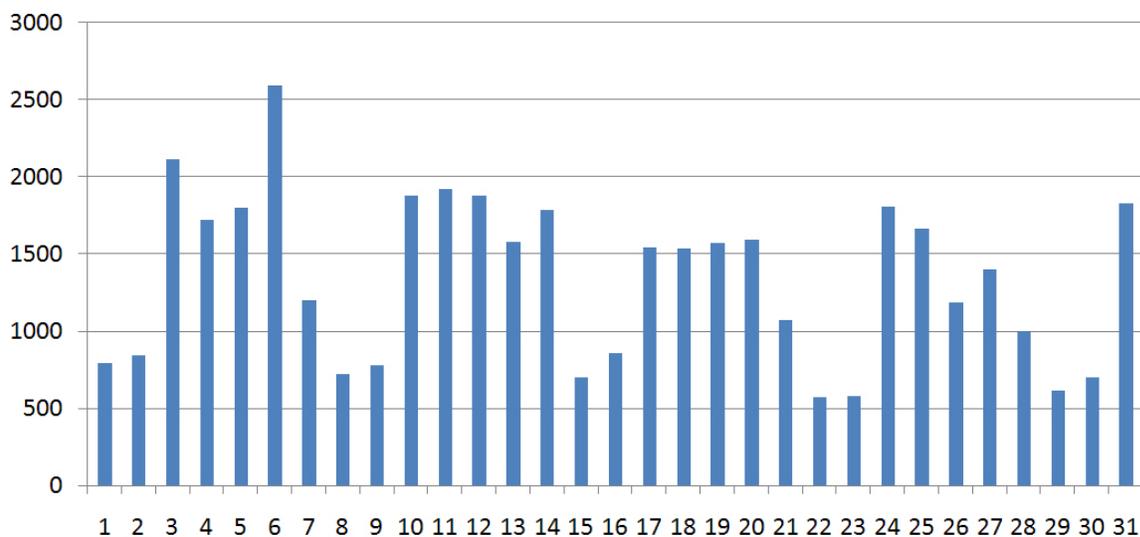
The richness of materials prepared for and from LI events is a mixed blessing, requiring intentional searching for or serendipitous encounter with materials of particular relevance to the searcher. This 2008 report to NSF, which will be included as the foreword to the *Handbook*, establishes its intellectual skeleton, assembling resources relating to the key project themes in a more accessible manner. Here is the "working" Table of Contents for the *Handbook on Institutional Transformation for STEM Leaders*:

I.   The Why & the How of *STEM* Transformation: Considering What to Teach, How to Teach & Who to Teach— 21st Century Drivers for Change

II.   Leadership in the Work of Institutional Transformation
- Vision: focusing on student learning
- Politics and planning: engaging the community
- Leaders and leadership: considering personal perspectives

III.   Transformation Toward New *STEM* Learning Environments
- Interdisciplinary: What to teach
- Research-rich: How to teach
- Science for all: Who to teach

IV.   Leadership Initiative Tools
- Case Studies
- Surveys

Given the capacity of the world-wide web, the *Handbook* will be disseminated virtually through the PKAL website (http://www.pkal.org). This will enable new contributions to be added and broader audiences reached. It is hoped that a summary report can be distributed in print form. Most materials included in the *Handbook* can also be accessed through normal search engines as individual resources.

In preparing this final report to the National Science Foundation, we incorporate in a summary of the *Handbook* some findings and insights from the several activities through which the PKAL Leadership Initiative was evaluated. The evolution of this Handbook will continue to be a work-in-progress, continuing to incorporate ideas and resources about promising practice that continue to emerge through the ongoing activities of PKAL and from the work of the larger community of leaders taking responsibility for shaping the future of undergraduate STEM learning in America.

V.   HANDBOOK (Summary as of July 30, 2008)

A. Part One: Vision & Leadership.

> **Vision**: *a direction or framework to guide people in their work. It is usually oriented towards the future, departs from current realities, and anticipates the creation of something new.*

> **Shared vision**: *the degree to which the vision becomes incorporated into the institutional culture, and is embraced by the broad campus community.*

The PKAL Leadership Initiative (LI) was based on the premise that general leadership theories could be translated in practice as leaders in undergraduate STEM tackled the challenging and urgent work of strengthening student learning in STEM fields. It was designed as a new approach to STEM faculty development, focusing on *leaders developing leaders* as fundamental to achieving meaningful and systemic institutional transformation. The definition of leaders/leadership driving the initiative was from the work of Alexander Astin and Helen Astin in *Leadership Reconsidered: Engaging Higher Education in Social Change:*

> *leadership is a process ultimately concerned with intentionally fostering change that is directed toward some future and/or condition which is desired or valued... all people are potential leaders and... leadership is a group process* (2000).

That definition describes the work of leaders in many different settings, but it was particularly helpful in the LI context by emphasizing that leadership is a group process not an individual act. It was also helpful in defining leadership from the perspective of the scientific/engineering community— focusing on the future and on building, enhancing, and sustaining a valued condition as a collaborative enterprise. Our focus on vision was specifically on visions for student learning, in the context of institutional circumstances, mission and identity.

The recent Howard Hughes Medical Institute (HHMI) publication, *Making the Right Moves: A Practical Guide to Scientific Management for Postdocs and New Faculty* (2006) connects leadership explicitly to the time-honored work of the scientist within a lab:

> *leadership is getting a group of people to enact a vision of what needs to be accomplished.... thus, leadership starts with a vision, and requires relationships with others to accomplish tasks.*

Attention to shaping a compelling, collective vision became a regular part of the LI agenda, at seminars and other meetings and through electronic publications. We found the capacity to question, to be uncomfortable with the status quo, to be a most salient and consistent characteristic of leaders observed.

Their questions are about 21st century students:

- Who are the students now coming into our STEM classrooms and labs? Are they different from past generations, and if so how? How do they learn?

- What do we know, as a community, about the learning experiences of our students now in our classrooms and labs? How do we know?

Their questions are about 21st century science:

- How is 21st century science and technology now being practiced? What can we anticipate will be advances in the next decade? How do we know?

Their questions are about our 21st century society, about the world in which students will live and work upon graduation:

- What are the skills and capacities needed for responsible citizenship in a democracy?

- What do urgent calls from a wide range of stakeholders— to shape a nation of learners and of innovators— mean as our campus community plans for our institutional future?

Asking such questions is not an intellectual exercise for those in positions of opportunity to shape their institutional future. Asking such questions is a means to examine present practices and the current reality— within and beyond the boundaries of the campus. How institutions with different identities and missions, culture and context explored such questions are some of the important stories collected during the PKAL Leadership Initiative, 2004 – 2007. In wrestling with these questions, institutional leaders began addressing key 21st century challenges: *what to teach*, *how to teach*, and *who to teach*.

- The *what to teach* challenge is how to bring 21st century science/technology into the undergraduate STEM learning environment, facilitate interdisciplinary learning, socialize students into the global S&T community, and prepare graduates to deal with real-world problems that call for scientific and

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technological solutions and their responsibilities as citizen.

- The *how to teach* challenge is how to ensure that research-based pedagogies (constructivist, contextual, student-centered, discovery-based) become standard practice in the 21st century STEM learning environment, used in ways that enhance the learning of all students, no matter their background, major, or career aspiration.

- The *who to teach* challenge is how to move from a central concern about producing candidates for STEM graduate schools to broader attention to "science for all," recognizing that the skills, capacities and self-knowledge that are desired outcomes from learning in 21st century STEM classrooms and labs are useful for a wide range of 21st century careers and of great value in preparing students for their roles as responsible citizens in a complex and changing world.

FINDING #1. Among the findings from this PKAL Leadership Initiative is:

> *The difficulty of clarifying and articulating a compelling vision.*

In applying to participate as an LI campus, institutions were asked to draft a vision of what they hoped to achieve (what *success would look like*) in strengthening student learning through their LI involvement. These earliest drafts were all over the map: some more strategic than visionary (how to get there rather than where they wanted to go); others with no mention of "students or student learning." Some were purely rhetorical, catalogue copy, non-institution specific. But, happily others clearly gave evidence of the current collective commitment of the community, what Northouse calls *a conceptual map for where the organization is headed:*

> *The vision is a focal point for transformational leadership... it gives meaning and clarifies the organization's identity. Furthermore, the vision gives followers a sense of identity within the organization and also a sense of self-efficacy* (Northouse, 2000).

The evaluation team for this PKAL LI project sought to determine *whether the LI experience advanced and informed visioning efforts on participating campuses.*

Their answer: *Yes and no. Through a review of institutional portfolios, of the outcome of the LI evaluation site visits, and of the project-end survey, it is clear the outcome is varied.*

Some reflections from the LI community as presenting in the Summary Survey to the question, *is there now a clear vision of student learning goals on your campus?* validate that finding:

- We are making progress at the divisional level in agreeing within programs as to what we are looking for from our students. Undergraduate research is highlighted in the newest institutional strategic plan, but we do not yet have clarity as to what that means at the program level.

- The college has had a whole series of discussions on student learning goals, but some members of the STEM division are still resistant to applying them directly to us.

- At the departmental level, there is a clear sense of student learning goals, but during a period of presidential transition, there is no mechanism in place to communicate those upstream.

- Our faculty, students and administration now have several years of experience with the new curriculum that emerged during our LI experience. Our LI goal was to create a research-rich learning environment for all students and such learning goals are strongly integrated into our institutional strategic plan.

- Still some way to go in some departments, but the progress on a clear statement about learning goals is very evident.

- Learning outcomes for all programs are now defined in the College Catalogue for 2007/2008.

- I think learning goals are clearly articulated in some STEM departments, but not others.

From ITF final report:

Vision was a very complex aspect of the project to evaluate, even though having a clear vision is one of the main assumptions of the LI project. But at the campus level it was not clear that "vision" was uniformly central to success in achieving institutional transformation and/or for creating more campus leaders who were agents of change.

Upon reviewing portfolios, it seems that the more clear, succinct and simple the vision, the more it served to drive the process of transformation. So, one of our recommendations is that helping campuses develop such a vision (an "elevator speech") is more important in the process than moving them toward developing a complex vision statement.

This is because campuses become mired in the visioning process. As noted by one LI member:

Given our institutional culture, in which the machinery of strategic planning seems to impede strategic thinking (visioning), we have instead focused on organizing groups to talk about specific things they might do in the future, about what we/they could do with new people, new spaces, new money, etc. It seems to be forcing the discussion away from current problems and how we do it now toward discussions about how they can do something different in the future and how individual action can contribute to the whole. Indeed, many are finding out that they do contribute to the whole, and their attitude is changing and their creativity unleashed.

LI teams on several site-visit campuses seemed to become "stuck" trying to develop a vision that they thought would make sense to the larger community; once stuck, they then began to back-track, to think about specific goals and strategies for student learning, prior to developing a vision. On one or two site-visit campuses, ITF learned that non-STEM faculty became confused when discussions began in regard to visions for student learning in STEM fields— the idea of vision seemed too nebulous. On several site-visit campuses (and others within the LI community) what seemed to work was when the conversations started from the point of what success would look like within specific projects or programs rather than a broad (nebulous) vision. However, it was interesting to note that on many campuses visited, when asked about their thoughts of the future non-STEM faculty made significant mention of increased numbers of students studying STEM fields, greater interdisciplinary work that cut across all disciplines and contributed to new faculty collaborations, more connections to high schools, etc.

Report from an LI portfolio: *As our focus is on addressing the institutional vision of preparing graduates to be ethical leaders of society, we expanded our LI team to include many colleagues from non-science disciplines. One catalyst for our conversations has been developing a major institutional proposal to the National Endowment for the Humanities (NEH). This has involved bringing many experts to the campus to advise on how to integrate ethics, interdisciplinary issues, leadership and service learning into courses across the curriculum. These conversations, the proposal writing charge and the external visitors are all helping to dissolve what had been impenetrable silos.*

Yet on other campuses, it was not the solo work of the LI team that was instrumental but the support by campus leaders to create a shared campus vision that made the difference. Clearly, one of the most important roles of senior leaders on PKAL LI campuses was to help create shared student-centered vision. Those in positional leadership roles were successful in creating and nurturing a culture in which non-positional leaders could take responsibility for translating the shared vision around student learning in new policies, programs and practices.

Comments from the Summary Survey further document the impact of senior leaders— positive, neutral, negative— on the process of visioning and of linking planning to that vision:

- Within the College of Science, we were able to agree on a common vision statement that grew out of our PKAL participation. We have started building consensus and cross-departmental conversations within the college by actively engaging department chairs in planning. One of the greatest challenges has been the change in senior administration.

- The transition in top-level administration delayed the task of translating the vision identified in the PKAL LI statement into goals, although the new Dean reacted favorably to our work.

- Our provost retired at the end of 2007, and much of the upper level administration also changed at that time— this transition actually aided the evolution and implementation of our vision and goals.

As noted by the ITF:

The role of vision in institutional change (transformation of the undergraduate STEM learning environment) is an area that needs further study and refinement.

Representative postings in PKAL Volume IV include:

- *A "Frog Journey" And Other Stories of Wisdom & Leadership*
  Karen Watson
  (http://www.pkal.org/documents/FrogJourney.cfm)

- *Leadership: Institutional Context & Culture*
  Richard Hughes
  (http://www.pkal.org/documents/HughesLeadershipInstitutionalContext.cfm)

- *On Leadership In STEM*
  P. Uri Treisman
  (http://www.pkal.org/documents/UriTreismanPresentationLeadershipInSTEM.cfm)

- *What is Leadership?*
  Alexander W. Astin & Helen S. Astin
  (http://www.pkal.org/documents/Vol4WhatIsLeadership.cfm)

B. Part Two: Politics & Planning.

> **Strategy:** *A strategy is a plan to reach a goal cleverly. While it is sometimes possible to reach goals in a muddling and fatalistic way, there are advantages in thinking strategically, in using forethought, and in combining tactics as skillfully as possible…strategic planning is creative problem-solving oriented toward change* (Adams, 1986).

Shaping a vision that clearly articulates institutional goals for learning for students in STEM classrooms and labs is an iterative process, one involving careful attention to the politics and processes of change by those in a position to make a difference. It calls for a leadership group of change agents that understands the need for exploring the breadth and variety of transformational strategies, continuing to ask what works for our peers and then what will work for us, given our particular circumstance and opportunity to achieve distinction.

i. Common Challenges.

PKAL's persisting focus on the kaleidoscopic perspective recognizes that patterns (strategies) for reform differ in different settings. But this perspective also signals the commonality of the pieces of the patterns, and thus that there are common strategies that seem to be crucial for achieving sustainable change: those that deal with faculty hires and faculty development, the campus culture, the external constituency and context, as well as with the roles and responsibilities of leaders–top-down and bottom-up. This reality of common challenges is validated by the concept of positive deviance (PD) as developed by Jerry Sternin. The PD concept is that any effort to make positive change at the local level will be more productive when there is deep understanding of how "positive deviants"— those with similar resources and in similar circumstances— are succeeding in addressing similar problems/opportunities.

> *The strategy of amplifying positive deviants is itself in accord with the pragmatic and "hands-on" precepts of scientific research. It emphasizes the key role of "outliers," whose example can empower a community or institution to achieve performance well beyond presumed limitations* (Hershbach, 2002).

An essay from the PKAL archive, crafted in the early 1990's, by Uri Treisman (http://www.pkal.org/documents/UriTreismanPresentationLeadershipInSTEM.cfm) for a meeting of the initial PKAL leadership group, makes the point this way:

> *For every problem anywhere, an elegant solution has already been found.*

So, in developing the agenda for the PKAL LI initiative, we sought best practices from PD campuses that could be "elegant solutions" to be adapted elsewhere. Again, some barriers from the initial applications:

- *We don't presume to be able to decide in isolation how STEM education today will serve the leaders of tomorrow.… We have some departments working quite well together, but not all.… We have not given attention to the two gen ed courses that our non-majors must take, or thought carefully about the role of technologies in learning.*

- *We still have a cohort of traditionally-minded and disciplinary-focused faculty, and we need leadership strategies to bring these people on board. Some questions that we need to wrestle with include: a) how do we combine our existing commitment to disciplinary rigor with our emerging vision of interdisciplinarity? and b) does disciplinary content need to be sacrificed in order to bring an interdisciplinary focus to student learning?*

In essence, the common challenges were:

- entrenched faculty attitudes
- communication problems
- external pressures
- significant turnover in senior administrative positions
- not taking advantage of key leveraging strategies in a timely manner.

At the heart of many conversations on campuses visited by the ITF were explorations about what the institution really wanted their graduates to know and be able to do upon graduation (Section III C). A sense of the collective discussions on these campuses is that tensions surfaced in regard to different mental images of what was supposed to happen in the classroom— one being the gatekeeper image of the faculty role, the other the inclusionist image. These were most often but not always generational splits.

Entrenched faculty attitudes. Most campuses visited by the ITF faced several challenges, often quite formidable ones. Entrenched faculty attitudes can be hard to overcome. Because resisters are often senior faculty, they tend to have more influence, with access to decision-making groups and committees. On one campus, efforts to deal with the significant portion of faculty attached to old ways of teaching was overcome by carefully gathering data and documenting the impact of new pedagogical approaches on student learning. As new initiatives were piloted, case study reviews were conducted to determine the success of these efforts. Many faculty on that campus attested to the

power of such studies— that yielded strong results and endorsements from students about active learning strategies— in encouraging them to revisit their entrenched views (and to change).

> Report from a LI portfolio: *Our focus has been on developing a formal faculty learning community from which discussions about common aspects of 'science across the disciplines' have emerged. We have even conducted some joint classroom research to determine how well our students' understanding of the nature of science is developing as we explore new ways of teaching.*

Communication problems.
Very related to entrenched values was the difficulty of getting communication to happen. Faculty on most campuses mentioned communication as having been a significant barrier to creating and sustaining change. They found it difficult to find the time to talk to different disciplines and different schools across campus. They also encountered differences in perspective as they communicated and often do not know how to translate ideas for people who come from different disciplines. They noted how structured dialogues such as learning communities (one of the major enabling strategies) had provided key outlets of communication and that these had worked very well to bring together like-minded people.

> *Look through the campus phone book to identify colleagues to advance reform efforts*, is the advice of Melvin D. George to the PKAL LI community. *Note who can contribute and how they can contribute, and then get them to the table.*

External pressures.
Although different in scope and intensity, many campuses were concerned that attention to external pressures such as accountability, greater transparency, potential loss of public support would derail their efforts to focus on transforming the environment for teaching and learning. Another somewhat "external" agency putting pressure on some campuses was the faculty union, wherein contracts defined narrowly what is meant by teaching and/or did not include professional development such as afforded by the PKAL connection as part of the contracted service.

Turnover in senior leadership positions.
For several of the campuses visited by the ITF, change in leadership at the level of the president, provost and other academic administrators brought particular challenges to the table. New leaders brought new priorities which did or did not coalesce with those that were emerging from the science division and/or from the work of their PKAL LI team.

On at least one campus, initiatives of a new president enabled the PKAL LI team to integrate their work into broader institutional strategic planning.

> Report from an LI portfolio: Our "take-home" message about what works in overcoming barriers is to take advantage of other "movements" underway. To illustrate, *it is hard to change the direction of a static program (a body at rest tends to remain that way). Like turning the steering wheel on a parked car, little is accomplished. But when movement is initiated (even when it is not directly related to your reform effort), changing course is possible*. Our new president asked our university to "re-imagine" itself in planning for our centennial. What would we look like? How would we be positioned to be an effective educational institution for the students of that day? The influence of PKAL on our F21 faculty and the vision of our PKAL leadership initiative team played a significant role as we underwent a comprehensive review of all academic programs. Our LI team worked in parallel with formal re-visioning teams across campus to introduce the benefits of a research-rich curriculum. We have sponsored a series of luncheons, funded by the dean and president, to introduce faculty to new thoughts on learning, new approaches to teaching, means to integrate scholarly activity of students in existing courses. The process of establishing required capstone courses for all programs and designating experientially-enriched courses for all students were independent strategies that helped provide the infrastructure for further "across the curriculum" initiatives.

On another campus, they recognized the challenge of presidential transitions and addressed them directly.

> Report from an LI portfolio: Given our vision of preparing graduates to be ethical leaders of society, and given transitions at the presidential level, there is a great deal of uncertainty. So, in this limbo period, we've added to our LI team and are expanding our LI initiative to the non-science disciplines. Our assumption is that the more people on campus informed about and interested in interdisciplinary activities (in research and in courses), the more likely it will be to convince our new administrators to support us, or at least not to stand in our way. We're using the catalyst of conversations around developing an NEH proposal to bring in experts to talk to all of us about how to integrate ethics, interdisciplinary issues, leadership and service learning into our courses.

ii. Promising Practices.

The ITF identified several promising practices from their visits, as well as from a review of institutional portfolios. A condition that appears to contribute to the success of transformation efforts was the breadth and variety of strategies by which leaders pursued their vision and goals— and the intentionality by which those strategies were developed and implemented.

Communication.
To encourage faculty conversations about the question, *what do we know about our students and about how they are learning?*, the provost on one campus initiated an assessment program through which all graduating seniors were interviewed about their experiences, including how they felt about the institutional graduation requirements in STEM. Further data were collected about the level of achievement in STEM courses of current minority students. These provided data for a baseline for evaluation of future changes and created the momentum for change by revealing the reality (perceived or not) of how the students felt about the present situation. From that point, the provost gave faculty the freedom to revise current courses and develop new courses in ways directly responding to the expressed needs and desires of students for learning in STEM fields. To further foster communication across campus, the provost supported a faculty-developed and -run year-long seminar series on new approaches in learning and teaching for promoting the success of faculty and students from groups traditionally under-represented in STEM.

On another campus visited, the president supported the development of learning communities to bring people together around common interests, for example service learning, sustainability, experiential learning. These communities were a place for initial and continuing conversations about issues that mattered to their members, with an invitation from the president to submit a request for funding of pilot initiatives. One outcome of these communities has been that champions for change have emerged, and colleagues support and motivate each other. A campus-wide, year-long speaker series focusing on the question *does science matter* was also begun, and both STEM and non-STEM faculty described how the open discussions created an energy and enthusiasm for what was happening in the science division.

As an outcome of lessons learned from participating in LI meetings, the provost on one campus began hosting a series of retreats for department chairs— a first-time gathering for discussion about their responsibility for developing faculty leaders. From original skepticism about their own capacity as leaders, after several years the retreats continue and the chairs have assumed a more intentional role as mentor of colleagues (first having to redefine for themselves what leadership is meant to be).

Retreats— often off-campus— seemed to be a common feature of the leadership group on many of the campuses visited by the ITF. Again (as with the story above), there was residual hesitancy in taking time for the entire faculty to talk about issues relating to student learning, leadership, and the like. Once begun however, the report from these campuses is that as people begin to see their similar concerns, their common interests in lab and classroom, the ideas about leadership in change move more easily across campus. To return to the point of intentionality of strategies, several of the campuses had worked through the difficulty of articulating a common vision, stepping back in these retreats to refocus the question to ask, *what can I do to move our institution forward?*

Another approach to refocusing the question was to ask what their community knows about how other institutions (their peers) are addressing similar issues. Particularly as campuses sought to become more research-rich, more interdisciplinary and/or to serve all students more creatively and effectively, this kind of due diligence broadens the discussion. This was seen as another way to bring new ideas to the campus.

Leveraging and timing.
One of the most intriguing insights from an examination of LI portfolios and from the site visits is how institutions build from current structures, programs, and opportunities. The point about the appropriate "timing" of moving forward was made by several LI campuses— timing in regard to: transitions in academic leadership, attention to major facilities projects, and opportunities to explore new programmatic initiatives.

> Report from an LI portfolio: *Our 'take-home' message about what works in overcoming barriers is that it is hard to change the direction of a static program (a body at rest tends to remain that way). Like turning the steering wheel on a parked car, little is accomplished. But when movement is underway, even when it is not directly related to your reform effort, changing course is possible. Our new president asked our university community to re-imagine itself in planning for our centennial, posing the hard question:*
>
>> *What would our institution look like into the future and how can we be positioned to be an effective institution for students for the coming decade and century?*
>
> *The vision that the LI team had been crafting played a significant role as our campus community underwent a comprehensive review of all academic programs. Our LI team worked in parallel with formal revisioning teams across campus to introduce the benefits of a research-rich curriculum. We sponsored (with presidential support) a series of luncheons to introduce all faculty to contemporary thoughts on learning and on contemporary approaches to teaching. Further, our discussions dealt with ways to integrate scholarly activities of students into all existing courses. The outcomes are required capstone courses for all programs and designated experientially-enriched courses for all students. We are now well-positioned to celebrate our centennial and move into our new century.*

External pressures and connections.
One significant external pressure was the involvement with the PKAL LI and other similar agencies. The ability to network with colleagues, share promising practices in overcoming systemic barriers, and learn from leading practitioners in the field accelerated the momentum on campuses that were moving toward change. Several LI campuses followed-up a particular LI meeting by inviting one of the major speakers to campus to engage in extended conversations with the entire community, thus broadening the conversation and the group of those who "owned" the change, as well as engaging that campus community with discussions about broader national issues.

Having a critical mass of allies dedicated to institutional change was among the most critical factors on campuses visited. Many LI institutions sent multiple teams to multiple meetings (another intentional strategy); these teams went beyond STEM, including admissions officers, directors of career services or multicultural centers. This engagement with PKAL helped these colleagues to understand both why and how active learning in a research-rich environment serves 21st century undergraduates. An intentional strategy on many campuses was looking broadly for allies beyond the STEM community.

> Report from an LI portfolio: *One university took on the challenge, during their LI involvement, of reshaping the natural science curriculum for non-science majors, in large part because they recognized "…the growing chasm between scientists and non-scientists in a culture where popular perceptions of science hover between apathy and distrust. Their driving question, according to the dean was:*
>
> *"Is how we are teaching majors the best way to teach non-majors?"*
>
> *In addressing that question, they invited a professor of religious studies to join their LI team. In shaping and ranking learning goals for a new non-majors STEM course, they developed a broad dialogue with the non-science faculty in their community. They sought to determine if there was congruence about the importance and ranking of student learning goals (there was close agreement across faculty). Finally they*

asked students in the pilot course about their perceptions of the important of each goal (their responses were more varied that than group of faculty).

Senior administrative support.
Perhaps the most important finding from the ITF visits and the review of institutional portfolios was the role of people in formal positions of leadership in supporting top-down and bottom-up leadership across campus. As noted earlier, major barriers on many campuses were the transitions in leadership. On campuses visited by the ITF that were having visible progress in achieving meaningful change, all interviewed spoke directly about the support from senior leaders for science. On these same campuses, there was a common story about "what success would look like" and about the road to that success. Presidents described conversations with alumni and donors about the vision; deans spoke about facilitating monthly meetings (with food) for all faculty working to shape a new interdisciplinary program. Another dean facilitated regular open discussions about the progress of the LI team, to keep the entire community informed and involved.

Recognition for faculty involved with change initiatives, support for faculty efforts to secure internal and external support to move ahead, establishing a culture of trust and openness were important ways that senior administrators provided the foundation for change. What happened on several campuses was a new mindset emerged, a philosophical belief that change could happen. From that, it was noted that the PKAL process of moving from vision to goals and strategies was being adapted for change initiatives beyond the sciences.

Representative postings in PKAL Volume IV include:

- *Faculty & the Politics of Change*
  Jane S. Halonen, Leonard W. ter Haar & George Ellenberg
  *(*http://www.pkal.org/documents/Vol4FacultyAndThePoliticsOfChange.cfm)

- *Institutional Policies & Practices*
  Diana G. Oblinger
  *(*http://www.pkal.org/documents/Vol4InstitutionalPoliciesAndPractices.cfm)

- *Preparing 21st Century Leaders: A Departmental Responsibility*
  The Department of Mathematics at the United States Military Academy at West Point
  (http://www.pkal.org/documents/Vol4Preparing21stCenturyLeaders.cfm)

- *On the Politics of Teaching Reform*
  Gregor Novak
  *(*http://www.pkal.org/documents/PoliticsTransformingLearningTeachingEnviron.cfm)

C. Part Three: Leadership Development.

The PKAL Leadership Initiative (LI) reflected our conviction that nurturing 21st century leaders calls for linking theory and practice, identifying and supporting STEM leaders at all career stages and in all spheres of responsibility. The LI was designed to integrate discussions about roles and responsibilities of academic leaders into the work of tackling a specific opportunity facing their community. This was the answer to one of the questions that drove the LI project:

> *How do you build and capitalize on a generation of leaders with the capacities for creative thinking, with the passion for making a difference for 21st century students, science, and society?*

The answer was by fostering a sense of community and by understanding that leadership is about relationships within a community of which one is a part. A community defined by a culture of leadership happens when opportunities are built into the system of conversations about things that matter— at all levels of the organization, at all levels in career stages of faculty and other members of the community. These conversations provide an

opportunity for the exchange of ideas about the present and the future, in the context of considering what to teach, how to teach and who to teach in the 21st century STEM learning environment.

This PKAL LI was informed by research on learning, as well as by practical guidelines from the corporate world about how to build a leadership culture. Involvement with the PKAL LI required "sign-off" by a senior academic administrator and ITF visits as well as our review of institutional portfolios makes it clear that neither top-down or bottom-up leadership is sufficient unto itself.

> From an LI portfolio: *What I have done is create a separate space for my cadre of bright, young faculty to work together, with a specific charge to produce and seek to implement ideas relating to our institutional vision of greater interdisciplinarity. This has brought faculty across all science divisions together in a new way. They have found great collegiality and have sparked great creativity. A vision is emerging that is grounded in their individual sense of where their disciplines are going.*
>
> *One important thing they are learning is how their 'piece' fits into larger institutional initiatives. These young faculty are gaining new insights about campus culture and politics, lessons it might have taken them years to learn if they had not been given this LI opportunity to step up to the leadership plate. Again, having an identified, institutionally-established team working on an assigned task from the senior academic office meant that there was support when the general*
> *faculty first voted down their plan. But since they knew they had my support, they preserved.*

Several findings from this and similar reports are that the senior administrator knew that faculty innovators are often isolated, seen as outside the mainstream of campus priorities and politics. He provided a unique opportunity for "sandboxing" for the rising faculty leaders on his campus.

A second finding is the power of reflection, by the senior administrator as well as by members of the leadership team, who were invited to meet monthly with the provost. Taking time for orchestrated and informed conversations about things that matter was one of the most oft mentioned values of involvement with the PKAL LI. Sometimes these conversations became a formal part of their institutional culture.

> From an LI portfolio: *We have established an interdisciplinary science board that includes STEM faculty and our administrative colleagues, including the associate dean for faculty development, development officers, directors for assessment, inter-cultural affairs and information technology. This board meets monthly to share ideas about potential new initiatives, based on their listening to colleagues in formal and informal settings. There is now planning for several joint curricular projects underway that will be more easily accomplished because everyone has owned them from the beginning.*
>
> From an LI portfolio: *When asked what works in motivating faculty to become agents of change, my response is: '…a provost who has good ideas, but even better— one who recognizes when others have good ideas and then works with us in a flexible way to make them happen' Separately, the provost stated, 'what works is giving faculty permission to have ideas, to voice their ideas, and to act on their ideas.'*

From the ITF Report: Attention to faculty.

On most campuses visited by the ITF, plans for shaping the faculty of the future included attention to the process of selecting and socializing new faculty appointees, as well as to activities under the "faculty development" umbrella. Senior administrators and departmental leaders on campuses visited understood the importance of hiring right to bring new energy, enthusiasm, and expertise to the community. One president noted, "the future is with the young."

The role of the president in setting science as an institutional priority, particularly in regard to shaping the faculty of the future was evident on another ITF campus, where a new president allocated new faculty/staff lines to certain of the STEM programs, signaling their priority. Again, interviews with faculty across the campus revealed wide-spread awareness of and agreement with new STEM hires, understanding the importance of these hires and of providing more human resources to advance interdisciplinary initiatives, reduce class size, and manage undergraduate research more creatively.

The importance of the hiring process to institutional transformation was particularly evident on one ITF campus, where over 40% of the STEM faculty are new to the institution over the past six years. As quoted earlier, the president noted, "our future is with the young," commenting on how this new faculty energy is transforming the way teaching, learning, and research connections are now being made. This hiring trend will continue, as their faculty demographics show a significant number of senior faculty are preparing for retirement. Their dean of undergraduate studies referred to this phenomenon as the *Trojan Horse of Change* that is energizing the campus.

On another ITF campus, a similar record of new faculty hires was evident, with one-third of the present faculty having been hired in the last decade. Here again both president and dean spoke of the impact of making the right hires, as these early career faculty bring an openness to new ideas to the campus. Almost all faculty and administrators on campuses visited by the ITF— whether or not they were in the sciences— mentioned the impact of new faculty on the institutional openness to change. Many of these campuses were beginning to incorporate leadership development into their traditional faculty development programs. From an LI application:

> *While we are blessed with individual faculty who possess effective leadership skills, not until the tenure of our current president has there been intentional leadership development. The newly created faculty development initiative was designed, in part as a support system for emerging faculty leaders and, if selected, the PKAL LI STEM leadership team would work closely with the PDSN.*

In working toward a research-rich learning environment, one LI campus connected the hiring of new faculty with interest and expertise in undergraduate research, the design and implementation of new interdisciplinary undergraduate degree programs that expanded research opportunities for students, seeking and securing major external support for faculty, students and programs, and the planning of new and renovated spaces for their program. These were seen as a tight tapestry of strategies, rather than as a parallel set.

Campus Culture— Conversations & Communication.

Attention to hiring alone will not transform a culture. Decisions about faculty appointments, faculty development, faculty involvement with new initiatives call for substantive discussions that involve the broader community. Leaders of several institutions visited by the ITF described various approaches to engaging their community in substantive conversations, such as the formal learning community described above.

Most indicated that there was significant hesitation at the beginning about the value of retreats (time away from the real work of the faculty), but when they became a more regular part of the life of the community, faculty and others realize they have similar concerns and interests and even like to get to know each other. The benefit of having a visible PKAL leadership group in catalyzing and facilitating these conversations was noted now and again as a means to drive an agenda with questions important to the community. Part of the benefit was the validation of these discussions by an external agency such as PKAL.

The third set of findings relate to the process of building leadership networks, within single campuses and among a group of campuses, as orchestrated by an external agency such as PKAL

- what works is an intentional and systematic approach to identifying, assembling and coordinating the work of teams of institutional STEM leaders, when there is wide-spread awareness within the community of how and why that work is proceeding, and when that effort has external validation

- what works is an intentional and systematic approach to providing iterative opportunities for teams of institutional STEM leaders from forward-thinking campuses to meet, share experiences about overcoming common barriers, addressing and capitalizing on common opportunities, and when that effort is connected to a larger national initiative such as PKAL.

Representative postings in PKAL Volume IV include:

- *Academic Schizophrenia & STEM Leadership*
  Robert C. Hilborn
  (http://www.pkal.org/documents/AcademicSchizophreniaSTEMLead.cfm)

- *Balancing Your Career & Personal Life*
  Interview with NSF Distinguished Teaching Scholars
  *(*http://www.pkal.org/documents/Vol4BalancingCareerAndPersonalLife.cfm)

- *Leadership Growth Plan*
  Sylvia Nadler
  *(*http://www.pkal.org/documents/Vol4LeadershipGrowthPlan.cfm)

- *Trust*
  Kenneth P. Ruscio
  *(*http://www.pkal.org/documents/Vol4Trust.cfm)

VI. POSTSCRIPT: CHALLENGES AND OPPORTUNITIES FOR THE FUTURE— CURRENT ACTIVITIES

Findings from this project, which emerged from the parallel work of the PKAL ITF (Inquiry Task Force) and from reviews of materials and self-reported surveys from PKAL LI campuses, inform current and anticipated PKAL activities.

A. NSF-funded: *Facilitating Pedagogies of Engagement.* (# 0717676) One of the driving questions in the LI project was how to promote and advance promising practices in institutional transformation of the STEM learning environment. Findings:

- *The critical role of senior academic officers—* encouraging, supporting, indifferent. LI campuses actively involved from start to finish had visible support (face-to-face and budgetary) of senior administrators. What worked was when there was institutional support for participation at the various LI meetings, as well as support for trying out new ideas at the local level, even if the new idea was a time for faculty to talk about new ideas. The LI teams who attended meetings with the provost or dean responded to requests for reflections, convened regularly with his or her leadership team, and seemed to make the most significant progress in achieving the goals they had set out for their LI involvement. The disturbance to the process of meaningful change caused by transitions in presidential and deans' positions was evident on a significant number of LI campuses that experienced such transitions, which resulted in discontinued conversations about vision and/or strategies, or with new ideas brought to the table without attention to ownership by the broader community.

  Thus the design of this new grant is to provide formal opportunities for engaging senior academic leaders in conversations about pedagogies of engagement and to elicit from them— as individuals and as representatives of a collaborating partner— specific plans for on-campus efforts and ideas about how to leverage existing resources of time, structure, and funds to support those efforts. The intent is to imbed reforms into the institutional infrastructure so they can be sustainable over the long-term rather than dependent on any one individual or leadership group.

- *The critical role of networks—* formal, informal accessible opportunities for sharing, within and beyond a campus. The isolated agent of change is a persisting myth (and a reality, indeed), yet both research-based and anecdotal evidence documents that networks are a most effective means to link agents of change to early adapters, who then become agents of change in another setting. If we are to attend to dissemination research and/or to research on the evolution of eco-systems, it is important to monitor and influence how networks are shaped and used to advance meaningful reform. The value of orchestrated and persistent network building within a campus (the PKAL LI leadership teams) was one

important finding; several teams noted the importance of having an "externally-validated" collaborating agent of change [PKAL] to make their activities more credible to their colleagues. Further, the collective network of the LI community became an important resource for ideas, materials, speakers, and sometimes purely moral support. This stands strongly in contrast to reform initiatives that engage only one faculty member from one discipline, focusing on one course at a time. The PKAL LI experience became one of a network of networks, within and beyond a single campus.

Thus, the design of this new grant is to build new STEM networks from within existing networks (state systems, regional consortia, local collaboration, disciplinary communities) and to outline a series of learning opportunities for institutional teams rather than the one person, one time, one course approach to pedagogical transformation. We will be giving more attention to the theory and practice of organizational change in regard to building sustainable networks.

▪ *The power of lessons learned—* those from the work of resident experts, positive deviants, forward-thinking institutions. Speaking to the PKAL leadership group 15 years ago, Uri Treisman (http://www.pkal.org/documents/UriTreismanPresentationLeadershipInSTEM.cfm) challenged PKAL leaders to remember that *for every hard problem, there already exists a beautiful solution somewhere.* This counsel has driven PKAL from the start and attention to positive deviant and forward-thinking campuses was ratcheted up during the LI initiative, catalyzed in large part by the work of Sternin on positive deviance and Csikszentmaihalyi on creativity. Evidence from experience of LI leadership teams is that time taken adapting rather than reinventing is a most prudent use of limited resources (people, time, dollars), particularly when the challenge to change is so urgent.

Thus, the design of this new grant has a two-pronged effort to discover, distill and disseminate lessons learned & promising practices in a format that makes that material most useable by the community of practitioners—including senior academic administrators, STEM faculty, faculty in non-STEM disciplines, and their administrative colleagues with responsibilities in assessment, admissions, program and budget planning, etc. whose expertise can contribute to meaningful transformation.

Following PKAL's mantra of "do not reinvent, but steal and adapt," we are working with a wide community of pedagogical and assessment pioneers, as well as with pioneers in dissemination practices. The issue is not the lack of informative information, but rather the sheer weight of available resources, which makes finding immediately relevant materials difficult. One major "deliverable" of this grant is an outline and template for an online Handbook on Pedagogies of Engagement that would be a first point of information for faculty and for their administrative colleagues involved in pedagogical and institutional transformation within the undergraduate STEM learning environment.

B. Funded by the W.M. Keck Foundation: *Facilitating Interdisciplinary STEM Learning.* One of the driving questions in the PKAL LI project was how to support campus-based efforts to have the experience of learning 21st century STEM reflect the experience of the practice of 21st century STEM. Findings:

The importance of attending to the increasing interdisciplinarity of the STEM world, as it is practiced and thus as it is learned. The original LI project outlined three distinct areas for transformation (interdisciplinary, science for all, research-rich). Early on it was clear that these could not be addressed individually and further—that interdisciplinary was becoming the umbrella under which most decisions would have to be made about the shape of a local STEM learning environment in the next decade. This insight from the LI experience was reinforced by the 2005 report, *Facilitating Interdisciplinary Research (IDR)*, from the National Academy of Sciences. Two points from that report connect ID to a "research-rich" agenda, as well as to one addressing "science for all:"

1) "interdisciplinary research … integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge…to solve problems whose solutions are beyond the scope of a single discipline or area of research practice."

2) ….students, especially undergraduates, are strongly attracted to interdisciplinary courses, especially those of societal relevance.

The thrust of the NRC report is facilitating IDR at the level of the organization, with primary attention to R1 campuses. Its recommendations reflected the findings and insights from our work with PKAL LI campuses.

Thus it seemed reasonable to adapt their work for a more focused PKAL initiative on *facilitating interdisciplinary learning* in the undergraduate STEM learning environment. Our (funded) request to the Keck Foundation described the process and lessons learned from the PKAL LI initiative, and outlined a three-year project designed to advance efforts of local leadership teams seeking to facilitate interdisciplinary learning within the undergraduate learning environment. The threads of this initiative weave attention to a) what/where ID learning is to happen (general education or capstone programs, topical programs such as environmental science or through linked programs, such as STEM/education or math/bio); b) what institutional policies and practices are needed to facilitate the evolution, scaling-up and institutionalization of such ID programs; and c) what will be the evidence of strong student learning in an intentionally interdisciplinary learning environment.

Everything about this new Keck/PKAL initiative is built on the PKAL LI experience (what went right and what could have been different). Fifty colleges and universities responded to the call for participating campuses; thirty-one were accepted: 50% private liberal arts colleges and 50% comprehensive and R1 universities. The range of institutional types involved is a first for PKAL, with first-time PKAL involvement of R1 campuses such as Florida A&M, the Ohio State University, and Indiana University. Collectively, the applications illustrated the wide-spread interest in interdisciplinarity, the creativeness with which campuses are working toward that end, and the urgency they feel to get it right with all deliberate speed.

C. NSF-funded: *Leadership development*. (# 0734998) The PKAL Leadership Initiative (PKAL LI) grew out of PKAL activities within since 1994 to identify and nurture current, rising and future leaders for undergraduate STEM— locally and nationally. Since the mid-1990's, NSF has supported PKAL "Baca" Summer Leadership Institutes (five-day, intense mentoring opportunities at Colorado College's off-site campus in southern Colorado). That it is possible to build leaders responsible for building a culture of leadership is clear and that it is essential to do so is equally clear. The summer 2008 institute is focused on mentoring in the context of departmental leadership. It is designed as a platform from which a next set of activities relating to "mentoring in the context of developing departmental and interdisciplinary programs, as well as continuing PKAL's emphasis on institutional transformation. That everyone has leadership capacities, responsibilities and opportunities and that:

leadership is a process ultimately concerned with intentionally fostering change that is directed toward some future and/or condition which is desired or valued..." (Astin & Astin, 2000).

All PKAL initiatives— current and future— build from the conviction that there is a desired and valued future for undergraduate STEM learning in American classrooms and laboratories. Further, to quote George Brown, Jr., from the first PKAL National Colloquium in 1991, that:

We must collaborate. The task is too urgent and the time too short to do otherwise.

Building collaborating communities of leaders— within individual campuses and beyond the boundaries of campuses— is our collective challenge for the future.

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